2475/3880

MONASH UNIVERSITY

THESIS ACCEPTED IN SATISFACTION OF THE
REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

ON............7 June 2002...............

[redacted]

Sec. Research Graduate School Committee

PROFESSIONAL DEVELOPMENT ORGANIZATION AND PRIMARY MATHEMATICS TEACHERS: EXPLORING CONNECTIONS WITH BELIEFS AND PRACTICE

Ronald William Smith

T.P.T.C. (1966) (Burwood)

B.A. (1970), B.Ed. (1976), M.Ed.Studies. (1990) (Monash)

Thesis submitted to fulfil the requirements for a Doctor of Philosophy

Monash University

Faculty of Education, December, 2001

ADDENDUM

Erratum:

p. iii line 30	"Implemented" should be "implemented"
p. 23 8 lines up	"He" should not be capitalised
p. 24 4 lines up	"They" should not be capitalised
p. 39 line 9	Insert: but it is also inclusive
p. 40 line 10	Change: then to than
p. 44 line 6	Insert: space in etal to read et al
p. 47 line 14	Correct spelling should be "McLaughlin"
p. 57 11 lines up	Insert: needs to be both
p. 69 line 21	Change: it's to its
p. 73 line 4	"(Johnson & Johnson, 1989)" should read "Johnson & Johnson (1989)"
p. 74 last line	"(Gervasoni, 1995)" should read "Gervasoni (1995)"
p. 75 line 8	"(Mason, Reys & Good, 1990)" should read "Mason, Reys & Good (1990)"
p. 112 last line	"(Fennema & Franke, 1992)" should read "Fennema & Franke (1992)"
p. 118 2 lines up	"(Beeby, Burkhardt & Fraser, 1980)" should read "Beeby, Burkhardt & Fraser (1980)"
p. 150 3rd quote	Change Nnumber to Number; Pprocedures to Procedures; Mmeasurement to Measurement
p. 204 line 10	Change: it's to its
p. 236 line 13	Insert: pupils' needs rather than by starting
p. 248 line 2	Change: Profesional to Professional
p. 320 11 lines up	"(Owen, 1988)" should read "(Owen et al, 1988)"
p. 355 line 2	Insert: be made more a part of the short course

Note to readers:

The reader needs to be aware that the thesis follows the chronology of the research and is not written retrospectively. For example, Chapter 3 is written in future tense which may interfere with the flow for the reader. The thesis represents a personal research journey.

TABLE OF CONTENTS

ABSTRACT

This study explored connections between primary teachers' attitudes to a list of research-based features of effective professional development and their beliefs and classroom practices. The investigation arose from concerns as to why some teachers benefited and made changes in their classroom practice as a result of professional development, while other teachers continued with their usual classroom practice. The professional development context for the study was a short course entitled *3Cs: Chance, Constructivism & Collaboration (3Cs)* and was undertaken by eighteen primary teachers over a period of two school terms.

Data was collected through classroom observations, interviews, and transcripts of the *3Cs* workshops. Analysis was made of one transcript of classroom interactions for each teacher prior to the beginning of the short course. This analysis enabled a two-way classification to be made of the teachers based on aspects of handling classroom discussion, with teachers being grouped as 'instrumental' or 'relational'. Instrumental teachers generally saw themselves as the holders of mathematical knowledge and believed that it was their rôle to impart this knowledge to their pupils. Relational teachers created a 'discourse community', where knowledge was constructed and shared between pupils and teacher.

This two-way classification was combined with a distinction based upon whether the teachers were beginning or experienced, yielding four distinct categories. One teacher was selected from each category and an in-depth case study made. The first part of each case study included reporting and analysis of the teacher's classroom practice and their beliefs about the nature of mathematics, the role of the teacher in the classroom and how children learn mathematics. From this, a prediction was made for each case study teacher on their possible reaction to the *3Cs* program and on their attitudes to the features of effective professional development. The second part of each case study included reporting and analysis of the teacher's reaction to the *3Cs* content and to the features underlying its organisational structure. Comparison was then made between the predictions and the findings from this second part of the case study. A number of insights were generated from the comparisons made and used as a basis for discussion on data from the whole cohort of *3Cs* participants.

Several findings resulted. Each teacher's beliefs, classroom practices and attitudes towards features of professional development was unique; many of the organisational features identified in the literature as effective were more suited to the relational teachers

because of their use of reflective practice both in the classroom and as a preferred learning style; the value of classroom trialling was diminished for those teachers whose beliefs and practice did not match the agenda of the professional development; and attending professional development with close colleagues provided a valuable shared experience as follow-up to workshop sessions. These four main findings led to recommendations being made for consideration by professional development planners and researchers in the field.

STATEMENT

To the best of my knowledge this thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other institution, nor material previously published or written by another person, except where due reference is made in the text of the thesis.

[redacted]

Ron Smith

ACKNOWLEDGEMENTS

I wish to acknowledge the unstinting support given by my main supervisor, Dr Barbara Clarke. Her guidance through the many rewritings of various chapters and assistance in thinking through the important issues has been crucial. Thanks must also go to Professor Alan Bishop who acted as supervisor in the formative stages of the project and continued to give valued advice throughout the writing of the thesis. The assistance and encouragement in the first year of the study given by Professor Gilah Leder, supervisor at that stage, is also acknowledged.

Thanks must go to the eighteen primary teachers who volunteered to participate in this study. They were prepared to allow me to observe them in their classrooms, ask difficult questions, and expect them to attend the *3Cs* workshops and trial activities. Without this group of dedicated primary teachers this study would not have eventuated. Their schools must also be thanked for supporting these teachers in their professional development, especially the two schools that acted as venues for the *3Cs* program.

I am most grateful to the support given to me by colleagues in the mathematics education community. In particular I must thank the colleagues that I worked closely with at Deakin University for the interest that they took in the study as well as the many friends in schools that asked about its progress. Special thanks must go to Dr Graham Ferres who acted as a sounding board and offered thoughtful comments about the study.

I am thankful for the study leave support given by Deakin University and to the encouragement given by my Heads of School, Professor Marjorie Martin and Associate Professor Susie Groves.

Most importantly I acknowledge the support of my family. To my sons, Brad and Scott, for their consideration, patience, interest taken and assistance throughout the time that I have undertaken this study. To my wife, Shirley, for her on-going assistance when I felt totally daunted by the task ahead, for listening to and discussing many issues and by just being there when support was needed.

To family, relatives, colleagues and friends who have continually asked, "Is it finished yet?" I can now enthusiastically and proudly say, "Yes, it's in!".

LIST OF TABLES AND FIGURES

GLOSSARY
INDEX OF ABBREVIATIONS

3Cs	3Cs: Chance, Constructivism, & Collaboration
AEU	Australian Education Union
AFL	Australian Football League
AAMT	Australian Association of Mathematics Teachers
CAPC	Computers Across the Primary Curriculum (an in-service course)
Course Advice	A Victorian Education Department publication listing good activities for the classroom and linked to the CSF
CSF	Curriculum Standards Framework (policy document distributed by the Victorian government)
DSE	Directorate of School Education
EMIC	Exploring Mathematics in Classrooms In-service Course
ENRP	Early Numeracy Research Project
Frameworks	A Victorian Education Department publication outlining major issues facing the teaching of mathematics
KLA	Key Learning Area
Kidmap	A way of recording pupil evaluation
LAP	Learning Assessment Project
MAB	Multi-Base arithmetic Blocks used for teaching number concepts especially place value and the formal processes
MAV	Mathematical Association of Victoria
MCTP	Mathematics Curriculum and Teaching Program
MERGA	Mathematics Education Research Group of Australasia
MIS	Maths in Schools
NCTM	National Council of Teachers of Mathematics (United States of America)
P-10	Preparatory to Year 10
PD	Professional development
Prep	Beginning year of school in Victoria
RMIT	Royal Melbourne Institute of Technology
SCAN	Systematic Classroom Analysis Notation
SCTP	Standards Council of the Teaching Profession (Victoria)
SOSE	Studies of Society and Environment
VEF	Victorian Education Foundation
WA First Steps	An in-service course focussed on the language curriculum area

CHAPTER 1

INTRODUCTION

THE CONTEXT OF THE STUDY

The state of mathematics education and calls for change

Sullivan (1989-A) notes that there is a gap between recommendations from the theory of mathematics instruction and apparent classroom teaching. He cites a number of examples of apparent practice that the 'theorists' criticize. Some examples include:

> • relying on short term goals (Skemp, 1971),
>
> • over-emphasising irrelevant formalism and rote learning (Willoughby, 1983), and
>
> • presenting content which is divorced from reality or any context (Hoyles, 1985; Lowe & Stephens, 1987)
>
> (Sullivan, 1989-A, pages 3 & 4).

He also notes that there are two major calls for change: firstly that pupil understanding needs to be paramount, and secondly that pupils need to see that the mathematics they are learning is relevant to everyday life.

It is this gap between apparent practice and theoretical advice that brings repeated calls for change in the way in which mathematics is taught. Two major statements - the 1982 British document *Mathematics Counts: Report of the Committee of Inquiry into the Teaching of Mathematics in Schools under the Chairmanship of Dr W H Cockcroft* and the National Council of Teachers of Mathematics (NCTM) in the United States document *An Agenda For Action: Recommendations for School Mathematics of the 1980s* - have brought such calls into international focus. Cockcroft (1982) wrote

> There has been increased public criticism of the education system, and especially of mathematics teaching, expressed by parents and employers as well as by many in political and public life. .... There are at present many pupils who are being offered mathematics courses which are not suited to their needs and many teachers of mathematics who lack suitable qualifications. For these and other reasons, the mathematical education which many pupils are receiving is not satisfactory. We therefore believe that major changes are essential. (Cockcroft, 1982, page 242-3)

An Agenda For Action sets out eight recommendations, such as, the inclusion of problem solving as a focus; taking full advantage of calculators and computers at all grade levels; and broader evaluation and assessment procedures (NCTM, 1980).

Calls for reform to mathematics teaching have continued from this time:

> We are convinced that school mathematics in virtually all countries around the world has been tried in the balance and found wanting. Fundamental changes are required: there needs to be a reconceptualisation of what school mathematics should be about (the "why"), what mathematics should be studied in schools (the "what"), how it should be presented and how it should be assessed (the "how"). (Ellerton & Clements,1989, page vii)

> Much time and money have been spent in efforts to improve the teaching of mathematics in our nations' schools. Nevertheless, the problem is still with us. (Skemp, 1992, page 44)

> It is widely acknowledged that the vision of mathematics classrooms presented by NCTM's two *Standards* documents is radically different from current practice and that implementing this vision will require considerable re-education of current teachers. (Weissglass, 1994, page 67)

> Over the past four decades, societal needs for scientific and technical knowledge have led to increased concern for the teaching of scientific subjects in school. ...... Despite repeated efforts to reform instruction and curriculum, observers in many countries agree that difficulties are not being overcome. (Comiti & Ball, 1996, page 1123)

Teacher professional development

Teacher professional development is seen as the vehicle for change in teaching practice and the consequent improvement in student learning. Recommendation Seven in the NCTM document refers to teachers and their professional development and states that :

> even the best prepared, competent, and dedicated teachers must continue their development to keep abreast of changing needs, tools, and conditions. (NCTM, 1980, page 24).

In late 1994 the Standards Council of the Teaching Profession (Victoria) (SCTP) undertook a project which involved consultation with more than 400 teachers across Victoria on their personal professional development needs. This project used as its definition of professional development the following:

> The term 'professional development' is taken to mean the process of growth in competence and maturity through which teachers add range, depth and quality to the performance of their professional tasks. Professional development mainly occurs and is manifest on the job through the work teachers do and through the career opportunities they have open to them. As such,

> professional development is a career-long issue. It occurs throughout teachers' careers as they face the challenges the job presents, acquire the knowledge and skills needed to perform in that job, experience a variety of teaching circumstances and grow in competence and maturity as they extend the range of tasks at which they are confident and successful.
>
> (Costello, 1991, page 131)

Costello (1991) points out that this view of professional development does not solely rely on 'off-the job education and training' but relies on the full gamut of experiences leading to professional growth. Although teachers involved in the 1994 SCTP project reported that collegial contact was the best source of professional development (SCTP, 1996), professional development opportunities for teachers can include 'in-service courses, formal study at a tertiary institution, involvement in supervision or appraisal, observation of colleagues at work and professional reading (Conners, 1991, page 62).

In this thesis professional development will be taken to mean 'the process of growth in competence and maturity through which teachers add range, depth and quality to the performance of their professional tasks'.

Conners (1991) in citing the writing of Schlechty & Whitford (1983) notes that professional development support has three functions: establishing, enhancement, and maintenance. The 'establishing function' supports the introduction of new and innovative practice, the 'enhancement function' focuses on the improvement of teachers' skills and knowledge, and the 'maintenance function' relates to essential understanding of organizational procedures. For professional development to be successful there needs to be a correct balance between each of these functions (Conners, 1991). Together the three functions support teacher change although the 'establishing and enhancement functions' would be the most influential.

Mathematics professional development opportunities in Victoria

In Victoria, where this study will take place,.the Ministry of Education took the lead from the Cockcroft and NCTM statements and called for change in mathematics education by claiming that

> There is an acute awareness that 'mathematics in schools' does not serve its clients well, and that there is a need for classroom approaches which encourage all students in their mathematical learnings. (Ministry of Education, 1988, page 10)

Since I began primary teaching in Victoria in 1970 various avenues of professional development support have been open to teachers. These avenues have included one-off activities, formal courses, short courses, and the availability of teacher journals. This professional development activity is aimed at fulfilling the 'establishing, enhancement and maintenance functions' and thus promoting the called-for changes to classroom practice. The following paragraphs describe some of the major examples of teacher professional development opportunities in Victoria that has been available to primary teachers.

Mathematics education journals and texts, particularly program-based manuals, are readily available to teachers in Victoria. One example would be *Prime Number* published by the Mathematical Association of Victoria (MAV). This journal has a focus on teaching mathematics in the primary school where most of the articles relate to innovative ideas regarding both content and teaching approaches.

Short term or one-off in-service activities have been common in Victorian schools, at least from the early 1980's, as each school is granted one pupil-free day for each school term. This day, designated a Curriculum Day, normally deals with an issue for that school and is sometimes directed towards the improvement of mathematics classroom practice or mathematics curriculum and assessment development. The MAV also organises one-off in-service activities covering a range of topics, many of these being related to interpretation and implementation of the latest government documents. As well, the MAV has an annual two-day December Conference of workshops and lectures with over two thousand teachers in attendance.

From the mid-1980's longer term professional development support has been offered to teachers. There are many examples where the organizational structure has varied. *Key Group* was an Australian federal government funded professional development package offered to primary teachers in the mid-to-late 1980's where the basic idea was that support would be provided for an autonomous group working within a school to change its own practice (Alexopoulos, 1986).

> A central feature of the Key Group was the notion of teachers as informed professionals, experts on education and learning, and individuals able to identify areas in their current practices most in need of change (Leder, 1989, page 219).

Key Groups were made up of three teachers in Prep to Year 3 from the same school and a mathematics consultant provided outside support. *Key Groups* initially came together for a three-day live-in conference where they each decided on what they wanted to improve and a plan of action for improvement. Such organization necessarily 'places teachers squarely at the centre of action' (Rice, 1991, page5). The program gave twelve days per year of teacher release. Approximately five months after the initial three-day conference a second conference was held for review and sharing.

Short course examples are numerous, two of them being *Exploring Mathematics in Classrooms* (*EMIC*) and *Maths Making Links*. The *EMIC* teacher development package was developed in late 1985-86 and followed the 'Structured Course' model outlined by Owen, Johnson, Clarke, Lovitt, & Morony (1988). Tutors for the program were selected on recommendation by a local consultant who knew of their excellence in teaching and particularly in mathematics teaching. Teachers involved in the program, mainly from Prep to Year 3, attended ten after-school sessions (often spread over two terms) in groups of about twelve; reflected on their current practice and tried out new ideas in their own classrooms; shared and worked co-operatively with other teachers; and received regular support and feedback from their tutors who visited their schools (Robinson, 1987; Whitford, 1988). The twelve teachers in each *EMIC* group were usually made up of three or four teachers from several schools. This was a requirement as it was felt that a small group from each school could work as a team and that change might be made easier because of this.

Maths Making Links was an in-service program organised by Deakin University, which ran for several years through the mid-1990's and was taken by large numbers of primary teachers. This program, like *EMIC*, followed the 'Structured Course' model. Rather than ten sessions *Maths Making Links* offered six two-hour sessions with the content aimed at teachers in Prep to Year 6. This made it suitable for whole staff groups to be involved, an option that appears to have been taken up by a number of schools. The content provided in the workshop sessions was based upon curriculum documents such as the *Curriculum Standards Framework* (Board of Studies, 1995) and the *Mathematics Course Advice* (Directorate of School Education, 1995), all of which had been recently released by the Victorian Department of Education. The focus of the content was to link teachers' programs with effective assessment strategies. The author of *Maths Making Links* saw that this focus was of immediate concern to primary teachers. Two of the features listed about the program were that it would involve teachers in trialling and evaluating teaching strategies as well as reflecting on their practice (Consultancy Development Unit, 1995).

Maths in Schools (*MIS*), a joint initiative of the Mathematical Association of Victoria and seven Victorian universities using funds from the National Professional Development Program, was a 'professional development venture which [would assist] schools to engage in effective change processes' (Ferguson & Montgomery, 1994, page 41). Applicants had to nominate an area of improvement and suggest how their whole-school or whole-faculty would engage in working together to improve this nominated area. The project in each school essentially ran for at least two to three terms and each project was assigned a university mathematics education lecturer as a facilitator. The *MIS* facilitator was to be someone who could balance the roles of support and direction, allowing the school to make its own decisions while still making a worthwhile and valued contribution (Montgomery, 1995-A). Each project school had to identify a key teacher whose role it was to provide leadership, liaise with the MAV and the facilitator. The *MIS* program started with a pilot study in 1994. From this pilot study a collection of case studies of the twenty schools involved was published along with an accompanying publication that sought to inform schools involved in *MIS* in the following years on effective professional development processes using the case studies as examples (Montgomery 1995-A; Montgomery, 1995-B).

Many examples of teachers being involved in formal qualifications exist. One particular example, funded by the Victorian Education Foundation, was organized by Deakin University and RMIT. One requirement of the funding was that the program had to have a school-based focus. In the case of Deakin University this requirement was met by involving small groups of teachers from schools in close geographical proximity – that is, the twenty teachers involved came from five schools in the Box Hill/Blackburn area of the eastern suburbs of Melbourne. The teachers took eight units over two years to complete a Graduate Diploma in Mathematics Education. Classes for half of these units were conducted in school venues and the school groups were encouraged to undertake 'school projects' as their assessment. A number of these school groups then made presentations of their 'school projects' at in-service activities and conferences and also published their work in *Prime Number* (Smith & Beeby, 1992/93).

From this brief summary it can be seen that a variety of avenues for professional development support have been available to primary teachers in Victoria.

A personal perspective

The author of this study has had involvement in many of these professional development activities: as co-editor of *Prime Number* from 1992 to 1996, presenter at MAV in-service activity and annual conference as well as co-ordinator of the in-service activity organised by the Outer East Branch of the MAV, *EMIC* tutor, co-ordinator of the VEF-funded formal qualifications program at Deakin, and *MIS* facilitator.

In many cases feed back to the organiser or presenter of a professional development activity of its impact on participants, particularly any long-term impact, is usually not readily accessible. The most obvious examples of this are journal readers and participants at one-off in-service activity where there is no personal contact either at the time of reading the journal article or in the follow-up from one-off in-service. In the short course examples such as *EMIC* or programs such as *MIS* the impact during the time of the program can be gauged if sharing and reporting back procedures are part of the routine, however, any long-term impact is usually difficult to assess without having some formal mechanism in place.

For me, many questions are raised about the actual impact of professional development activity. In journal articles which presented ideas and activities stand out and are implemented by teachers? What makes these articles stand out? Is it readability, is it because the content addresses an immediate concern for the reader, is it because the article connects with teachers because it contains classroom stories and student work? Do the attitudes towards teaching and/or mathematics held by the reader influence whether the article is relevant to that specific reader? In the case of in-services and short courses why do some teachers take on board with enthusiasm the ideas presented, where others undertake the minimum or very little trialling of ideas? What factors are in place? Is it to do with the content of the material being presented, or the way in which the material is presented, or the presentation style of the presenter? Is it to do with organizational detail? For example, with a short course were there too many sessions or were the sessions scheduled far enough apart to allow for classroom trialling? Are teachers who attend professional development activity as a group from their school more likely to trial classroom activities than those teachers who are the only attendees from their school? What is the importance in the teacher change process for teachers to trial activities from the professional development activity and share the outcomes with the activity participants at the next session?

Consideration of questions such as these are important for the ultimate goal of improving student learning. It has been shown that teachers in Victoria have now had the opportunity to experience professional development support in various ways. What are their reactions to the various approaches being taken? Just as the students in a class are all unique individuals, teachers bring to the classroom a unique set of beliefs, attitudes and abilities. How does this 'uniqueness' interact with the outcomes of professional development activity undertaken?

This thesis will investigate the attitudes that teachers have towards the organizational features of professional development support. Connections will be explored between these attitudes, along with how they are played out in classroom practice, and the teachers' beliefs and classroom practice.

Educational change and teacher professional development in Victoria

In Victoria in the mid-1990's, schools faced massive change initiated by a change of government. The Australian Education Union Research Officer, John Graham, states that,

> The litany of change schools are being asked to consider or implement goes something like this: the *Curriculum and Standards Framework*, the LAP, the key competencies, dual recognition and other vocational education and training courses, the Internet, KIDMAP and numerous other information and learning technologies, compulsory timetabled sport, civics education, gifted education. (Graham, 1995-A, page 12)

These changes include an $8.5 million Teacher Professional Development Planning scheme which requires schools to develop whole school professional development plans (Graham, 1995-B). The implementation guide, 'Teacher Personal Professional Development Planning', states that

> Professional development is a key strategy in ensuring [effective leadership and effective teaching]. It is important that schools develop a comprehensive approach to professional development that incorporates a school plan, complemented by individual professional development for each teacher. (Directorate of School Education, 1995, page 2)

This means that each teacher at the local school level is involved in writing predictions of their intended professional development with these predictions being linked to an overall plan for the whole school. The scheme recommends that these personal plans should involve discussion/interview with the principal (Graham, 1995-B). This represents a shift from the central bureaucracies being the main providers of professional development to one setting policy, implementing high priority programs and acting as auditors and reviewers of the professional development functions devolved to schools (SCTP, 1996).

This will place changing emphases on the role of professional development that educators and researchers will need to take into account. School culture in reference to professional development could change radically as schools look to more effective methods and programs of effecting change in teaching practice. Initiators and researchers of professional development and teacher change programs will need to reflect upon this changing scene and match the most effective models of professional development to specific situations in schools. This study aims to add to the current available literature in this area.

Professional development, classroom practice and teacher beliefs

Professional development support aims to 'establish, enhance and maintain' the role of the teacher in the classroom. Although many factors are at play classroom practice is shaped by the individual teacher's beliefs (Ernest, 1989; Clarke, 1993-A; Clarke, 1993-B; Perry, 1996). *The Mathematics Framework: P-10,* (Ministry of Education, Victoria, 1988) presents a model in the form of a three-dimensional graph with the three axes representing themes of major concern to mathematics education. The major concerns are listed as students as learners, teaching methods, and views of mathematics as a discipline (see figure 1.1). According to *Frameworks* the 'student as learner' continuum ranges from a 'view of students from the perspective of society's needs' through to 'recognition of stages of growth and different interests of students' (page 11). Society's needs sorts and ranks students in readiness for work or for further education. The 'teaching methods' continuum ranges from 'teacher exposition and passive learning' through to 'learning seen as active engagement where problem solving and investigative approaches are the norm' (page 11). The 'views of mathematics' continuum ranges from seeing mathematics as a 'sequenced, cumulative, abstract discipline' through to regarding mathematics as a 'way of thinking and of modelling reality', attempting to concern itself with 'application to everyday problems' (page 11). These three distinct themes equate to distinctions made by other writers [for example, Fennema & Franke (1992) and Ernest (1989)] and will be used in the literature review discussion about teacher beliefs and practice. These themes of major concern also correspond closely to the three general outcomes of effective professional development listed, that is, 'changes in teachers' beliefs and attitudes; changes in teachers' content knowledge; and changes in teachers' instructional practice' (Conners, 1991, page 58). These three themes will inform the nature of the content for the professional development course to be used as the context in this study.

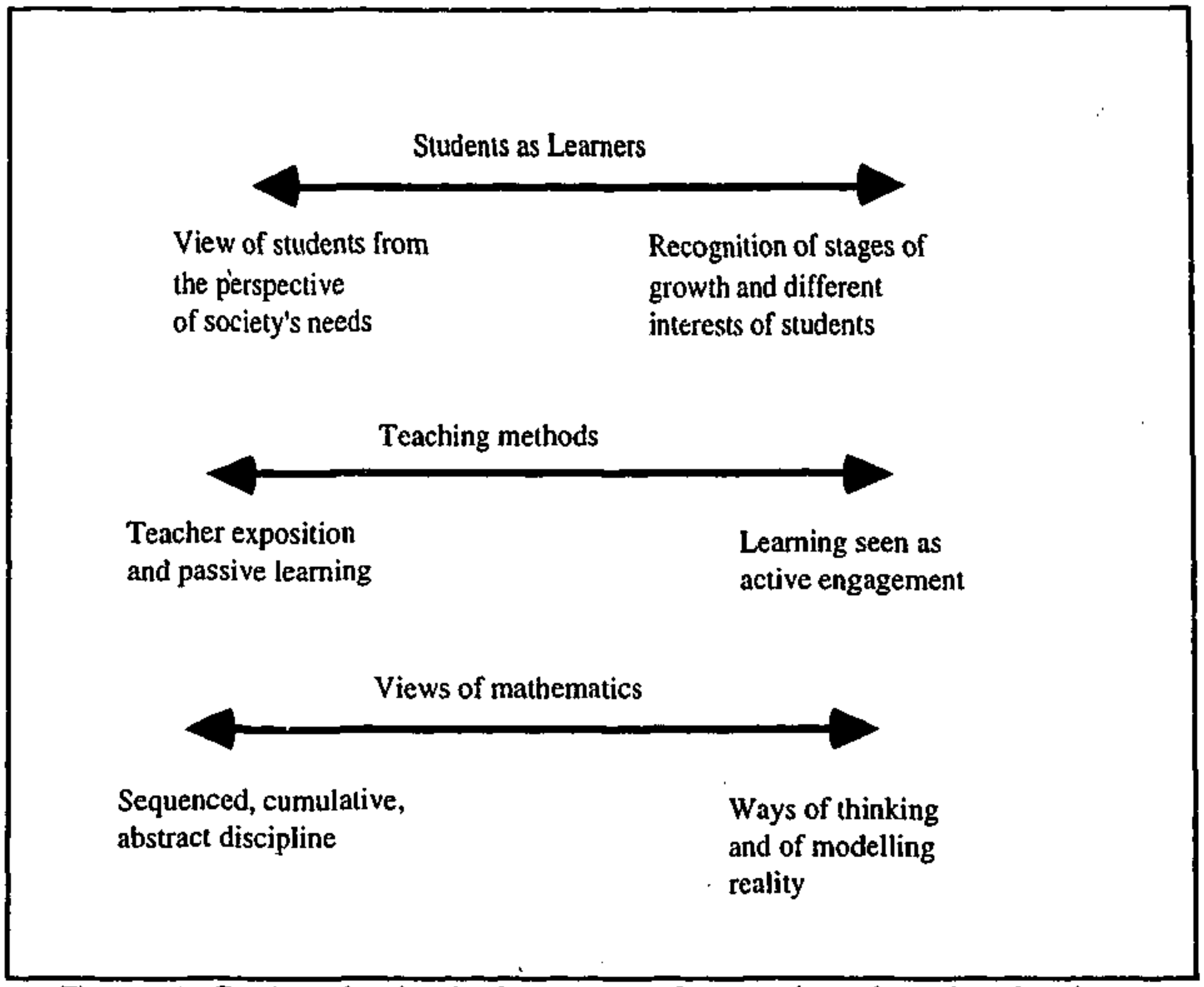


Figure 1.1: Continua showing the three aspects of concern in mathematics education

There are many recorded case studies that demonstrate that there are teachers with varying views about students, teaching methods and mathematics (Wood, Cobb & Yackel, 1991; Etchberger & Shaw, 1992; Clarke, 1995-B). These views will be interconnected: for example, teaching methods chosen are likely to be a reflection of the teacher's view of mathematics and a result of what they see as effective children's learning models. The theory-practice gap described by Sullivan (1989-A) is apparent on either ends of each of the above continua and from Sullivan's point of view for change to occur there needs to be a shift along these continua towards the right.

In the examples of professional development support for mathematics education in Victoria there are a number of organizational features that the relevant organizers considered to be important. When I was co-editor of *Prime Number* preference was given to publishing articles by practising teachers. *Key Group* required a small group of teachers to work together on a project devised by those teachers. *EMIC* and *Maths Making Links* involved teachers trialling activities and sharing the results of trialling with other participants. *MIS* was whole-school inclusive and involved working on a facet of mathematics teaching that was considered by the staff to need development. Organizational structures such as these are well documented as effective features of professional development activity (Owen et al, 1988; Clarke, 1994; Sparks & Loucks-Horsley, 1990; Guskey, 1995). The focus for this study is to consider such features and their relationship to the beliefs held by teachers.

ORGANIZATION OF THE STUDY

Selecting the short course option

Recommendation 12 of the 1994 SCTP Report states that

> Encouragement be given to short course professional development programs delivered over a period of time which allow for reflection and practice during the period of the program.(SCTP, 1996, page 52)

Because of this recommendation this study will use as the basis for data collection a group of 15-20 primary teachers undertaking a short course. As well, it is possible to include many of the effective professional development features noted from research in the implementation of short courses. Primary teachers in Victoria would have familiarity with this model because of the large numbers of teachers that undertook *EMIC*. The time that the author of the study and the professional development presenter could allocate to the study is more suited to the short course model.

Primary teachers have been selected as the subjects of this study because this is the level of teaching that the author of this study has had most contact with and knowledge about. As well primary teachers have more scope to implement innovative ideas and teaching strategies because they are less restricted by syllabus pressures and subject co-ordination which occur in secondary schools (Sullivan, 1989-A). The majority of primary teachers in Victoria would be familiar with the short course model of professional development, if not in mathematics in some other curriculum area.

The short course will consist of six two-hour sessions and be conducted over two school terms thus meeting the SCTP recommendations of being 'delivered over a period of time' to allow for 'reflection and practice'. Participants will be volunteers with preference being given to groups of teachers from a school. Other organizational features of the short course will be given consideration in light of the findings of the review of the literature pertaining to effective features of professional development support to be undertaken in Chapter 2.

Structure of the thesis

The following chapters of this thesis are organized as follows. Chapter 2 is a review of the appropriate literature and specifically considers two topics - beliefs held by teachers and effective features of professional development support. The implementation of the effective features of professional development support in relation to the proposed short course is considered in Chapter 3 along with the specific course content of each session. Chapter 4 discusses the research methodology approach. Chapter 5 is the first of four chapters that describes and analyses the collected data. Chapter 5 will use transcripts of classroom discussion in order to classify each teacher's approach to teaching. From this classification a teacher representative of each major category will be selected for detailed analysis in Chapters 6 and 7. It is anticipated that there will be between 4 and 6 case study teachers. Detailed analysis of the classroom practice and beliefs will occur in Chapter 6 and in Chapter 7 their attitudes towards effective features of professional development support as well as their reactions to the organization and content of the short course will be studied. In Chapter 8 the commonalities and differences found between the representative teachers will be extrapolated to the findings for the whole group of teachers involved in the short course. Implications of this study and recommendations for further research will be considered in Chapter 9. The context for this study is within the discipline of mathematics: the teacher beliefs studied will relate to teaching and learning mathematics; the classroom practice observed will be of mathematics lessons; and the content of the short course will include the specific topics of Chance and Data.

Aims of the study

In summary this study aims to investigate:

- the classroom practice and beliefs of a group of primary teachers who are engaged in a short course professional development program;
- the attitudes the group of teachers have towards organizational features of short course professional development and the extent to which these attitudes impact on the effectiveness of the short course example which is to be part of this study;
- the extent of implementation of the specific short course content offered as part of this study;
- any connections which may exist between teacher beliefs and practice and their attitudes towards the organizational features and content of short course professional development.

CHAPTER 2

LITERATURE REVIEW

INTRODUCTION

This chapter considers previous research that is relevant to the topics within this study. The focus of this study is to investigate the existence of connections between the beliefs held and implemented by teachers and their attitudes towards features of effective professional development. Thus this literature review is divided into two main sections: firstly teacher beliefs and classroom practice; and secondly professional development.

After considering some general comments and definitions relevant to teacher beliefs and practice, the first section of the literature review considers theoretical perspectives on beliefs about the nature of mathematics as a discipline. From here a number of research projects involving case studies of teachers are summarised. In each of these case studies of teachers the researchers have established the teacher's beliefs on the nature of mathematics. These beliefs are then used as a starting point to develop two contrasting 'pictures' - one of an 'instrumental-type teacher' and the other of a 'relational-type teacher'. These 'pictures' include the beliefs that particular teachers have about the nature of mathematics as a discipline, how children learn mathematics, the sorts of teaching strategies they value and how these three components - nature of mathematics, pedagogical beliefs, and valued teaching strategies - come together in classroom action. These 'pictures' will be used as the basis for classification of the teachers who are the research subjects of this study.

The second section of the literature review covers teacher professional development. This section begins with various lists of features for effective professional development that have been noted by researchers in this field. The features from these various lists are then amalgamated and consequently categorised under four main headings. Each categorized feature is then briefly considered. This will provide input for possible interview questions, as well as provide information for the development and organization of the professional development course to be planned as part of this study.

TEACHER BELIEFS AND CLASSROOM PRACTICE

What is meant by beliefs?

> ..... everyone has a set of beliefs about how mathematics is learned. These beliefs have an influence on all aspects of teaching. They govern what is considered appropriate to include in a curriculum and when topics should be taught; they determine the importance the educator attributes to gauging readiness skills or exploiting children's curiosity and interests; and they effect how educators teach skills and concepts, evaluate progress and remedy difficulties. In brief, whether conscious or not, beliefs about mathematics learning guide decision making and, in the end, influence our effectiveness as mathematics educators. (Baroody, 1987, page 5).

In this statement Baroody (1987) suggests that teacher beliefs influence classroom practice. What is meant by beliefs? Thompson (1992), who undertook an extensive review of the research into beliefs within mathematics education, uses the term 'conception' when referring to beliefs. She defines a teacher's conception of the nature of mathematics as that 'teacher's conscious or subconscious beliefs, concepts, meanings, rules, mental images, and preferences' (page 132). She claims that beliefs and knowledge are closely related but that distinctions between the two can be made. For example, she cites Scheffler (1965) when stating that knowledge relates to truth and certainty compared to the notion that beliefs can be disputed. Because beliefs are not judged by any particular criteria people can hold a range of differing beliefs. Beliefs can change over time but so too can knowledge. If the evidence upon which certain knowledge is based becomes unfounded or changes then that knowledge must also change. Thompson (1992) further notes that beliefs over time may later become knowledge as evidence is gathered to support the belief.

She also notes that beliefs can be held with varying levels of conviction. Other writers have also categorised beliefs into various levels: for example, conscious or sub-conscious beliefs (Baroody, 1987), deep-level or surface-level beliefs (Raymond, 1997), beliefs held and/or implemented (Southwell, 1995), or central or peripheral beliefs (Green, 1971). According to Raymond (1997) surface beliefs when compared to deep beliefs are not really part of a person's philosophy and have little impact on what is then implemented in the classroom. Southwell (1995) distinguishes between the concepts of 'values' and 'beliefs' and notes that an individual might have beliefs but does not necessarily put them into practice because they have not integrated such beliefs into their value system and act upon such a system consistently. Southwell's explanation continues by stating that 'values are the beliefs we hold which determine how we live [whereas] beliefs are opinions we hold but do not necessarily live by' (page 478). Southwell lists three important elements for consideration. The cognitive' element refers to the judgements of worth or obligation that form the basis of implemented beliefs. The 'affective' element pertains to the varying intensity with which beliefs can be held. And the 'volitional' element refers to the varying depth or commitment in which beliefs can be held.

Beliefs and teacher knowledge

Some of the links between beliefs and knowledge have already been briefly referred to in the previous section. Fennema & Franke (1992), in writing an extensive review of the research literature on teacher knowledge, lay claim to the fact in their introductory section that 'it is impossible to separate beliefs and knowledge' (page 147). Although the major components of teacher knowledge include content knowledge, knowledge of learning, knowledge of mathematical representations (that is, knowledge of the ability to transfer mathematics into a form that is meaningful to the learner), and pedagogical knowledge, it is important to see the inter-connectedness between all of these (Fennema & Franke, 1992). Within content knowledge they distinguish between the nature of mathematics and the teacher's mental organization of the knowledge. In their wide-ranging review of teacher knowledge, they raise other notions relevant to this research, including the idea that knowledge is not static and the related concept of situated knowledge. Situated knowledge is that which is gained through context. Teacher discipline knowledge in mathematics is almost wholly derived from in-school situations. Teacher's early impressions of classroom approaches and of children's learning are also gained from an in-school environment, but as pre-service training and actual teaching proceed teacher knowledge of this becomes more and more based upon experiences that occurred in context, and hence situated knowledge.

Even, Tirosh & Markovits (1996) conducted a long-term research and development project which included in its overall aims the exploration of teacher knowledge where they distinguished between teacher subject-matter knowledge and pedagogical content knowledge. With subject-matter knowledge they found that it was not easy to define 'knowing' although it was useful to distinguish between 'knowing that' and 'knowing why'. In response to the difficulties encountered they developed an analytic framework of necessary subject-matter knowledge for teaching a specific mathematics topic. The framework, based upon the teaching of the function concept, has seven aspects as follows: '(i) essential features of the concept; (ii) different representations; (iii) alternative approaches; (iv) strength of the concept; (v) basic repertoire; (vi) different kinds of knowledge and understanding; and (vii) epistemological knowledge about the nature of mathematics' (pages 120-121). The studies undertaken by these researchers and their colleagues have indicated, in many cases:

> that teachers' knowledge of mathematics influences their pedagogical content-specific decisions ..... [and also indicates] the importance of this knowledge since lack of such knowledge impedes teachers' ability to determine the correctness of a student's answers, leads them to respond to students in ways which are mathematically inadequate, and to provide ad-hoc responses that do not take their long-term impact on students into consideration. (Even, Tirsoh & Markovits, 1996, pages 121-122)

They also make an analysis using the following dimensions: (i) awareness of the student's conceptions; (ii) types of teacher responses; and (ii) content knowledge. Their studies show that there is a wide range of teacher awareness of pedagogical knowledge and resulting implications. For example, even where a teacher does understand a student's difficulty they may resolve the difficulty by focusing on mechanical thinking and achievement of short-term mastery-of-skills type of objectives.

Beliefs about the nature of mathematics

Ernest's perspectives

Ernest (1989) presents the notion that mathematics can be viewed in three ways: problem-solving, Platonic, and instrumentalist views. With his problem-solving view he sees mathematics as 'a dynamic, continually expanding field of human creation and invention, a cultural product' and adds that 'mathematics is a process of inquiry and coming to know, not a finished product, for its results remain open to revision' (page 250). The Platonic view he regards as a static but unified body of knowledge where mathematics is discovered and not created. The instrumental view has mathematics as an accumulation of often unrelated facts, rules and skills which are used to produce an external result. Ernest goes even further by suggesting that these three views form a hierarchy with instrumentalism at the lowest level, followed by the Platonic view, and then at the highest level the problem-solving view.

Raymond (1997) researched the connection between classroom practice and beliefs of novice primary teachers. In analysing the data she made use of the above three views of the nature of mathematics espoused by Ernest to develop a continuum that had five distinct reference points. The reference points for this continuum were labelled as 'traditional', 'primarily traditional', 'even mix of traditional and nontraditional', 'primarily nontraditional' and 'non-traditional'. Table 2.1 outlines the descriptors attached to each reference point:

traditional	• Mathematics is an unrelated collection of facts, rules, and skills. • Mathematics is fixed, predictable, absolute, certain, and applicable.
primarily traditional	• Mathematics is primarily an unrelated collection of facts, rules, and skills. • Mathematics is primarily fixed, predictable, absolute, certain, and applicable.
even mix of traditional and nontraditional	• Mathematics is a static but unified body of knowledge with interconnecting structures. • Mathematics is equally both fixed and dynamic, both predictable and surprising, both absolute and relative, both doubtful and certain, and both applicable and aesthetic.
primarily nontraditional	• Mathematics is primarily a static but unified body of knowledge. • Mathematics involves problem solving. • Mathematics is primarily surprising, relative, doubtful, and aesthetic.
nontraditional	• Mathematics is dynamic, problem-driven, and continually expanding. • Mathematics can be surprising, relative, doubtful, and aesthetic.

Table 2.1: Connections between practice and beliefs based on views espoused by Ernest (Raymond, 1997, pages 556-557)

Lerman's absolutist and fallibilist contrasts

Lerman (1983) takes the writing of Lakatos to come to a two-way classification of views of the nature of mathematics: absolutist and fallibilist. According to Lerman, the absolutist view is seen as 'the paradigm of knowledge, certain, absolute, value-free and abstract, with its connections to the real world perhaps of a platonic nature' (cited in Thompson, 1992, page 132). Lerman adds that procedures and rules are the important component of this view and that mathematics has been successfully taught if such procedures and rules have been properly conveyed, practised, and assessed. This leads to the notion that application and understanding comes later. He states that for this view 'mathematics is a steadily accumulated body of knowledge, linear or hierarchical, dependable, reliable and value-free' (page 62).

The opposing view, the fallibilist view, Lerman regards as a result of seeing mathematics as a searching out of solutions to problems. He states that students must be encouraged to propose ideas and suggest methods; they must be led to test these hypotheses themselves, to try to generalise their methods, compare them with other possibilities and search out other problems of a similar nature that may have been previously solved.

When Thompson (1992) compared the views of the nature of mathematics given by Lerman and Ernest she concluded that 'the parallelism between Lerman's absolutist and fallibilist views and Ernest's Platonic and problem-solving views is readily observable' (page 132).

Skemp's ideas on mathematical understanding

Skemp (1976) sees that there are two differing views of understanding – instrumental and relational. Skemp describes his instrumental view as 'rules without reason' (page 20) whereas his relational view he sees as 'knowing both what to do and why' (page 20). He cites many examples in mathematics instruction where teacher explanations are instrumental: for example, 'borrowing' in subtraction, circumference equals π times the diameter, and the angles within a triangle total 180^0.

Through the many mathematical examples given Skemp's notion of instrumental understanding of mathematics is based upon a view that sees mathematics as a collection of many disconnected rules, that specific methods match specific problems, and an awareness of the lack of connection between mathematical ideas. Skemp's notion of instrumental understanding can then be equated with Ernest's instrumentalist view on the nature of mathematics.

Skemp's notion of relational understanding of mathematics allows for connections to be made between fundamental ideas and sees that mathematical principles having broad application. Skemp's notion of relational understanding is then more closely aligned with the problem-solving and the fallibilist views put forward by Ernest and Lerman respectively.

Developing contrasting situations

Included as one of the aims of this study is the investigation of the classroom practice and beliefs of a group of primary teachers. In order to do this it is intended to develop two contrasting teacher profiles so that the group of teachers involved in the study can be classified under one of these profiles. I have decided to use the terms 'instrumental' and 'relational' for the two contrasting profiles.

At this stage it would appear to be possible to begin to develop these contrasting profiles beginning with beliefs about the nature of mathematics - one set in 'instrumental' terms and the other in 'relational' terms. Table 2.2 makes comparison between 'instrumental' and 'relational' beliefs about the nature of mathematics. Each dichotomy has been given a 'dimension' to make later referral easier.

Dimension	Instrumental beliefs	Relational beliefs
Rules or process	Mathematics is a collection of unrelated facts, rules, and skills.	Mathematics is finding solutions to problems based on making connections to previous understanding and experience.
Fixed or developing	Mathematics is seen as a fixed body of knowledge which is predictable and certain.	Mathematics is seen as dynamic, changing, and open to revision.
One or multiple solutions	Regarded that there is usually only one solution path to a problem.	Regarded that there are multiple solution paths to solving a problem.
Mastery or developing inquiry	Mastery of solution methods is seen as important.	Developing a process of inquiry is seen as important.

Table 2.2: Comparison between instrumental and relational beliefs about the nature of mathematics

Further on in this literature review the contrasting profiles will be added to in other dimensions of beliefs in regard to learning and teaching. As well contrasting profiles will be developed for classroom practice.

Beliefs about teaching and learning and their implications for the classroom

Do beliefs relate to classroom practice?

When Perry, Howard & Conroy (1996) surveyed a large number of primary teachers in New South Wales on their beliefs they found that many of the beliefs were connected in a statistically significant way. The teachers' beliefs were categorized in three ways: beliefs about the nature of mathematics; beliefs about mathematics learning; and beliefs about mathematics teaching. One of a number of examples of inter-connectedness in their study is the belief that 'mathematics is computation' (a belief statement in relation to the nature of mathematics) being highly correlated to 'being able to memorise facts is critical in mathematics learning' (a belief statement in relation to mathematics learning) as well as 'the role of the mathematics teacher is to transmit mathematical knowledge and to verify that learners have received this knowledge' (a belief statement in relation to mathematics teaching) (page 458). As well as these 'transmission/absorption-type' beliefs being significantly related, the same, although not as statistically strong, was found for a set of 'child-centred-type' beliefs.

Ernest (1989) notes that the practice of teaching depends on:

> the teacher's mental contents or schemes, particularly the system of beliefs concerning mathematics and its teaching and learning [as well as] the social context of the teaching situation, particularly the constraints and opportunities it provides; and the teacher's level of thought processes and reflection. (page 249)

He claimed that a teacher's views would generate the approach taken by the teacher in the classroom. He used his three categories of beliefs about the nature of mathematics to describe three types of teachers: instructor, explainer and facilitator. In the same way he also developed a classification for learning models: 'compliant behaviour/mastery of skills; knowledge reception; active construction of knowledge, and exploration and autonomous pursuit of own interests model' (page 251). He further linked these notions to beliefs about the nature of mathematics. This set of connections are listed in Table 2.3.

	Instrumental view	Platonist view	Problem-solving view
Teacher as:	Instructor	Explainer	Facilitator
Learning model as:	Compliant behaviour and mastery of skills	Reception of knowledge	Learning as the active construction of understanding, possibly including autonomous pursuits

Table 2.3: Ernest's connections between beliefs about the nature of mathematics and classroom practice

When Clarke (1993-B) drew on a number of studies for the purpose of compiling a list of the components of the role of a teacher in a reformed classroom he made the claim that 'there is considerable evidence in the research literature that beliefs and practice are dialetically related' (page183). For example, he considered the following aspect of a teacher's role: 'the development of a "mathematical discourse community", with the teacher as "fellow player" who values and builds upon students' solutions and methods' and linked this to three beliefs about teaching and learning mathematics. These three beliefs were: 'an atmosphere of conjecture and justification of mathematical ideas enhances learning; teachers should be open about their own struggles with mathematical problems; and students' solutions and methods provide the basis for discussion of problems' (page 184). In his research Clarke (1993-A) was able to observe specific classroom practice and make positive connections to beliefs stated in interviews (refer further on in this literature review to the case study summary of Ms Bartlett and Mr Martin). Clarke's research was confirming of the conclusion that he had made from the research literature and added weight to the notion that classroom practice is driven by the beliefs held by teachers.

Thompson (1992) cites Kuhs and Ball's (1986) four categories of mathematics teaching and states that one measure of teacher beliefs of how students best learn mathematics is by the role they expect students to take in lessons. Kuhs and Ball's four categories are classroom-focussed, content-focussed with an emphasis on performance, content-focussed with an emphasis on conceptual understanding, and learner-focussed. In their descriptions of each category the similarities with the previous beliefs about the nature of mathematics can be seen. The 'classroom-focussed' category assumes that students learn best when lessons are clearly structured and follow principles of effective instruction. The teacher role in this category is more as director - presenting, monitoring, and managing effectively to avoid interruptions which might disrupt the flow of the planned activities and the student role is one of listening to the teacher and completing set tasks. The 'content-focussed with an emphasis on performance' category bases the teaching more upon rules and drill and being able to demonstrate mastery. In this category the mathematical content - skills and concepts - is hierarchically organised. In this category the student role is one of listening, responding to teacher questions, and practising problems according to the example demonstrated by the teacher. These first two categories have similarities to instrumental views. The 'content-focussed with an emphasis on conceptual understanding' category contrasts to the other content-focussed category in that the emphasis is on the individual student. The learner-focussed category sees mathematics teaching from the point of view of the students making personal constructions of mathematical knowledge and hence typifies the constructivist views espoused by such theorists as von Glasersfeld (1996) and Cobb, Wood & Yackel (1991). This view centres on active involvement by students where the teacher essentially facilitates and stimulates student learning by providing appropriate investigations and by asking probing questions. In this category the student is responsible for decision-making and direction, needs to support and defend their decisions and conclusions, and is assessed by a measure of the 'consistency between [their] constructed ideas and the shared meaning of the idea in the discipline' (Thompson, 1992, page 136). These latter two Kuhs and Ball's categories more closely resemble the beliefs inherent at the relational end of the dichotomy.

However, espoused beliefs and observed practice do not always correlate (Thompson 1992). A case study example of a beginning primary teacher was given by Raymond (1997) which illustrates this. The beginning teacher had non-traditional surface beliefs on pedagogy which were outweighed by her traditional deep-seated beliefs on the nature of mathematics and when it came to classroom practice the deep-seated beliefs dominated. The deep-seated beliefs on the nature of mathematics were primarily based upon prior school experiences whereas the surface beliefs on pedagogy were based upon relatively limited teaching experiences. For this beginning teacher classroom management was problematic and consequently placed her in a position where her deep-seated beliefs had more influence on classroom practice than her surface-level beliefs. Also in a study of beginning teachers, Sullivan (1989-B) found that pupil behaviour and a lack of confidence in mathematics content knowledge were among the constraints that prevented implementation of beliefs about learning and teaching. This is important for this study because it indicates that interviews ascertaining beliefs will not be sufficient for determining classroom practice. In order to get a clear picture of an individual teacher's classroom practice it will also be essential to include classroom observation as part of data collection.

The 'Instrumental Teacher' and the 'Relational Teacher'

Thompson (1992), in her major review of attitudes to mathematics and mathematics teaching cites research by Steinberg et al (1985) and Owens (1987) when she claims that studies report that most teachers' views of the nature of mathematics are based on school mathematics (arithmetic, algebra and geometry) and hence a very strong absolutist/instumentalist/Platonic view being developed and espoused. She also notes that the mathematics education community has been very critical of teaching that has grown out of instrumental beliefs. This form of teaching has been referred to by many names: traditional (Bishop & Goffree, 1986) and conventional (Sullivan, Bourke & Scott, 1995) being two terms used. (Sullivan, Bourke & Scott, 1995) give the following scenario for what they term 'conventional teaching':

> Consists of teacher demonstration of one or more exercises, with explanations and demonstrations linked to examples. Students predominantly work on drill and practice exercises. If the feedback is negative, students do more practice; if the feedback is positive then the class moves onto new exercises. Students are likely to see mathematics as a collection of rules and exercises. (Sullivan, Bourke & Scott, 1995, page 484)

Bishop & Goffree (1986) describe what they call a traditional 'lesson frame' which adds further insights to what they describe as instrumental teaching:

> [The mathematics lesson] is construed as an 'event' with a definite beginning, an elaboration and a definite end. It has a fixed time duration. Typically all children will be engaged in the same activities which are planned, initiated and controlled by the teacher. Lessons are pitched at the level of the average child with appropriate modifications for 'faster' and 'slower' ones. Typically, instruction, exposition, 'chalk and talk', boardwork, question and answer, are the principal modes of teaching, together with seatwork, practice, and the individual help of those children who 'need help'. The teacher must keep between the limits of going too fast so that not all children will be able to keep up and going too slow so that the syllabus won't be covered. Time is of essence. (Bishop & Goffree, 1986, page 311)

Prawat (1992) summarises the approach in an appropriate way by claiming that traditional practice is best characterised as a 'transmission' approach to teaching where teachers are 'tellers of the truth', and an 'absorptionist' approach to learning where learners act out a role of 'accumulators of material who listen, read, and perform prescribed exercises' (page 356). Prawat, in discussing achieving teacher change, lists four beliefs underlying traditional transmission teaching and learning which he sees as counter-productive for encouraging teachers to adopt practices in line with constructivist ideals. He views the role of the teacher in 'traditional practice' to involve curriculum management, running of activities and organization of students. Firstly, he refers to the view where learner and curriculum content are relatively fixed entities. That is, students are viewed in non-interactive, static terms and thus teaching is mainly based on 'delivery' rather than such things as student meaning-making and selecting content. In this scenario individual differences are catered for by varying style and pace of instruction. The second view Prawat terms 'naive constructivism', where activity is equated with learning and calls on Dewey's point that student engagement is not the best measure of educational value. The third view distinguishes between comprehension and application, learning and problem-solving. This view is based on the notion that knowledge transfer can occur from one context and be readily applied by the learner in another context. The fourth view sees the curriculum as a fixed agenda with a definite course to run and having pre-determined objectives to be met. He regards this view as treating the curriculum as a road map where the teacher's primary role is that of manager or orchestrator.

In further discussion Prawat reveals corollaries to each of these views and gradually builds up an alternative view based upon constructivist ideas as he sees them. The constructivist corollary for one view sees subject matter and setting and the resulting interaction made by the teacher between these as important. Thinking cannot take place in a void and thus thinking or student sense-making is highly contextualised. Thus the teacher should be focussing on the range of understandings students develop when coming to grips with concepts and also needs to make conjectures about student thinking as a part of content or subject-matter preparation. Teachers also need to carefully note the various student interpretations. Prawat would see that knowledge *about* subject matter is just as, if not more important than knowledge *of* subject matter. When discussing the second view He claims that the constructivist would use ideas as opposed to activities as being the basis for teacher planning. In discussing his third view Prawat insists that real learning will take place if it is thoroughly considered within a context where 'big ideas' are applied to specific problems, that is, the connection between knowledge and context is drawn out. He considers the notions of 'negotiation' and states that 'from a constructivist perspective, it is essential that the classroom environment be perceived as one in which individuals are free to explore ideas, ask questions, and make mistakes' (page 380). The corollary to the fourth view has the curriculum being viewed 'more as a matrix of ideas to be explored over a period of time [where the matrix would be entered] at various points depending on where students are in their current understanding (page 358). The constructivist view of the curriculum for Prawat then sees the planning of it and associated lessons as providing a balance of equilibrium and dis-equilibrium with teachers needing to decide when to challenge students' ideas or when to be supportive. Prawat believes that teachers should set broad curriculum goals and it would be for the teacher and students to negotiate some of the curriculum. To be able to manage this process teachers need to develop a global view, understand the network of big ideas and be able to make connections between the ideas. In general terms he sees the constructivist classroom as one in which the role of the teacher as collaborative action with the students in in-depth exploring of important notions.

As noted earlier Clarke (1993-B) undertook a search of the literature relevant to teachers in 'reformed classrooms' to develop a list of components related to the teacher's role and their beliefs. His 'reformed classroom' is in contrast to a classroom dominated by instrumental instruction and could be equated to the role and beliefs of a 'relational teacher'.

Components of the role (what the teacher does)	Related beliefs about the teaching and learning of mathematics
1. The use of non-routine problems as the starting point and focus of instruction, without the provision of procedures for their solution.	Students can solve non-routine problems without first being taught a procedure.
2. The adaption of materials and instruction according to local contexts and the teacher's knowledge of student's interest and needs.	Mathematics needs to be studied in living contexts which are meaningful and relevant to students, including their languages, culture and everyday lives.
3. The use of a variety of classroom organizational styles (individual, small-group, whole-class).	Differences in mathematical tasks and preferred learning styles of individuals demand variety in classroom organization.
4. The development of a 'Mathematical discourse community, with the teacher as "fellow player" who values and builds upon students' solutions and methods.	An atmosphere of conjecture and justification of mathematical ideas enhances learning. Teachers should be open about their own struggles with mathematical problems. Students' solutions and methods provide the basis for discussion of problems.
5. The identification and focus on the big ideas of mathematics.	Important mathematical ideas are not confined to specific procedures in isolated content areas, but rather mathematics is seen as an integrated whole, in which the processes of problem solving, reasoning, and communication are central.
6. The use of informal assessment methods to inform instructional decisions.	Observing and listening to students provides a "window" into their thinking which can be used to plan further instruction.

Table 2.4: Role and beliefs of the 'relational teacher' (Clarke, 1993-B, pages 183-184)

In this section a number of 'pictures of teaching' have been described. These 'pictures of teaching' will now be further explored by describing some research involving case studies of primary teachers. It is anticipated that through the situations already described and with the reporting of the case studies it will then be possible to add to the two contrasting beliefs profiles began earlier in the literature review.

Case studies of primary teachers' beliefs and their actions in the classroom

A number of case studies will now be summarised in the anticipation that 'pictures' of an 'instrumental teacher' and a 'relational teacher' can be developed. The case studies included make use of the notions presented by Ernest, Lerman and Skemp and make connections to other beliefs and classroom practice. As well as beliefs on the nature of mathematics, these 'pictures' need to include beliefs on how children learn mathematics, as well as the sorts of teaching strategies valued and employed.

It is important that the case studies are of primary teachers, and preferably from the middle/upper levels of the primary school, thus matching the teachers that will be the anticipated subjects for this study. It would be misleading to include case studies of secondary mathematics teachers as they would have, on the whole, a quite different mathematics knowledge base. The mathematics context to be used in the professional development program is to be Chance with some reference to the topic of Data (this will be discussed further in Chapter 3). Callingham, Watson, Collis & Moritz (1995) collected data on personal confidence and teaching confidence in topics within the Chance and Data strand from a sample of Tasmanian primary and secondary teachers. They found that primary teachers were lower on both categories than secondary teachers.

Grade 2 teacher (Wood, Cobb & Yackel, 1991)

As part of a larger project on constructivist learning in a second grade classroom, Wood, Cobb & Yackel (1991) made a study of the teacher involved and the change process that took place with that teacher's approach in instruction and in beliefs and attitudes. In the abstract to their paper They note that the grade two teacher involved in the study changed her beliefs about the nature of:

(a) mathematics from rules and procedures to meaningful activity,

(b) learning from passivity to interacting and communicating, and

(c) teaching from transmitting information to initiating and guiding students' development of knowledge. (Wood, Cobb & Yackel 1991, page 587)

These changes match nicely a shift from instrumental-type approaches to relational-type approaches. What was the classroom practice that had been taking place? From their report it is possible to gain a glimpse of classroom practice both before the change, that is an instrumental approach, as well as the relational approach that was gradually taken up as a result of the intervention program with the children in the grade.

The teacher involved was described as at mid-career and had been teaching grade two for fifteen years. The organizational structure appears to be like the Victorian situation where the teacher instructed her pupils for most curriculum areas although they went to specialists for such learning areas as music and physical education. What might be different is that the class was limited to twenty pupils. Before the intervention took place the teacher had been very dependent on the teacher's manual to the mathematics textbook used by the pupils. Her typical mathematics lesson involved either reviewing or introducing a new procedure. For this, step-by-step instruction was given followed by pupil practice of examples from the textbook. The pupils worked quietly at this which either enabled her to take aside a small group of pupils that were having difficulty where she went over the same step-by-step procedure or otherwise she sat at her desk and did correction. This teacher viewed mathematics as a procedure-oriented subject, that children should work individually, and that she was the sole source of information and authority. Her only way of learning about children's mathematical thinking was by their ability to get correct answers using the method that she prescribed.

During the intervention phase there was no directives or instructions from the researchers as to what the teacher should do. However, at weekly project meetings there was discussion about the events of the week and classroom activities were developed for the next week. Thus the teacher made her own decisions as to how to implement the activities and how to handle the discussion during the activity time with her pupils. It was this latter process where the teacher encountered situations that conflicted with her prior beliefs that encouraged her to question and hence re-shape her classroom approach. She realised in this new situation that if the children were to discuss their own problem-solving methods, that they might offer incorrect solutions or methods and that she had to respect their thinking and accept their ideas, which in turn meant not imposing her own methods or making judgements. Examples of classroom discussion given by Wood, Cobb & Yackel demonstrate that the teacher took on broad practices that indicated to the children that she valued their methods as well as their answers, practices that allowed the children to explain their own methods, practices that were accepting of incorrect answers and practices where questioning of accompanying explanation led the children to fuller understanding. Her practice now involved more skilful listening to children's explanations so that she could ask questions or offer suggestions which were not seen as over-directing or intervening. This teacher gradually came to the position where she recognised that her role was more one of facilitator than of being the sole source of knowledge. She realised that by allowing children to struggle with their own conflicts and confusions in their mathematical thinking that this was providing situations where real learning might take place. Her teaching moved from one of imposition to one of negotiation, that is, to a situation where conflict could be resolved, meaning could be negotiated, and being accepting of other children's views.

Jessica – Grade 5 teacher (Etchberger & Shaw, 1992)

The case study by Etchberger & Shaw (1992) presents an interesting scenario of a teacher who moved from an instrumental mode to a more relational mode. The story of Jessica, a teacher of grade five, is described from observations, interviews and entries in a journal kept by the teacher made over a four-month period. Jessica made a transition from 'individual teacher-dispensed mathematics to cooperative teacher-assisted mathematics' (page 412). Etchberger & Shaw described how Jessica passed through three stages of professional growth: (1) instrumental teacher-dispenser/individual student-receiver; (2) instrumental teacher-dispenser/cooperative student receivers; (3) relational teacher-provider/cooperative student-constructors.

Jessica taught science using cooperative learning groups where the pupils constructed knowledge from activities and experiences. To Jessica this seemed a natural way to teach and for children to learn. Etchberger & Shaw found that her 'image of mathematics was purely instrumental' (page 413). Thus, she could not see how mathematics could be taught in such a way mainly because mathematics required procedural steps to be taught, and individuals could not be assessed in group settings. She also felt that the amount of time available was not appropriate for the amount of mathematics that needed to be covered. She saw herself as the 'holder of knowledge', dispensing correct methods to use to children who practised these methods in silence. Etchberger & Shaw describe her approach to teaching as being:

> presentation of new material, examples and non-examples given, questions asked designed to confirm procedures, samples tried together, students [doing] individual samples which [were] checked for accuracy, assignment explained, and work given. (Etchberger & Shaw, 1992, page 412)

Jessica became dissatisfied with her mathematics instruction when she observed the results of her science teaching. This initially put her into Etchberger & Shaw's second growth phase. Jessica taught in the same way but allowed her pupils to help each other when in difficulty. She thought she was offering them the chance to construct concepts but in fact they were only assisting each other in teacher-designed and teacher-directed exercises.

Dissatisfaction with this approach led Jessica to a new vision where she was to be:

> no longer the dispenser of concepts but ..... provider of situations from which learners derive or build concepts ..... she sees herself as a provider of situations, a guide, a questioner ..... has freed herself and her students to become explorers [where] her image of students has developed into that of information gatherers, reflectors, constructors, collaborators, and discoverers. (Etchberger & Shaw, 1992, page 415)

Joanna - Beginning primary teacher (Raymond, 1997)

Joanna, a fourth-grade teacher was in her first and second year from teacher training when Raymond (1997) undertook her research. The organizational situation in Joanna's school was that she worked in a team arrangement taking the mathematics for three grades. She had chosen mathematics because she had originally imagined that there would be less preparation time needed. This was a surprising choice because she had hated mathematics at school and during teacher training. She had 'traditional' beliefs about the nature of mathematics and felt that mathematicians would devote their time to working with numbers and equations. She believed that mathematics was mostly memorised facts and procedures and that it was predictable, certain, absolute and fixed. She did,however, see that problem solving was an important facet but she regarded this more as a 'topic' to be completed in the classroom than part of her overall philosopy. She attributed her philsophy on the nature of mathematics to mainly a reflection of her own learning experiences at school which had been very traditional and lacking in inspiration.

Joanna's pedagogical beliefs contrast to her beliefs about the nature of mathematics and she saw these pedagogical beliefs as a reflection of her own teaching practice. Raymond (1997) categorized Joanna's beliefs about learning mathematics as 'primarily non-traditional', but this was struck as a balance between the holding of some very 'non-traditional' beliefs and a number of more 'traditional' beliefs. For example, Joanna felt that students learn better by working together, that manipulatives are useful in the learning process and yet on the other hand she felt that working hard and being naturally good at mathematics was one way to success. In regard to beliefs about teaching mathematics Joanna was also classified as 'primarily non-traditional'. Her 'primarily non-traditional' beliefs included the notion that teachers should provide activities from a variety of resources and use manipulatives rather than closely follow textbooks. However, she also believed that increased effort on her part would improve student understanding. Raymond suggests that these non-traditional beliefs on pedagogy may have been a result of Joanna's desire not to give her own students the negative attitude towards mathematics that she developed when she was at school.

Raymond also observed Joanna's teaching practice by considering the classroom environment established, her planning approach and assessment procedures, types of tasks provided and the nature of classroom discourse and found her teaching practice to be 'primarily traditional'. Joanna's classroom had desks arranged in rows with the students' sole work mode to be at their desk. Joanna's actions hinted that learning would only take place if the environment was controlled by her, where the students were quiet and on task. She had fostered an established and regular routine that the students recognised and with which they complied. Classroom discourse was limited to teacher-student and student-teacher dialogue, with Raymond never observing student-student discussion although Joanna reported in interviews that she did have lessons where there was student-student discussion along unstructured lines. Most of the mathematics time was spent with the children working individually from textbooks. Use of manipulatives was never observed. There was, however, a 'Problem of the Day' presented to the students at the beginning of each session. The student's solutions were handed in after five minutes to be corrected before the next lesson and at that next lesson Joanna would have a student with a correct solution demonstrate how it was achieved. Student assessments were gained from written tests and homework. For planning Joanna followed the text and in her program book only wrote down the relevant page number and topic. In interview she said that she wanted to keep the three grades going at the same pace and that the external assessment conducted by the state meant that she was responsible for three grades of children and not just her own. This put pressure on her to gain good results otherwise it might reflect on her own performance.

From this description of beliefs and classroom practice it is obvious that there is inconsistency between them. Raymond puts this down in part to Joanna's concern about maintaining discipline. This concern would over-ride any initiative to implement the 'non-traditional' pedagogical beliefs that she holds. This was illustrated in an interview when Joanna said that she had lessons using base-ten blocks that became chaos mainly because of time constraints. Raymond points out that this is typical for novice teachers - that is, allowing external concerns such as standardised testing or channelling most energy into maintenance of classroom order to overshadow the implementation of innovative lessons.

Ms Bartlett and Mr Martin - Grade Six Teachers (Clarke, 1993-A & B; Clarke, 1995-B)

Clarke (1993-A) intensively studied the changing teacher roles of two grade six teachers - Ms Bartlett and Mr Martin - while they were engaged in the implementation of innovative mathematics curricula. This implementation was as a result of participation in a four-session professional development program, part of which involved teaching a six-week unit of work consisting of non-routine problems based upon the discovery of a bone belonging to a 'mystery person'. The 'teacher categorizations' of Ernest and Kuhs & Ball were used to make some judgements about the two teachers. The two teachers involved, like primary teachers in Victoria, had responsibility for teaching in curriculum areas other than mathematics. The change processes that occurred, if any, were to be monitored and change was measured by the movement of the role of the teacher towards what Clarke termed a 'reformed classroom'. To ascertain what a 'reformed classroom' would look like seven studies that had features in common with 'the vision of mathematics education reform' were analysed and these findings have already been noted in Table 2.4. Clarke then had this implied overview that movement through Kuhs & Ball's four categories beginning with 'classroom-focussed' through to 'learner-focussed' as being movement towards a 'reformed classroom'.

The two teachers that Clarke studied were part of a team teaching unit involving four staff where all four believed that their students should be actively involved in doing mathematics. Because of this the mathematics lesson for the four of them followed the same organizational pattern: a 'warm-up' session involving five to ten minutes with such things as mental arithmetic or word problems; homework review; and then the major 'activities' for the day. Even though this was the situation the research provided the 'opportunity to document the ways in which different individuals perceive and respond to very similar opportunities for, and impediments to professional growth' (Clarke, 1993-B, page 184). However, Clarke (1993-A) considered that both teachers were positive towards implementing change in their teaching and that 'their teaching was a constant process of refinement and learning from previous experience' (page 139).

Clarke (1993-A) notes that because Ms Bartlett's 'big ideas of mathematics were equated with traditional topic headings such as fractions and decimals [that] her view of the nature of mathematics would best be described as instrumental' [in Ernest's (1989) terms] (page 157-8). Using the Kuhs and Ball (1986) categories, Clarke chose as the most appropriate for describing Ms Bartlett's beliefs and practice as 'content focussed with an emphasis on performance'. He considered that Ms Bartlett was structured in the way she thought about student movement through the curriculum. The major activity part of Ms Bartlett's lesson might involve initial teacher demonstration followed by classwork of some kind otherwise an activity based lesson would involve group work. She thought that it was important for students to be able to *do* mathematics and that they should see that there was a variety of ways of problem-solving methods. Although she made use of the school's testing program she did value informal assessment procedures. Even though Ms Bartlett had described herself as a risk taker, Clarke noted that during the trialling of the lessons presented at the professional development that she tended to set out from the outset what knowledge and skills were needed. Over the course of the professional development Ms Bartlett didn't alter the way she used small group work but became more convinced that it was a useful teaching strategy. This was for two reasons: firstly from her own group work experiences in the professional development and secondly from her observations of her own students. Clarke considered that Ms Bartlett's class did not develop as a 'mathematical discourse community' in the truest sense where a collaborative situation exists between teacher and student. He did not see her acting in the role of 'fellow player'. In place of this, the course of the lesson followed the plan, most discussion was teacher-directed, and students gave brief responses to teacher questioning. The implication on Clarke's part here is that 'a mathematical discourse community' [and] 'role of fellow player' belong to a Kuhs and Ball category of higher order to where he places Ms Bartlett. Outside of lessons provided by the professional development program, Ms Bartlett reverted to skill-based activity citing the reason as 'making sure that they've got the skills they need for grade 7' (Clarke, 1993-A, page 174). Ms Bartlett treated the grade as a whole and didn't consider catering for the individual.

Clarke, although tentative, senses that Mr Martin's views are closest to Ernest's (1989) 'Platonist view'. This notion is based on the observation that Mr Martin gave a lot of thought to what grade six students needed as appropriate mathematics and seemed to grasp some of the 'big picture' concepts. The tentativeness that Clarke showed towards this classification was partly based on the fact that when mathematics outside of the trialling of the innovative curriculum materials took place Mr Martin reverted to what would be referred to as skill-based activity. Mr Martin's reason for this reversion was 'a hedge against the newness of things' (Clarke, 1993-A, page 174). When Mr Martin was asked to describe a typical mathematics session he made the point that when he first started teaching, the approach then was with the teacher at the front giving explanation to the students followed by silent working on problems. Although Mr Martin's typical session organization is like Ms Bartlett's he refers to the fact that there is no real structure and that communicating and thinking have become important outcomes for him. It was observed that Mr Martin increased his willingness to allow students to struggle with problems in preference to intervening. This resulted from realising the power of the solutions that the students, themselves, developed. The professional development experience encouraged Mr Martin to question his students more on what they were doing, why they were doing it and he saw the need to slow down the pace of the classroom to allow his students to be able to reflect more about their learning (Clarke, 1995-B). Clarke (1993-A) considered that Mr Martin was more relaxed than Ms Bartlett and allowed for off-task behaviour and the connection of mathematics ideas from other things that happened in the class such as news reports. If the two classes combined, posing problems and the resulting discussion for the main part of the session was usually taken by Mr Martin. Ms Bartlett's perception was that she wasn't as confident with this as Mr Martin and this may have been due to Mr Martin's previous undergraduate mathematics studies. Mr Martin used a variety of ways for organising students to complete tasks, and during the trialling of the innovative curriculum materials small group work dominated. Mr Martin saw mathematics as problem-solving and that the purpose of teaching mathematics was to provide students with a 'tool that they [could] use to solve real problems' (Clarke, 1993-A, page 123). During the period of the professional development it was noticed that he was increasingly prepared to 'step back and let students struggle with problems' although observations suggest that Mr Martin's approach to whole class discussion was teacher-centered and did not allow for true collaboration between student and teacher . Another change during the professional development, for Mr Martin, was in the area of assessment. Clarke had observed the giving of a formal test prior to the in-servicing but by the end of the professional development Mr Martin was giving consideration to alternative assessment procedures even if he didn't take up some of the suggestions from the professional development. During the trialling of the materials Mr Martin gave increasing emphasis to student reflection by having them keep learning logs. The focus questions he provided for this reflected his 'big picture' views of mathematics. When asked why he adapted materials Mr Martin indicated that adaptations were made because of a feeling of what would work at grade six. Clarke concluded from this that Mr Martin treated the grade as a whole and didn't consider catering for the individual.

Further development of contrasting situations

It has already been stated that one of the aims of this study is the investigation of the classroom practice and beliefs of a group of primary teachers. The development of two contrasting teacher profiles was begun earlier in this literature review with two contrasting 'pictures' of beliefs on the nature of mathematics. The discussion covering beliefs and practice, especially with the information provided in the preceding case studies, it should now be possible to develop further the profiles or 'pictures' of an 'instrumental teacher' and a 'relational teacher' that includes further dimensions. The following profile tables are in two parts: one on beliefs and the others on classroom practice. Dimensions in the beliefs table (Table 2.5) are grouped under the headings of 'beliefs in regard to the role of the teacher' and 'beliefs in regard to how children learn mathematics'. The classroom practice tables are divided into the topics of 'lesson planning' (Table 2.6), 'what happens in a lesson' (Table 2.7), and 'the place of classroom discussion' (Table 2.8). The instrumental and relational descriptor for each dimension should only be considered as a pointer towards a particular type of teacher and not be considered as definitive. The development of these profiles is to allow for the classification of the group of teachers involved in this study.

BELIEFS ABOUT LEARNING AND TEACHING		
Dimensions	'Instrumental teacher'	'Relational teacher'
	In regard to the role of the teacher the teacher believes that:	
Knowledge source	• s/he is the sole source of information and authority	• teachers need to respect, value, accept and build upon pupil's responses rather than impose their own methods or make judgement on the pupil's ideas
Lesson format	• lessons should be teacher-directed where pupils have no part in the development of mathematical ideas	• their role is to be the provider of situations where the children have a pivotal and active-learning role
Lesson outcome	• the important outcome of a mathematics lesson is the children's ability to get correct answers	• the important outcome of a mathematics lesson is the children's ability to understand and explain to others their solution process
Context provision	• instruction can be meaningful without a context being provided	• provision of a context is an important factor for gaining meaningful understanding
	In regard to how children learn mathematics the teacher believes that:	
Pupil working mode	• pupils should work individually, particularly for assessment	• pupils learn better by working collaboratively
Pointers to success	• one can be naturally good at mathematics and that working hard can aid success	• all pupils have the potential to be successful mathematicians within the bounds appropriate to their intellectual development
Use of manipulatives	• manipulatives are not needed for explanations	• manipulatives are useful for mathematical understanding
Measure of learning	• for learning to take place children must demonstrate mastery of specific solution methods	• for learning to take place children must struggle with their own constructions of knowledge
Rewards	• extrinsic rewards are needed to support schoolwork	• intrinsic rewards are sufficient outcomes in the learning process

Table 2.5: Comparison between beliefs about teaching and learning

	CLASSROOM PRACTICE	
Dimensions	'Instrumental teacher'	'Relational teacher'
	In regard to lesson planning teachers	
Lesson source	• depend on an externally written program (Teacher's manual and pupil textbook)	• take activities from a variety of resources rather than rely on one set text
Individual differences	• plan lessons that do not allow for individual differences, and factors such as pace of instruction may be used for those pupils not demonstrating understanding	• plan lessons that allow for individual differences
Innovation	• might take on board a new idea or innovation as it has been in-serviced but are not able to apply these new found approaches to other classroom situations in mathematics	• take on board new ideas and innovations and apply these new found approaches to other classroom situations in mathematics
External factors	• allow external concerns (for example discipline concerns, external testing) to prevent planning of innovative instruction	• plan so that learning outcomes are the focus and are not hamstrung by other factors
Assessment	• rely solely on written tests for assessment	• use a variety of assessment practices including informal procedures
Lesson pace	• set a lesson pace which is dependent on achieving stated aims	• allow for reflection time even if this means that the pace of the lesson needs to be slower
Lesson initiation	• use activities rather than ideas as a starting point	• use ideas rather than activities as a starting point

Table 2.6: Comparison between beliefs about classroom practice – in regard to lesson planning

	CLASSROOM PRACTICE	
Dimensions	'Instrumental teacher'	'Relational teacher'
	In regard to what happens in a lesson teachers	
Teaching style	• give teacher-directed explanation (for example, chalkboard exposition.), with pupils being taken through a step-by-step procedure	• would vary the structure of a lesson to match what they considered was the best means for achieving the stated learning outcomes taking into account the mathematics involved and the preferred or appropriate learning modes of their pupils
Pupil working mode	• have pupils working individually and quietly on practice examples	• use collaborative teaching strategies
Deviation from lesson plan	• do not allow for deviation in lesson plan and from the goals set down in preparation	• are prepared to deviate from what was set and take risks with the direction the lesson might follow
Using manipulatives	• do not make use of manipulatives	• use teaching aids / manipulatives to assist understanding
Dealing with student lack of understanding	• do not consider alternative explanations for pupils having difficulty but go over the same explanation perhaps at a slower pace	• use alternative explanations, explanation by other pupils or alternative activities for pupils who lack full understanding
Reaction to pupil working time	• allow for little teacher-pupil interaction while pupils are doing practice examples	• use pupil working time as an opportunity to gain further insights into pupil understanding by questioning and listening
Dealing with pupils who are struggling with a problem	• intervene when a pupil is having difficulty and take control of the situation rather than let the child struggle with the problem	• allow students to struggle with problems rather than intervene
Making connections	• focus solely on the lesson aims without bringing into the lesson presentation what else is occurring in the classroom	• make connections into what else is happening in the class

Table 2.7: Comparison between beliefs about classroom practice – in regard to what happens in a lesson

CLASSROOM PRACTICE		
Dimensions	'Instrumental teacher'	'Relational teacher'
	In regard to the place of classroom discussion teachers	
Classroom layout	• arrange pupil seating arrangements that are not conducive to pupil-pupil discussion	• allow flexible seating arrangements to match lesson intentions and planning
Handling pupil discussion	• in discussion judge whether the pupil's responses are worthy of consideration and impose own solution method	• facilitate a 'discourse community' where the children's ideas are accepted and built upon
Dialogue directions	• generally include teacher-pupil dialogue and not pupil-pupil dialogue	• include pupil-pupil interactions and teacher-pupil interactions
Questioning approach	• use questioning to ascertain whether pupils understand the procedure that they have presented	• listen to the ideas that children have and then use questioning techniques that allow children to further develop their thoughts by asking why- and how-type questions
Type of questioning	• use questioning that does not allow for open-ended responses	• use questioning techniques that allow for opened-ended situations
Giving explanations	• are the sole giver of explanations / rule bound explanations that lack contexts	• uses both pupils and teacher involved in giving explanations / meaningfully covered using contexts such as real world applications, illustration and manipulatives

Table 2.8: Comparison between beliefs about classroom practice – in regard to the place of discussion

Current teaching directions

Are the expectations of the teaching of primary mathematics held by the mathematics education community and the school system in Victoria closer to instrumental teaching or to relational teaching? Gervasoni (1995), for a study of beliefs of students and teachers, analysed what major Victorian documents and professional development programs over the period 1988 - 1995 were saying about the improvement of quality mathematics learning and teaching. For this analysis Gervasoni referred to *The Mathematics Framework P-10* (1988), the *MCTP Professional Development Package* (1988), the *Exploring Mathematics in Classrooms (EMIC)* In-service Course (1990), *A National Statement on Mathematics for Australian Schools* (1990), and the *Mathematics Curriculum and Standards Framework* (1995).

The 'images' presented by these documents were summarised by Gervasoni in the following fourteen points:

> A mathematics teacher
>
> (a) helps students develop positive attitudes towards mathematics;
>
> (b) helps students understand that learning involves taking risks;
>
> (c) utilises constructivist learning approaches;
>
> (d) challenges students' existing conceptions;
>
> (e) provides opportunities for st[illegible]ect on their learning;
>
> (f) provides feedback to students about their mathematical learning;
>
> (g) provides challenge within a supportive framework;
>
> (h) utilises co-operative learning models;
>
> (i) develops activities which are purposeful, interesting, and build upon and respect students' life experiences;
>
> (j) gives students the opportunity to talk and write about mathematics;
>
> (k) uses gender and culturally inclusive language, resources and activities;
>
> (l) involves students in problem-solving activities;
>
> (m) enables students to experience the process through which mathematics develops; and
>
> (n) uses a variety of assessment strategies and records. (Gervasoni, 1995, page 293)

Many of these points listed by Gervasoni can be directly matched or compared positively to the classroom practice pointers for the 'relational teacher' noted in Tables 2.6, 2.7 and 2.8 (refer to Table 2.9 on page 38).

It is clear from the documents analysed by Gervasoni that the expectations and the direction promoted by the Victorian Department of Education and of professional development in Victoria are directed to relational approaches to teaching and learning. It could then be expected that the teachers to be involved in the professional development program to be offered as part of this research have, over the past ten years, been influenced by the documents issued by the Government and have attended and been influenced by professional development in a direction towards encouraging them to adopt relational approaches in their mathematics teaching.

Gervasoni's list	CLASSROOM PRACTICE: 'Relational teacher'
Directly matching:	
(e) provides opportunities for students to reflect on their learning	• allow for reflection time even if this means that the pace of the lesson needs to be slower
(h) utilises co-operative learning models	• use collaborative teaching strategies
(n) uses a variety of assessment strategies and records	• use a variety of assessment practices including informal procedures
Positively compared:	
(b) helps students understand that learning involves taking risks	• facilitate a 'discourse community' where the children's ideas are accepted and built upon
(c) utilises constructivist learning approaches	• use questioning techniques that allow for open-ended situations
(d) challenges students' existing conceptions	• listen to the ideas children have and then use questioning techniques that allow children to further develop their thoughts by asking why- and how-type questions
(g) provides challenge within a supportive framework	• allow students to struggle with problems rather than intervene

Table 2.9: Comparison of Gervasoni's list with the lists compiled for 'Classroom Practice – relational teacher'

PROFESSIONAL DEVELOPMENT

Beliefs and professional development

In Chapter 1 the three major concerns for teachers of mathematics, as outlined by *The Mathematics Framework: P-10* (Ministry of Education, Victoria, 1988) were noted. These concerns were: views of mathematics as a discipline, teaching methods, and the student as learner. These three concerns correspond to the major themes of the discussion in this chapter in relation to the beliefs held by teachers and their application in classroom practice, that is, the nature of mathematics, teaching approach, and learning models. In a similar way Lappan & Theule-Lubienski (1992) refer to these three aspects as domains of knowledge:

> Teachers need knowledge of at least three kinds to have a chance to be effective in choosing worthwhile tasks, orchestrating discourse, creating an environment for learning, and analyzing their teaching and student learning: knowledge of mathematics, knowledge of students, and the knowledge of the pedagogy of mathematics. ..... Teachers work in the intersection of these domains of knowledge. It is the interplay of the various considerations that leads to defensible pedagogical reasoning on the part of teachers. (Lappan & Theule-Lubienski, 1992, page 253)

The interplay between these three strands of beliefs and their application in the classroom has already been noted and discussed (Skemp, 1976; Ernest, 1989; Perry, Howard & Conroy, 1996; Clarke, 1993-B; Thompson, 1992).

Jaworski (1989) considers that a teacher judges the effectiveness of a lesson by reconciling what actually occurred with their beliefs about teaching and learning. Yaxley (1991) draws upon theories of personal constructs to explain how teachers develop and change in their classroom practice. He bases this on the assumption that 'teachers construct meaning about teaching on the basis of their experience in teaching' (page 87). Yaxley's 'experience in teaching' draws upon activities that include classroom experiences but it also inclusive of a range of other experiences including professional development.

I previously noted that one of the outcomes of professional development was to promote change in classroom practice. Jaworski (1989) in relation to her comments noted above states that struggling to implement change is more a struggle with belief. Thompson (1984) confirms this notion by claiming that efforts to improve mathematics teaching will be misguided if teacher's beliefs, views and preferences and their connection to teaching practice are not considered or dealt with. The case studies (Wood, Cobb & Yackel, 1991; Etchberger & Shaw, 1992; Raymond, 1997; Clarke, 1993-A) previously described all note the struggle with changing beliefs that each teacher was faced with as part of their change in classroom practice.

Excellent teachers travel through an evolving process that may never reach finality (Philipp, Sowder & Flores, 1992). Sparks & Loucks-Horsley (1989) argue that this evolving process is individualistic as teachers will perceive and process information in different ways. In fact the working conditions of relative isolation in most schools often means that teachers can only process new knowledge as individuals in isolation (Doyle & Ponder, 1977-78). When the change processes were compared for four teachers involved in the ARTISM program the results were quite individual and relied on a number of varying factors even though all received the same external input (Peter, 1995). These varying factors included: personal characteristics, individual responses to new ideas, and level of collegial support.

Joyce & McKibbin (1982) conducted a long-term inquiry into the nature of staff development and teacher professional growth. They found that 'personal characteristics' played an important part in the way they categorised teacher growth states. One of the domains they used was the way in which teachers used staff development opportunities. Owen, Johnson, Clarke, Lovitt & Morony (1988) refer to this as 'different appetites for in-service education' (page 11). Joyce & McKibbin (1982) established the following categories: Omnivores, Active Consumers, Passive Consumers, Resistant, and Withdrawn. For example, in relation to making use of staff development opportunities, the Omnivores:

> Use every available aspect of the formal and the informal systems that are available to them. ..... They have found professional colleagues with whom they are close and interchange ideas. They actively attempt to improve the schools in which they work. ..... They appear to be able to overcome obstacles, and they do not carry emotional baggage that prevents them from profiting from a great variety of activities. They do not spend energy complaining about colleagues, administration, poor presenters at workshops, and so on. They simply take what they can where they can get it, which does not mean they are indiscriminate – their energy is simply oriented toward their growth rather then towards impediments to it. (Joyce & McKibbin, 1982, page 37)

The Omnivores contrast greatly to the Resistants who:

> Are not likely to seek out training [and] where they do take training it is likely to be in areas where they already are feeling successful. ..... they will seldom take courses unless there is a material benefit, such as a salary increment. Innovations that change the way the school's curriculum operates are usually viewed with suspicion, particularly if they might result in a change that would suggest current classroom practices are inadequate. Change to them means that they are not doing a good job and therefore are threatened. ..... In the informal domain, entrenched teaching is manifested by the use of the informal system of the school to control and stifle. (Joyce & McKibbin, 1982, page 39)

The factor of 'individual responses to new ideas' referred to by Peter (1995) was also the focus of a study by Clarke (1995-A). Clarke's study investigated the way in which two Year 7 mathematics teachers implemented innovative curriculum materials. One of the teachers was comfortable with the unexpected incidents that occurred whereas such incidents for the other teacher were problematic. She noted that the teaching styles of the two teachers contrasted: the teacher who felt 'comfortable' organised her classroom in a student-centered way whereas the teacher who found the situation 'problematic' taught in a teacher-centered manner. In the previously described case study by Clarke (1993-A) the two teachers responses to the innovation that was the core content of the professional development that occurred were also played out differently in their classroom practice. Clarke (1993-A) was able to make connection from the way in which the innovation was implemented to the beliefs the two teachers held.

The factor of 'level of collegial support' mentioned by Peter (1995) was provided both by peers and principal and can be an organizational feature when planning professional development. The examples of Victorian professional development outlined in Chapter 1 – *Keygroup, Exploring Mathematics in Classrooms, and Maths In Schools* – all had as a central feature some component of collegiality. There are other features considered to be crucial for effective professional development (Owen et al, 1988) that could also impinge on teachers, as individuals, in the change process.

Features of effective professional development

A number of examples of professional development activities undertaken in Victoria were described in Chapter 1 (pages 3-6). It was noted that the planners of these activities had various organizational details that they considered to be important. *Key Group* involved a small group of teachers from a school working on a problem designated by that group of teachers. *Exploring Maths in Classrooms (EMIC)* committed teachers to participation over an extended time with an additional requirement being that the teachers were to trial classroom tasks between sessions. *Maths in Schools* (*MIS*) had an 'expert' facilitator working with school teams on an aspect of mathematics teaching considered by the school team to need improvement. A number of researchers have developed lists of principles or practices considered effective for successful professional development (Owen et al, 1988; Clarke, 1994; Sparks & Loucks-Horsley, 1990; Guskey 1995). Their lists are reproduced in Table 2.10 on page 42.

Principles listed by Owen, Johnson, Clarke, Lovitt & Morony (1988) (page 16): • Involve groups of teachers rather than individuals from a school • Uses the services of a consultant and or critical friend • Involves a conscious commitment on the part of the teacher • Provides opportunities for reflection and feedback • Takes place over an extended period of time • Addresses issues of concern recognised by the teachers themselves • Takes place as close as possible to the teacher's own working environment • Have the support of both colleagues and the school administration • Enable participating teachers to feel a substantial degree of ownership.
Principles listed by Clarke (1994) (page 38): • Address issues of concern and interest, largely (but not exclusively) identified by the teachers themselves, and involve a degree of choice for participants • Involve groups of teachers rather than individuals from a number of schools, and enlist the support of the school and district administration, students, parents, and the broader school community • Recognise and address the many impediments to teachers' growth at the individual, school and district level • Using teachers as participants in classroom activities or students in real situations, model desired classroom approaches during in-service sessions to project a clearer vision of the proposed changes • Solicit teachers' conscious commitment to participate actively in the professional development sessions and to undertake required readings and classroom tasks, appropriately adapted for their own classroom • Recognize that changes in teachers' beliefs about teaching and learning are derived largely from classroom practice; as a result, such changes will follow the opportunity to validate, through observing positive student learning, information supplied by professional development programs • Allow time and opportunities for planning, reflection, and feedback in order to report successes and failures to the group, to share the 'wisdom of practice', and to discuss problems and solutions regarding individual students and new teaching approaches • Enable participating teachers to gain a substantial degree of ownership by their involvement in decision making and by being regarded as the partners in the change process • Recognises that change is a gradual, difficult, and often painful process, and afford opportunities for ongoing support from peers and critical friends • Encourage participants to set further goals for their professional growth.
Effective practices listed by Sparks & Loucks-Horsley (1989) (page 40): • Programs conducted in school settings and linked to school-wide efforts • Teachers participating as helpers to each other and as planners, with administrators, of in-service activities • Emphasis on self instruction, with differential training opportunities • Teachers in active roles, choosing goals and activities for themselves • Emphasis on demonstration, supervised trials and feedback: training that is concrete and on-going over time • On-going assistance and support available on request.
(Guskey 1995)'s principles (various pages): • Recognize change as both an individual and organizational process • Think *big*, but start *small* • Work in teams to maintain support • Include procedures for feedback on results • Provide continued follow-up, support and pressure • Integrate programs so that there is a coherent framework for improvement.

Table 2.10: List of features of effective professional development

There are a number of common features that arise from the above lists. These features are listed below and grouped together under four major categories. Although many of these features are inter-connected each one will then be briefly discussed. In the discussion the feature will be defined in relation to the view about that feature held by the researchers (Owen et al, 1988; Clarke, 1994; Sparks & Loucks-Horsley, 1990; Guskey, 1995). Where appropriate further discussion will be included and the use of that feature in the professional development examples from Victoria will be noted.

Providing procedures for support and collaboration

- Involves groups of teachers rather than individuals from a school
- Supportive principal
- Facilitator or professional development leader seen as part of a team

Providing a teacher-centered focus for content and organization

- Linked to school-wide efforts
- Conducted in school settings
- Variety of approaches, but with a focus on modelling and actual practice
- Addresses 'issues of concern' recognised by the teachers themselves
- Ownership by the teachers involved in the program

Providing opportunities for observing outcomes and reflection

- Participants researching in classrooms and reflecting on the responses
- Seeing advantages for their pupils
- Takes place over an extended period of time

Providing a philosophy on teacher change

- Recognise that for change to occur teachers need to demonstrate commitment but realise that it is difficult and needs to occur at both individual and school levels
- Recognise that professional development needs to be implemented gradually and coherently, with a long-term plan in mind.

Providing procedures for support and collaboration

This grouping of features covers many of the players involved in professional development: colleagues, principal (and other school administrators), and professional development leaders. It is considered that the particular players mentioned in these features can be supportive of the individual teacher involved.

Involves groups of teachers rather than individuals from a school

This feature was mentioned by Owen etal (1988), Clarke (1994) and Guskey (1995) and could also include the ideas of collegial support (Owen et al, 1988)) and 'teachers participating as helpers to each other' (Sparks & Loucks-Horsley, 1989). Most of the eight models of professional development put forward by (Owen et al, 1988) rely on this feature. For example, the 'In-school Intensive' model requires the cooperation of a group of teachers or the whole staff in a specific development project, the 'Activity Documentation' model involves the creation of a network of teachers, and the 'Peer Tutoring' model needs the non-threatening support of a colleague (Owen et al, 1988, page 14). Sparks & Loucks-Horsley (1989) note when discussing the organizational arrangements for their five models of professional development that:

> Teachers are more likely to persist in using new behaviours when they feel the support of colleagues and when they believe that professional risk taking (and its occasional failures) are encouraged. (Sparks & Loucks-Horsley, 1989, page 52)

For example, one of the underlying assumptions for their 'Inquiry' model is that cooperative study by teachers into problems and issues is an effective approach to professional development. In regard to their 'Observation/Assessment' model they refer to the notion of 'another set of eyes' where both the teacher being observed as well as the observer gain from the experience of classroom observation and shared comment.

Although teachers identify their peers as being the main source of assistance Johnson & Johnson (1987), school culture and environments traditionally have teachers working in isolation (Clarke, 1994). Guskey (1995) and Ahlstrand (1994) note that making change is difficult enough without it being compounded by having to work in isolation. In citing Rosenholtz's (1989) study of 'stuck' and 'moving' schools Fullan (1995) notes that teachers in the 'moving schools' believed that teaching was difficult and hence they needed to continue learning about teaching and reasoned that they would sometimes need advice. In this environment gaining assistance did not imply incompetence but part of the quest for improvement. Teacher collaboration in these 'moving schools' lead to greater teacher confidence and certainty. And in quoting from Rosenholtz (page 73) Fullan noted that:

> It is assumed that improvement in teaching is a collective rather than individual enterprise, and that analysis, evaluation, and experimentation in concert with colleagues are conditions under which teachers improve. (Fullan, 1995, page 260)

In fact teacher collaboration can lead to a 'community of discourse' within a school where risk-taking and questioning become more apparent and where professional development is seen as embedded into the school culture (Fullan, 1995).

This is not surprising if the three modes of working (Johnson & Johnson, 1987) - competitively, individualistically, or cooperatively - are considered. The competitive mode encourages a teacher to maximise personal gain at the expense of others, and the individualistic mode gives one a sense of only being concerned in their own performance with the success and failures of others bearing no relevance. Johnson & Johnson (1987) found that the cooperative mode promoted higher achievement, more positive interpersonal relations, greater social support, and higher self-esteem. They concluded that organising teachers to work together should result in greater productivity and expertise, staff cohesion as well as those outcomes already mentioned. However, they note:

> [That this will only be successful when] groups have carefully structured positive interdependence, face-to-face interaction, personal responsibility, and periodic group processing [as well as group members possessing] the necessary skills in leadership, communication, trust building, decision making, and conflict management (Johnson & Johnson, 1987, page 30).

Because achieving change is a challenging process Baird (1991) reasons that collaboration with others is one means for supporting teachers through change. He notes that this could be with only one other colleague or with a large group and that listening and meaningful reflection are important factors . Gaining purposeful collaboration is not straight-forward. For example, Guskey (1995) notes that in early stages of planning and decision-making large-scale participation is often counterproductive. Lieberman (1986) lists a number of guidelines for collaborative work. Among these are factors such as realisation that it takes much energy to work with other people, and that conflict is inevitable but that it can be potentially used in a productive way. One other important factor is that time needs to be provided for collaboration (Lieberman, 1986).

Ahlstrand (1994) noted that teacher collaboration can be either formal or informal in nature. From a study of teachers working together in small teams she concluded that teachers choose to have discussion at a more informal level than a formal one. She found that through the use of teacher teams the teachers were more likely to communicate with each other about the difficulties they were encountering and that the isolation factor had been diminished. It is interesting to note that when comparing their professional development models Owen et al (1988) note for this feature of teacher collaboration that in several models teacher collaboration will occur 'between sessions'. The implication of this is that the collaboration would most likely be of an informal nature.

One example where professional development has taken on a collaborative format is that of coaching.

> Coaching is a process in which education professionals assist each other in negotiating the distance between acquiring new skills or teaching strategies and applying them skillfully and effectively for instruction. (Showers, 1985, page 46)

Showers (1985) claims that coaching has three main purposes: to build communities of teachers; to develop a shared language and common understandings; and to provide a structure for on-going professional development. Coaching involves firstly observation and feedback followed by mutual exploration of new approaches. Following a research project into coaching Showers made a number of conclusions. In regard to the concept of the ability of peer coaches to train other teachers she concludes that there is little doubt that this can occur, claiming that the experience proved positive on the part of both the peer coaches and the teachers. Worth noting is the idea of collegial interaction and how Showers determined its existence by pinpointing when teachers began to control or contribute to the agendas of the coaching conferences. To Showers this appeared to suggest that, when this occurred, the teachers and coaches were colleagues working together to solve problems.

This feature was apparent in most of the Victorian examples of professional development where either small groups of teachers or whole school staffs were involved. Rice (1991) notes in a case study of one school involved in *Key Group* that:

> [There has been] a shift in the patterns of interaction and collaborative work practices have increased dramatically [whereas] prior to *Key Group* teachers worked very much as individuals in the area of maths (Rice, 1991, page 11).

With *EMIC* each group of teachers attending a workshop required at least 3 or 4 from the one school. The basis of *MIS* was that each project was devised and carried out by a whole school or department. In the case of one *MIS* project school – Yawarra Primary School – teacher collaboration was given a high priority.

> [A] concern for the [Yawarra] Mathematics Committee was to encourage interaction between teachers within and across year levels in the school. This was seen as important for a number of reasons: to encourage staff from the merged schools to come together, to offer staff with limited experience at varying levels the opportunity to work with each other and thus increase their flexibility, and to encourage the spread of innovative teaching practice. (Munday, Hoey, Gringhuis, Sullivan & Smith, 1995, page 46)

Supportive principal

This feature is taken from the notion of a 'supportive school administration' along with 'teachers participating ..... as planners with administrators of in-service activities' (Owen et al, 1988; Sparks & Loucks-Horsley, 1990). Clarke (1994) cites the writing of McEvoy (1985) for the inclusion of this feature in his ten key principles for effective professional development. Clarke (1994) lists a number of points made about the role of the principal by McEvoy including: dissemination of professional materials; publicly stating what they see as their preferred direction of school issues; and facilitation of collegial discussion and support (Clarke, 1994, page 40). Owen et al (1988) note that this is a strong feature in their 'In-school Intensive' model where the actual functioning of the activity relies on school support. Their other models vary on their reliance on this feature from little presence ('Activity Documentation' model) to occurring between workshop sessions ('Structured Course' model). Sparks & Loucks-Horsley (1989) note that much research [citing the work of Mclaughlin and Marsh (1978); Fielding and Schalock (1985); Loucks and Zacchei (1983); and Huberman (1983)] suggests that principals and other administrators are key leaders in staff development and change. They summarise this by stating that teachers can develop and grow when the work-related organization is effective and has the capacity for self-renewal (Sparks & Loucks-Horsley, 1989, pages 51-52).

Many other researchers comment on the unique place that the principal has in the success of professional development (Showers, 1984; Herrington, Sparrow & Swan, 1995; Leithwood & Montgomery, 1982).

> Principals must work to establish new norms that reward collegial planning, public teaching, constructive feedback, and experimentation. Professional growth must be seen as a valuable and expected process and clearly separated from the evaluation of performance......... [principals] are also perfectly situated to facilitate the implementation of peer-coaching systems through collaborative problem-solving with their teachers. (Showers, 1984, page 58)

In reviewing the research in regard to the role of the principal in program improvement, Leithwood & Montgomery (1982) studied typical principal behaviours, effective principal behaviours and obstacles to principal effectiveness. They reasoned that an effective principal would be the 'facilitator' of teacher growth and thereby indirectly effect student learning. They saw the teacher as the 'mediator' or central agent in this change process. In assessing the information from the set of research studies they attempted to match dimensions of principal behaviour to either the effective principal or ineffective (they call it typical) principal. Both types of principals attempt to effect all the factors listed - what distinguishes effective principals from ineffective principals is what it is about each factor that they believe to be important to influence. Leithwood & Montgomery found that effective principals had in common with most teachers the goal of improving student achievement and happiness. They note that this shared goal promotes effective principal-teacher communication. They also found that effective principals worked closely and regularly with teachers to make decisions on school and classroom improvement and to how such improvement would be achieved.

In comparing the outcomes of professional development activity in three different settings Herrington, Sparrow & Swan (1995) found that the role of the principal was pivotal in each setting. They state that:

> Projects where the principal took an active interest in the projects rather than one of delegation were more stable in their progression. (Herrington, Sparrow & Swan, 1995, page 343)

They claim that principal involvement influenced the degree of success in each project.

This fundamental role of the principal was taken into account in many of the examples given in Chapter 1 of professional development activity in Victoria. School principals were required to provide teacher release time for each *EMIC* participant and in many instances principals actually took the classes in order to achieve this requirement. In the *MIS* project the principal had to sign off the school's action plan and commit specific curriculum days and staff meetings to the project.

Facilitator or professional development leader seen as part of a team

This feature is taken from the comments: 'uses the services of a consultant and or critical friend' (Owen et al, 1988), 'ongoing support from peers and critical friends' (Clarks, 1994), in conjunction with the notion of 'teachers participating as ..... planners [along] with administration' (Sparks & Loucks-Horsley, 1989). For each of their eight professional development models Owen et al (1988) detail the role of the facilitator or leader through three phases of the activity: initial trialling, implementation, and continuation. Table 2.13 gives one example by listing the actions that need to be taken by the facilitator/leader in the 'Structured Course' model.

Initial trialling	Implementation	Continuation
• workshop the new approaches with participants • arrangements by which an 'outside consultant' or participant can demonstrate new approaches • provide theoretical support for new approaches • building a commitment among participants to try activities in their schools • linking the need for the approach to the existing views of the teacher	• encouraging teachers to create and document • encouraging teacher to trial these new activities in their schools • hosting feedback sessions on these activities	• encouraging teachers to write unit outlines • hosting feedback on these tasks

Table 2.11: Role of the consultant/leader for the 'Structured course' model (Owen et al, 1988, page 20)

It can be seen from the items in Table 2.11 that the role of the facilitator/leader in the 'Structured Course' model is one where the inclusion of the input of the teacher participants is important particularly with between-sessions trialling and the consequent sharing of the results of the trialling in the sessions.

> Teachers are expected to use intervening periods to actively trial new activities and approaches in their own classrooms. ..... The approach is predicated on a cyclic notion of change involving new information, trial, and feedback. This is repeated a number of times during the course. Thus there is a gradual increase of knowledge and skills as the work of one cycle builds on the previous one. (Owen et al, 1988, page 21)

However, Owen et al (1988) note that the 'Structured Course' is organized and largely conducted by the facilitator/leader. However the 'Structured Course' model along with the other seven models proposed by Owen et al (1988) are a sharp contrast to the 'One-shot' model [an ineffective model according to Owen et al (1988)] where they equate the facilitator/leader role with one of information giving.

Sparks & Loucks-Horsley (1989) note that research into professional development reveals that involving participants in the decision-making process results in a greater impact. They cite the notions put forward by Lieberman and Miller (1986) of 'top-down' and 'bottom-up approaches where the 'top-down' involves broad directions being set by people in leadership positions and the 'bottom-up' involves teachers setting goals and planning appropriate actions. Successful professional development involves an appropriate balance between the 'top-down' and the 'bottom-up' approaches.

The facilitator's role in both *EMIC* and *Maths Making Links* mirrors the role outlined by Owen et al (1988) in Table 2.11. However, the role of the facilitator in *MIS* was very different. In *MIS* the facilitator needed to balance support and direction and allow the school to follow its own agenda. Montgomery (1995-A) lists a set of features for effective *MIS* facilitators as:

- Being interested in the team and their project issue
- Being an active listener
- Encouraging the staff to direct the agenda
- Visiting regularly at a time that suits the staff
- Visiting on the 'school turf' (the teachers' workplace)
- Establishing an equal relationship with teachers
- Carrying out tasks the teachers see as valuable
- Not presenting as an 'expert'
- Helping the team to keep to the project focus (or shift the focus when needed)
- Giving affirming feedback to teachers where appropriate.

(Montgomery, 1995-A, page 19)

The *MIS* approach to facilitation more closely resembles that put forward by Sparks & Loucks-Horsley (1989).

Providing a teacher-centered focus for content and organization

This grouping of features focuses on the content and organizational demands in professional development. Each of the effective features in this grouping emphasise that the participating teachers are central to the success of the professional development.

Linked to school-wide efforts

This feature is directly taken from Sparks & Loucks-Horsley (1989). Guskey (1995) also notes in discussion that reform in education must be flexible enough to suit local 'values, norms, policies, structures, resources, and processes' (page 117). He adds that this 'optimal mix' will alter over time because of the changing context and the dynamics of the people who participate.

This would not have been a feature of *EMIC* or *Maths Making Links* unless a participant school had also included part or all of the course content as one of their objectives for school improvement. In some cases a whole school staff completed *Maths Making Links* so in this instance the program would most likely have been linked to a whole school agenda. With *MIS* this feature was a necessary part of whole school improvement:

> Maths in Schools encourages teachers to engage in curriculum improvement within their own school setting. In this way a genuine curriculum issue can be resolved by classroom teachers in their everyday work environment. ..... It is vital that the school or teacher group wants to engage in curriculum improvement in mathematics. Teachers need to be prepared to actively involve themselves in the process. (Montgomery, 1995-A, pages 6-7)

In the case of Yawarra Primary School development work on the strand of Chance and Data was seen as the beginning of a review of the school's mathematics policy (Munday et al, 1995).

Conducted in school settings

This feature comes in part from 'programs conducted in school settings' (Sparks & Loucks-Horsley, 1989) and the key idea advocated by Owen et al (1988) that professional development 'takes place as close as possible to the teacher's own working environment'. The workshops for *EMIC* and *Maths Making Links* were usually run in one of the participating schools. As well the *EMIC* facilitator would visit each school involved in the program and make observations and give 'model lessons' in the participant's classroom. This feature was built-in to the way in which *MIS* was organised.

Varieties of approaches, but with a focus on modelling and actual practice

This feature brings together a number of points including: demonstration and self-instruction (Sparks & Loucks-Horsley, 1989); follow-up and support procedures (Guskey, 1995); modelling desired classroom approaches and using teacher participation in activities (Clarke, 1994). For Sparks & Loucks-Horsley the notions that underpin their point of demonstration and self-instruction are basic assumptions for their 'Training' model. These notions are based on the idea that teachers are excellent learners and if new techniques are modelled for them and opportunities exist for trialling and feedback then there is a good chance that the teachers will incorporate the new techniques into their classroom practice. The points raised by Clarke are based on the idea that teachers may learn more effectively when the experience is experiential and informal.

An *EMIC* workshop session would be broken up into a variety of different segments: a 'This Works For Me' component involving teaching sharing of an activity or strategy that has worked well; teacher sharing of the outcomes of their classroom trialling; up-front workshop leader initiated activities; group discussion on issues; hands-on participant activities (Ministry of Education, 1989). With *MIS* the specific organizational approaches were decided upon by each school's steering committee. For example, Yawarra Primary School's approaches to *MIS* included university facilitator-run workshops during several staff meetings; a curriculum day presented by an external consultant; a 'rotation day' where pupils in multi-age groups did a variety of activities with different teachers; and team teaching where the university facilitator provided classroom release (Munday et al, 1995).

Addressing 'issues of concern' recognised by the teachers themselves

This feature is directly taken from Owen et al (1988) and is apparent in all of their eight models of professional development. For their 'Structured Course' model the implementation of this feature required the application of appropriate skills and techniques by the planners and presenters:

> The ['Structured Course'] approach relies heavily on the ability of consultants / curriculum leaders to provide sessions which link together to provide a coherent offering which reflects the needs of the teachers. (Owen et al, 1988, page 21)

This contrasts to the approach in their 'School Cluster Groups' model where it is possible for the teachers involved to have a greater role in the decision-making process:

> The ['School Cluster Groups'] model relies on mutual support and the transfer of expertise between teachers for its effectiveness in spreading knowledge about new approaches ..... the role of the consultant / curriculum leader is to set up the network, provide the links between the new approaches and the teachers concerned, provide on-going support as the work of the cluster develops, and assist teachers in decisions about termination of the network when it has achieved its objectives. (Owen et al, 1988, page 37)

Clarke (1994) also refers to this feature and notes that professional development is more likely to be successful if it is perceived by teachers as meeting their needs – both for content and organizational structure. Clarke (1994), in part, bases this rationale on the research work of Hall & Loucks (1978) where they found that teacher change was a highly personalized and individual process.

Seeing that *MIS* schools chose their issue or project it would be assumed that something of concern to the teachers would form the basis of the initial decisions made by the steering committee and principal. The Yawarra Primary School Mathematics Committee chose study of the Chance and Data strand as a beginning of the staff's reappraisal of their existing school-based number policy (Munday et al, 1995).

Ownership by the teachers involved in the program

One of the impediments listed by Clarke (1994) was 'the lack of commitment, and ownership of, the proposed changes' (page 41). Clarke (1994) claims that if this impediment (along with a number of other impediments) is not addressed by professional development organizers then the expected outcomes will be reduced. Thus he noted that for professional development to be effective the teachers needed to identify their 'issue of concern'. This feature was also noted by Owen et al (1988) and also incorporates the 'teachers choosing goals and activities' component from Sparks & Loucks-Horsley (1989). The feature as Owen et al refer to it has varying degrees of implementation depending which professional development model is chosen. According to Owen et al ownership could involve teacher input into planning course design, identification by teachers or a school staff of the issues needing change or improvement, working within a network of teachers on a common goal or working within a school staff in a collaborative way.

With the 'Structured Course' model Owen et al (1988) note that it 'develops over time' (page 15). They also point out that:

> In a structured course it is important not to have too detailed a plan before the first meeting of teachers. Leave some room for teacher input into the course design, and after preparing a draft plan, consult with them again before finalizing the plan. (Owen et al, 1988, page 22)

The participant ownership is also strengthened in this model by the between-sessions classroom trialling and subsequent sharing of the outcomes at the next workshop. The notion put forward by Sparks & Loucks-Horsley (1989) of balance between 'top-down' and 'bottom-up' approaches to planning has already been noted. They claim that professional development has its greatest impact when participants are involved in decision-making.

Seeing that *EMIC* and *Maths Making Links* were designed by planners external to the teacher groups involved then this feature would not have been strongly represented although there are some ways in which opportunities for teacher ownership can be built in to short course planning. It is possible that a sense of ownership would develop over time as indicated by Owen et al (1988). It has already been noted that school staffs involved in *MIS* were involved in key decision-making and hence would have ownership of the professional development activity.

Providing opportunities for observing outcomes and reflection

This grouping of features has a common focus of providing opportunities for reflection. In the first of the listed features this reflection results from trialling activities and making observations in the classroom. The second listed feature results from teacher consideration of workshopped activities or ideas presented at professional development sessions and the need to make a decision as to whether these activities or ideas can be implemented by them as part of their teaching repertoire. The third feature acknowledges that extended time and re-visiting new ideas is required for acceptance, and then meaningful implementation, of innovations.

Loughran (1994) states that the writings of Schon (1983 & 1987) have refocused the attention of teacher educators on the process of reflection and that this is reasonable because of the 'common-sense link between teaching and learning' (page 14). In citing MacKinnon (1989), Loughran (1994) notes that reflection is 'the process by which a teacher structures and restructures personal, practical knowledge' (page 29). Schon considers two forms of reflective thinking: reflection-on-action and reflection-in-action. Reflection-on-action is a 'thinking back on what we have done' and 'reflection-in-action' is a reshaping of 'what we are doing while we are doing it' (Schon, 1987, page 26).

Participants researching in classrooms and reflecting on the responses

This feature comes from a combination of 'opportunities for reflection and feedback' (Owen et al, 1988), 'changes [being] derived mainly from classroom practice' (Clarke, 1994), 'supervised trials and feedback' (Sparks & Loucks-Horsley, 1989), and 'procedures for feedback on results' (Guskey, 1995). Reflection and feedback are features of each of model described by Owen et al (1988) except the 'Postal' model. Active classroom trialling between workshop sessions is expected in the 'Structured Course' model and formal feedback and reflection are expected to occur at the subsequent session. Clarke (1994) regarded this process of trialling as giving the participants a foundation on which to base further discussion on a specific activity or strategy. When Sparks & Loucks-Horsley (1990) consider their 'Training' model of professional development they claim that it is based on the fact that teachers are able to competently replicate behaviours that were not previously part of their routine provided they are given adequate training. Guskey (1995) notes that feedback is necessary so that success is noted otherwise teachers are likely to abandon the innovation that has been in-serviced. He adds a caution that feedback needs to be timely and not too obtrusive and notes that feedback can take many forms including formal assessment of student learning.

Thompson (1992) notes that some teachers experience no conflict between their beliefs and classroom practice, others compromise their beliefs when it comes to practice mainly because of external factors, and there are other teachers who re-organise their beliefs to match their classroom practice. She points out that the marriage between beliefs and practice for an experienced teacher depends largely on their reflection of their classroom practice.

This feature was apparent in both *EMIC* and *Maths Making Links*. Participants in both programs trialled activities in their classrooms between workshop sessions and discussed the outcomes of the trialling in the next session. Hollingsworth (1996), in her research into the level of teacher change apparent in *EMIC* participants, notes that in a case study of two participants that both teachers engaged in classroom experimentation, reflected on their teaching practice and worked in collaboration with other staff.

For *MIS* this feature would have only been apparent if the school chose it to be part of their organization. At Yawarra Primary School this feature was strongly represented through the rotation day, team teaching and sharing of activity trialling at the staff meetings (Munday et al, 1995). The Yawarra staff shared, reflected and received feedback in both informal and formal ways within the school setting and for some of the staff opportunities occurred for this in broader educational settings (Smith, 1997).

Seeing advantages for their pupils

This feature was noted by Clarke (1994) when he concluded that 'changes in teachers' beliefs ..... will follow the opportunity to validate, through observing positive student learning'. Clarke (1994) also notes that there are two approaches when considering this feature. One approach is for the teachers to make a prior commitment to the innovation before classroom implementation, that is, to change their beliefs before implementation. Then putting it into practice and observing positive pupil outcomes is then a confirming experience. The second approach is based on Guskey's model. Guskey (1985) argues that a change in teacher beliefs will not occur until teachers have seen a change in student learning outcomes. He offers the following model (Figure 2.1):

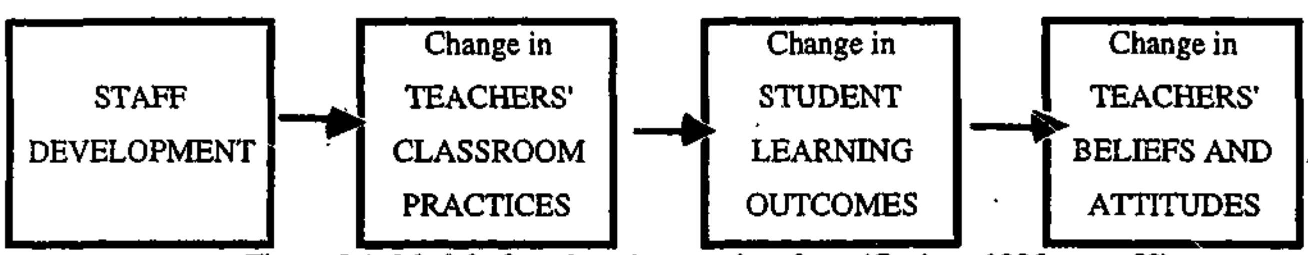


Figure 2.1: Model of teacher change taken from (Guskey, 1985, page 58)

Guskey (1985) bases his model on research into the implementation of a Mastery Learning Program where a group of middle and upper secondary teachers undertook a professional development program in mastery learning. His study noted that change only occurred with teachers who implemented the mastery learning techniques and saw strong student improvement. Change did not occur with those who implemented the techniques and did not observe a strong student improvement nor with those teachers who undertook the training program but did not attempt implementation. He drew from this that professional development alone nor professional development followed by implementation were sufficient for the teacher to take up the innovation, but that professional development and implementation need to be associated with evidence of improved student outcomes. To ensure that this latter aspect happens teachers need to receive regular feedback on the improvements being made in student learning outcomes. Guskey (1986) supports his model with the notion that teachers define their success in terms of their pupils' successes and failures rather than in terms of themselves. In citing Crandall (1983) he further adds that teachers are not committed to an innovation until active engagement takes place with the innovation in the classroom.

Interaction with students and observing the benefits was a key part to the success of the professional development component and introduction into schools in Wisconsin of the innovation referred to as Cognitively Guided Instruction (CGI) (Chambers & Hankes, 1994). One of the CGI teachers interviewed claimed that:

> When we came back from the workshop and tried some of the ideas, we saw our kids getting excited. Then we got more excited. .... Maths is wonderful for their self-esteem. That's one of the big plusses. The kids really gain a lot of self-confidence. ..... Some students used to say, 'I'm not very good at math.' I don't hear that anymore. (Chambers & Hankes, 1994 page 292)

Even using CGI-experienced teachers to tell of their classroom successes to the CGI professional development groups and using video clips of children solving problems had some impact (Chambers, 1994).

From the report by Hollingsworth (1996) on her case study teacher Geoff, who completed *EMIC*, she noted that his reflection was very much centred on benefits to the pupils in his class. For example Geoff noted that his class had done 'great things' in fractions when using concrete materials and that one student who had difficulty staying on task with Geoff's previous mode of teaching could now work with much greater concentration using teaching strategies introduced in *EMIC* (Hollingsworth, 1996, page 293).

Takes place over an extended period of time

This feature is directly taken from the list developed by Owen et al (1988) but the other lists of effective features use the terms 'on-going support' (Clarke, 1994), 'on-going over time' (Sparks & Loucks-Horsley, 1989) and 'continued follow-up' (Guskey, 1995). Owen et al (1988) note that this feature is apparent in most of their professional development models including the structured course model where 'cyclic notion of change' requires a series of activities or workshops over an extended period of time. All of the professional development models presented by Sparks & Loucks-Horsley (1989) require extended time and on-going assistance. Their 'Individually-Guided Staff Development' model has participants working through four phases of activity: identification, planning, action, and evaluation. Their 'Training' model, which mirrors the 'Structured Course' model devised by Owen et al (1988) uses as one of its research underpinnings the need for teachers to have time for classroom practice and peer coaching between workshop sessions because this in turn generates problem-solving discussion between colleagues. Guskey (1995) makes the point that in the early phases of the implementation of a classroom innovation some problems can be readily encountered and that it is at this stage particularly that on-going support is needed. He further notes that it is this feature that is the most neglected and points out that professional development should be seen as a 'process' rather than an 'event'. The notion referred to by Guskey (1995) of 'process' and the reference made by Owen et al (1988) to 'problem-solving discussion between colleagues' infers that effective professional development will involve the participating teachers in reflective practice and acknowledges that change takes effort and time.

EMIC, *Maths Making Links* and *MIS* were all conducted over an extended period of time: the first two involving a succession of workshops and *MIS* being conducted over at least two school terms. Montgomery (1995-A) justified this feature for *MIS* as follows:

> Because effective change takes time, Maths in Schools is best conducted over a long timeframe spread across most of the school year. This allows teachers time to trial new ideas in the classrooms and reflect upon the effects. A long timeframe also allows the project to ebb and flow around the hectic school times. (Montgomery, 1995-A, page 8)

Providing an appropriate philosophy on teacher change

This grouping of features recognizes that making meaningful classroom change requires a supportive environment, individual commitment, and that each professional development activity needs to be part of a long-term plan for each individual teacher.

Recognise that for change to occur teachers need to demonstrate commitment but realise that it is difficult and needs to occur at both individual and school levels

Both Owen et al (1988) and Clarke (1994) refer to the notion of teacher commitment. This feature also brings together the notion mentioned by Clarke (1994) of 'impediments' and 'change [being] gradual, difficult and painful' with the idea from Guskey (1995) of recognising that change needs to both at an individual and organizational level. Clarke (1994) lists twelve impediments under four distinct categories: '[those] external to the school; [those] related to school organization and administration and to the school community; [those] related to teachers' beliefs, knowledge, and practice; [and those] related to the content of staff development sessions' (pages 40-41). The second category of impediments includes the notion of 'professional isolation' where a lack of time prevents effective joint planning, individual reading and reflection. The impediments in the third category include lack of commitment, the 'practicality ethic, and teacher's inadequate knowledge' (page 41). A significant impediment noted by Clarke (1994) in his fourth category is the notion that much professional development works on a 'deficit model' rather than building professional growth.

Guskey (1995) points out that change is best achieved if the correct balance is struck between change at the individual level and change at the organizational level. He illustrates this with an example:

> In some situations, individual initiative and motivation might be quite high, but organizational structures stand in the way ..... in others progressive and supportive organizational structures may be in place but the lack of personal incentives for collaboration and experimentation inhibits any meaningful change in classroom practice (Guskey, 1995, page 119).

There is no available record of the significance of this feature for *EMIC, Maths Making Links* or *MIS.*

Recognise that professional development needs to be implemented gradually and coherently, with a long-term plan in mind

This feature brings together two of the points made by Guskey (1995): 'think big, but start small' and the realisation that professional development needs a framework. This sits well with the feature of setting 'further goals' which was noted by Clarke (1994). Clarke (1994) points out that teachers need to revisit their professional development plans on a regular basis and regard this as a process rather then a series of events. Guskey (1995) in his 'think big, start small' statement sees that there is a need for an optimal mix in what is going to be possible for implementation and successful against what will still present a professional challenge.

During each year several seminars were held for key teachers and facilitators involved in *MIS.* Ferguson & Montgomery (1994) report that from one of the seminars held in 1994 participants noted that, among a number of observations, that schools are keen to undertake school-based professional development activity to solve their own issues but that curriculum improvement takes time.

SUMMARY

This chapter has provided a literature review of the two topics that form the basis of this study – teacher beliefs and classroom practice, and features of effective professional development. This literature review provides a foundation for the following chapter which outlines the professional development program to be used as the context for this study. Firstly, the significance or inclusion in the planned professional development activity of each feature of effective professional development is outlined. Secondly, the topic content of the planned professional development course is described. This content is designed to challenge the beliefs held by the participating teachers and to consequently impact on their classroom practice. Later chapters will investigate possible connections existing between the two topics considered in this literature review.

CHAPTER 3

PROFESSIONAL DEVELOPMENT PACKAGE

INTRODUCTION

The purpose of this chapter is to describe the professional development context to be used for this study. A short course, *3Cs: Chance, Constructivism, & Collaboration* (referred to in much of the further discussion as *3Cs*), will be developed and delivered to a group of primary teachers. In this chapter discussion firstly focuses on the application of the features for effective professional development listed in Chapter 2 (see page 42). Secondly detailed consideration will be given to the *3Cs* workshop content – chance and data, constructivism, and teaching strategies for collaborative learning. A substantial literature review is used to support the content selection. It is important to note the relative significance of each feature in the organization and structure of *3Cs* and to describe the course content as knowledge of both of these aspects are needed for consideration of the research aims of this study (see Chapter 1, page 12). There are a number of references to Appendix A in this chapter where 'page A-23' refers the reader to page 23 of Appendix A.

The professional development program *3Cs: Chance, Constructivism, & Collaboration* will provide the context for much of the data collection for this study: for example, some interview questions will focus on the participant's reactions to the organizational aspects of the professional development and to the workshop content; and transcripts of the workshop sessions will provide additional insight into the beliefs, and pedagogical and discipline knowledge held by the participants.

The organizational aspects and content of *3Cs: Chance, Constructivism, & Collaboration* will be developed by the researcher and delivered by a workshop facilitator employed for this purpose using a grant from Monash University. The professional development presenter to be employed to lead the *3Cs* program is a very experienced presenter and also a current primary school teacher. Her background includes taking teacher education courses and teacher professional development in both the fields of mathematics and science education.

APPLYING THE FEATURES OF EFFECTIVE PROFESSIONAL DEVELOPMENT

In Chapter 2 a list of features of effective professional development was made comparing and amalgamating lists devised by (Owen, Johnson, Clarke, Lovitt & Morony, 1988; Clarke, 1994; Sparks & Loucks-Horsley, 1990; Guskey, 1995). The list developed in Chapter 2 was categorised under four major headings. In the description by Owen, Johnson, Clarke, Lovitt & Morony (1988) of the Structured Course Model the effective features are present at different levels. For example, 'over an extended period of time' is noted as a strong feature of the model whereas the feature related to 'teacher ownership' is described as developing over time. Seeing that the organizational structure of *3Cs* is based upon the Structured Course Model then the level of presence of the features of effective professional development within *3Cs* will also vary. As well there are organizational and financial constraints on the delivery of *3Cs*. The *3Cs* participants will be volunteers and the researcher has no control over the extent to which they or their schools make this professional development part of any school-wide plan or part of any personal long term professional development plan. Thus the number of features that can be included in *3Cs* will be limited.

In addition to the organizational features the course content reflects some of the underlying notions inherent in the features and this may provide some interesting analysis of data. The content topics of constructivist approaches and teaching strategies for collaborative learning involve pupils working as a group and being given time for reflection. These approaches to learning are mirrored in the feature 'groups of teachers' as well as the features under the category of 'Providing opportunities for observing outcomes and reflection'.

Each of the features listed in Chapter 2 will now be considered in relation to how they will be implemented in the professional development program *3Cs: Chance, Constructivism, & Collaboration.*

Providing procedures for support and collaboration

Involves groups of teachers rather than individuals from a school

Teachers will only be accepted into the *3Cs* program where there are at least two from a participating school although the preference would be for at least four teachers from each participating school. It is anticipated that approximately twenty teachers will undertake the program so it is possible that up to five or six schools could be involved. Every step will be taken to minimise the number of schools involved and to maximise the number of teachers from each participating school. This is for two reasons. Firstly, the larger the group attending from any particular school means that within that school there is the potential for increased collegial support between workshop sessions for classroom trialling and teacher sharing. Secondly, the researcher needs to make the best use of the time he has available for the study by reducing time taken up with organizational detail as well as with travel. However, an added feature of short course professional development involving small groups of teachers from a number of schools is that sharing can also occur on a school-to-school basis. Such sharing can occur during the workshops either in whole group discussion or small group activities. It is planned that in the *3Cs* workshops the participants will very often work in small groups where the small groups will include both working with the teachers from their own school as well as with teachers from other schools. School-to-school sharing may also occur outside of the organized workshop program. As much as possible the participating schools will be drawn from the same geographic area and this may accommodate some increased sharing between teachers from different schools.

This feature also mirrors the content topic of teaching strategies that promote collaborative learning, to be discussed in greater detail later in this chapter. In each workshop session there will be activities that involve small groups engaged in solving a mathematical problem and/or discussing the merits of particular teaching and learning approaches. Such small group sharing should provide a rich context for professional development as teachers explain their ideas to colleagues as well as listen to and reflect on the ideas of their colleagues, whether they are from their own school or another school. Such discussion also has the potential to encourage continued sharing back in the individual schools.

Supportive principal

Initial contact with potential participating schools will be with the principal and any continuing contact with that school will depend on their reaction to and their support of the professional development proposal. Thus participating teachers will come from schools where principals give initial support. However, the researcher and/or the *3Cs* program will have little control over the extent of continuing principal support. Whether the outcomes of the *3Cs* program result in influencing what occurs at the school as a whole will be controlled to a certain extent by the continuing interest and support shown by the principal (and/or others in leadership positions). This feature will be important initially but not a planned continuing feature.

Facilitator or professional development leader seen as part of a team

(Owen, Johnson, Clarke, Lovitt & Morony, 1988) note that the 'Structured Course' is organized and largely conducted by the facilitator/leader. This will be the situation with *3Cs* where the researcher will complete the organizational detail as well as devise the course content. An overall plan for the content will be devised prior to the program beginning but, where appropriate, the content will reflect the on-going participant reaction and comments from Interview 3.

The researcher and presenter have previously worked together as a team in several teaching projects and as editors of *Prime Number,* the primary teacher journal published by the Mathematical Association of Victoria. A close working relationship between researcher and presenter will be essential for the delivery of the *3Cs* program because the researcher will be the author of the *3Cs* content and will need to convey to the presenter the ideas being put forward. The researcher, in the author role, will also need to take into account ideas from the presenter as well as accommodate the presenter's teaching style and level of mathematics discipline knowledge.

To some extent the researcher, when devising the content of the *3Cs* program, will be influenced by observations made in the *3Cs* participant's classrooms, comments in interviews, and reactions to each workshop session. As well participants will comment on their classroom trialling at each workshop and the presenter will incorporate the ideas presented in the teaching and use them as springboards into further discussion for that particular session. So even though the participants may not feel that they have taken part in the planning process much of the content will be influenced from their involvement in the study.

Providing a teacher-centered focus for content and organization

Linked to school-wide efforts

The feature 'linked to school-wide efforts' will only become relevant if participants make a conscious decision to share the outcomes of the program with other colleagues in their school. If teachers at a particular school level all attend *3Cs* then the planning for their particular level will hopefully be influenced by the outcomes of the *3Cs* program

Conducted in school settings

3Cs will be conducted in one of the participating schools, possibly the one with the most participants. Other participants should not have too far to travel if the participating schools are located in close geographical proximity.

Variety of approaches but with a focus on modelling and actual practice

The workshops at *3Cs* will include a variety of approaches in presentation of content. Some of these are listed below with an example taken from the course content and page reference (from Appendix A) included in brackets.

- Participant involvement in playing of games and reflection on the mathematics learning outcomes of these games (Dicetracks, page A-7);
- Watching video snippets of children's explanations (Lucky die, page A-12);
- Workshop presenter modelling of classroom practice (Jigsaw, page A-24);
- Participant discussion and sharing (Between sessions sharing, page A-21);
- Hands-on activity (Hat, Scarf and Belt, page A-38);
- Listening to stories of classroom activities (Ten Green Bottles, page A-37); and
- Development of own materials (Writing your own clue cards, page A-46).

There will be an emphasis on between-sessions classroom trialling so that some of the workshopped and modelled activities are put into practice in the participants' classrooms.

Addresses 'issues of concern' recognised by the teachers themselves

As noted later in the chapter the three topics chosen as content for the *3Cs* program are very timely, especially the topic of Chance and Data because of the introduction of this topic in a revised version of the mathematics curriculum for Victorian schools. Many teachers will be unsure about appropriate activities for teaching Chance and Data and may not have a philosophy of how children learn stochastic concepts. In this sense there will be many teachers who have concerns about covering the topic of Chance and Data with their classes.

Both the researcher and the workshop presenter have worked extensively with practising primary teachers and it would be assumed that they have a feel for what would be the 'issues of concern' held by many teachers. These 'issues of concern' will be addressed in the writing of the *3Cs* content material. As the course progresses the *3Cs* participant discussion and sharing, along with an interview of each participant midway through the program, will make it clear what other concerns need to be addressed and the course content will be appropriately modified.

When the presenter was shown a list of features of effective professional development and asked to select the most important features for her she chose 'addresses issues of concern recognized by the teachers themselves' and 'seeing advantages for the pupils'. The following discussion occurred:

> I think there has to be deep personal engagement by the participants. So whether their principal supports them or not it's sort of immaterial. It has to be stimulated very much by the participant's point of view and a deep need not something because "we really ought to do this". I see the motivation of the person doing some PD as absolutely crucial. All of these other things that you've listed have got real benefits but if I didn't have something that I recognized as an advantage for me professionally that benefits my students and enriches their life through me or if I didn't feel deeply connected with the ideas myself the PD would just be a bit empty. (Interview with presenter, March, 1997)

The presenter is a skilful and very experienced professional development presenter and is more than able to fulfill her comments above. She has the expertise to ensure that she monitors and discovers the concerns held by the teachers and address them appropriately.

Ownership by the teachers involved in the program

For a number of practical reasons it will not be possible for the participating teachers to be involved in the planning of how *3Cs* will be organized or in decision-making about it's major course content. However, included in the workshop session outline there will be planned time for participant sharing, either as a result of a workshopped activity or as a result of classroom trialling. In both teacher education courses and teacher professional development the presenter has involved herself in the pursuit of encouraging teachers to adopt a constructivist role in the classroom, a role that she puts into practice in her own primary teaching.

> [My teaching role is] to let children go a lot. So I allow for a lot of conversation while children are working and I expect children to work together and so I expect them to talk. I mean the noise level in my classroom is very high. I expect them to share ideas and talk about ideas. We've been doing maths project books at the moment where there is a topic and they're creating their own book about the topic they've chosen. (Interview with presenter, March, 1997)

The presenter's expertise in encouraging children to give their own mathematical explanations is apparent in many articles she has written. For example, see (Peterson, 1995-B), and (Peterson, 1995-A). Inherent in the presenter's teacher role is a stepping back from being the explainer to the role of facilitator. It is expected that the presenter will take a very similar approach when presenting the *3Cs* program, that is, one where the ideas of the participants are acknowledged, accepted and built upon in further discussion. Such a presentation style could create an atmosphere of teacher ownership of the outcomes of the program.

Providing opportunities for observing outcomes and reflection

Participants researching in classrooms and reflecting on the responses

Participants at *3Cs* will be encouraged to trial workshopped activities between sessions and to report back on the outcomes of the trialling at the following session. The teachers will try in a hands-on way the implementation of various activities. They will then reflect on the success or otherwise of the experience, share this experience and reflection with colleagues, consider the responses and also hear of their colleague's own experience and reflection. Classroom trialling and reflection should be seen as a process of teacher learning parallel to the notion of constructivism for children's learning.

Seeing advantages for their pupils

This feature is closely tied to the previous feature. Most classroom outcomes are judged by the perceived advantages for pupils so if classroom trialling and reflection lead to a positive response then teachers will view the innovation or activity that they were trialling as an appropriate addition to their classroom practice.

The hands-on approach to be taken in the *3Cs* workshops allows the participants to judge at that point in time the value of the presented activities. It would be expected that judgements would be made with a number of factors in mind. These factors would include the perceived advantages for their pupils and whether the approach taken matched the individual's teaching style of instruction.

Takes place over an extended period of time

The professional development program *3Cs* will consist of six two-hour workshops conducted over two school terms. The sessions will be at least a fortnight apart, if not longer, so that teachers have sufficient time for between-sessions trialling of activities and time for reflection upon what they have been doing. This feature is required, in part, to allow time for classroom trialling to occur and for participants to be able to reflect on their ideas and strategies being put forward.

Providing a philosophy on teacher change

Recognise that for change to occur teachers need to demonstrate commitment but realise that it is difficult and needs to occur at both individual and school levels

and

Recognise that professional development needs to be implemented gradually and coherently, with a long-term plan in mind.

These two features address the 'life-long' nature of professional development and in that sense are beyond the scope of *3Cs* implementation and of this research study. For either of these to occur the individual participant or school needs to see that *3Cs* is a part of on-going professional development and teacher change.

However, the individual teacher commitment to the *3Cs* program is quite high. As well as attending the six two-hour workshops and meeting the expectation of between-sessions classroom trialling the participants will be requested to undertake five thirty minute interviews and be observed in their classrooms on four occasions. The research components of interview and observation could also be considered as part of each teacher's professional development, particularly the interviews, as they will involve the teachers in reflection on their beliefs and practice.

Changes in beliefs and practice will result from those participants who meaningfully reflect upon the implications of activities and ideas presented in the workshops and of the outcomes of classroom trialling. The professional development program *3Cs* offers many opportunities for teacher reflection including small group discussion at workshops, video snippets of children explaining their ideas, observation of the results of classroom trialling and then sharing these observations with colleagues.

Summary of application of effective features with the *3Cs* program

Table 3.1 summarises the level of planned presence of each feature in the organization of *3Cs*.

Category of feature	Effective feature	Planned presence	Indirect presence
Providing procedures for support and collaboration	• Involves groups of teachers rather than individuals from a school	√	
	• Supportive principal		√
	• Facilitator or professional development leader seen as part of a team.		√
Providing a teacher-centered focus for content and organization	• Linked to school-wide efforts		√
	• Conducted in school settings	√	
	• Variety of approaches but with a focus on modelling and actual practice	√	
	• Addresses 'issues of concern' recognised by the teachers themselves		√
	• Ownership by the teachers involved in the program.		√
Providing opportunities for observing outcomes and reflection	• Participants researching in classrooms and reflecting on the responses	√	
	• Seeing advantages for their pupils	√	
	• Takes place over an extended period of time	√	
Providing an appropriate philosophy on teacher change	• Recognise that for change to occur teachers need to demonstrate commitment but realise that it is difficult and needs to occur at both individual and school levels		√
	• Recognise that professional development needs to be implemented gradually and coherently, with a long-term plan in mind.		√

Table 3.1: Summary of features applied in *3Cs*.

CONTENT OF THE PROFESSIONAL DEVELOPMENT PROGRAM - *3CS: CHANCE, CONSTRUCTIVISM, & COLLABORATION*

It was noted in Chapter 1 that *The Mathematics Framework: P-10* (Ministry of Education, 1988) listed three major concerns for mathematics education: students as learners, teaching methods, and views of the discipline of mathematics. In the discussion in Chapter 2 concerning the beliefs held by teachers three sets of beliefs were established: beliefs about the nature of mathematics, beliefs about the role of the teacher, and beliefs about how children learn mathematics. In fact the major concerns and the teacher-held beliefs cover the same three aspects. Effective professional development should address these major concerns and challenge the beliefs held by teachers. The specific intention of the *3Cs* content and the approach to be modelled by the presenter is to promote relational beliefs and classroom practice and to challenge the *3Cs* participants' instrumental beliefs and practice. So that *3Cs* offers a rounded approach in its content an appropriate component of each of these aspects will be included. The following topics have been chosen: the topic of Chance and Data for the mathematics discipline component; teaching strategies that promote collaborative learning for the 'teaching methods/role of the teacher' component; and the notion of constructivism for the 'students as learners/how children learn mathematics' component.

This section contains consideration of each of the three topics of the *3Cs* content. In particular, the inclusion of each topic is justified and it's content is more fully described and discussed. Each workshop session is summarized and some of the intended *3Cs* activities are sampled. Much of this section needs to be read in conjunction with Appendix A.

Chance and Data

Justification of the topic of Chance and Data for inclusion in the *3Cs* program

The discipline content area of Chance and Data has been chosen for the *3Cs* program for a number of reasons. Firstly, Chance and Data, and more specifically Chance, has been a recent addition to the primary mathematics curriculum in Victorian schools. This represents a shift from viewing the teaching of probability as an academic pursuit to one of 'basic numeracy or mathematics for all' (Borovcnik & Peard, 1996). Although some teachers may have been undertaking classroom activities in the topic of Chance and there have been some well-known texts with model lessons involving Chance concepts (Ministry of Education, 1989; Lovitt & Clarke, 1988), the topic was not formally introduced into the national mathematics curriculum until the release of *A National Statement on Mathematics for Australian Schools* (Australian Education Council, 1990). This publication set out the following three aspects for the Chance and Data strand:

> *Chance* deals with the concepts of randomness and the use of probability as a measure of how likely it is that particular events will occur.
>
> *Data handling* deals with collecting, organizing, summarizing and representing data for ease of interpretation and communication.
>
> *Statistical inference* deals with drawing conclusions and making predictions based on both data and principles of chance. (Australian Education Council, 1990, pages 27-28)

The recently released *Curriculum and Standards Framework: Mathematics* (Board of Studies, 1995) outlining the mathematics course content for schools in Victoria had as its basis the content suggested by *A National Statement on Mathematics for Australian Schools.* Much of the content for the Chance and Data strand was new to the primary curriculum, in particular the content related to Chance and to Statistics. In the *Curriculum and Standards Framework: Mathematics* the Chance and Data strand was divided into the four substrands of Chance, Posing questions and collecting data, Summarising and presenting data, and Interpreting data. In a study comparing various aspects of the professional development program, *Maths in Schools (MIS)* with corresponding aspects in another professional development program *Learning in Primary Science,* the emerging picture for the teachers in the *MIS* schools that undertook professional development in Chance was that there was 'unfamiliarity with either the concepts underlying [the topic], classroom activities to support it, or the logic of its inclusion within the mathematics curriculum' (Tytler, Smith, Grover & Brown, 1996). Edwards (1996), in his research into primary teacher confidence in teaching statistics in New Zealand, found that the teachers were confident in teaching familiar topics such as data collection and bar graphs, but had lowest confidence in the teaching of the recent additions to the curriculum such as stem and leaf plots and probability. Because of this 'unfamiliarity', stochastic notions from each of the primary levels of the *Curriculum and Standards Framework: Mathematics* will be included in the *3Cs* course content. This will enable the *3Cs* participants to gain an understanding of the development of the topic from the preparatory year through to year 6.

Secondly, there is research literature that demonstrates that many adults have a lack of understanding of stochastic notions and that misconceptions are common place particularly in Chance (Shaughnessy, 1992). One of the misconceptions is referred to as 'representativeness' (Kahneman & Tversky, 1972). A person who relates chance to representativeness will chose an outcome that appears to be representative. For example, in a series of 6 coin tosses there are 64 equally likely outcomes. When faced with the task of choosing the most likely outcome of the sequences HHHHHT or HHTHTT, the respondee relying on representativeness would chose the second option basing this on the assumption that Heads and Tails should appear in a more 50-50 arrangement. Another misconception is referred to as 'availability' (Kahneman & Tversky, 1973). With this misconception the person relies on how readily an example of the event comes to mind. For example, some people like to buy their Tattslotto tickets from an agency that has announced that they have had recent winners. Lack of understanding and possibly the presence of misconceptions is also apparent in teacher knowledge and (Shaughnessy, 1996) suggests that teachers are likely to have the same naïve conceptions about stochastics as their students. Research with primary teachers in Tasmania showed that they had a low confidence level in understanding the notion of median (Callingham, Watson, Collis & Moritz, 1995). Other research by Greer & Ritson (1994) found that primary teachers in Northern Ireland were 'ill-prepared' to teach Data Handling and research by Azcerate & Cardefioso (1994 that the understanding of randomness by pre-service primary teachers in Spain was conceptually poorly formed. The importance of meaningful understanding of Chance and Data concepts is stressed in *A National Statement on Mathematics for Australian School*:

> A sound grasp of concepts in the areas of chance, data handling and statistical inference is critical for the levels of numeracy appropriate for informed participation in society today. 'Data' provide us with a powerful means of forming opinions and reaching conclusions quite different from those we would reach if we relied upon, for example, 'authority' or 'hearsay'. Assessing the credibility of arguments based on information given should be the basis of the study of chance and data. As the amount and variety of quantitative information confronting people have increased, however, so too has the need to understand the strategies for data collection and analysis, the nature of chance processes and the effect of chance on data collection, and the assumptions that underlie procedures and predictions. Statistical inference underlies such diverse matters as weather prediction, economic indicators, medical and other research design, risk insurance, gambling and quality improvement. Ultimately, it affects the lives of all people individually and collectively. (Australian Education Council, 1990, page 163)

Thirdly, undertaking Chance and Data activities in professional development allows a strong connection to be made to constructivist notions, especially through the use of teaching strategies promoting collaborative learning. This will be further discussed in a later section.

So, for the above three reasons, professional development in Chance and Data in the primary school would be very timely in that it could provide a bank of Chance and Data classroom activities, encourage participants to reflect on pedagogical issues in relation to children's knowledge of Chance concepts, and also provide personal background discipline knowledge.

Selecting Chance and Data content for the *3Cs* program

The Chance and Data content planned for the *3Cs* program aims, as a minimum, to cover that which is developed in the first four levels of the *Curriculum and Standards Frameworks: Mathematics* (refer pages A-8 & 9). However, the activities included cater for the threefold purpose of the program: provide a bank of classroom activities, make connections to pedagogy, and develop personal discipline knowledge.

Session 1 focuses on the language of chance where a continuum of chance words, never through to certain, will be established. Several activities make use of this continuum and the idea that the continuum can be labelled with various number sequences involving percentage and fractions is put forward. Notions of fairness and luck are also considered. In session 2 the notion of random generation will be discussed through the use of games and between-session sharing. Finding all possible outcomes of an event will be the focus of session 3. The major focus of session 4 is the connection between ratio and the calculation of the probability of an outcome. Some simple statistical notions will be introduced in session 4. Session 5 aims to explain the difference between independent events and conditional probability. The topic of sampling will be the major focus of session 6. Table 3.2 summarises the Chance topics for each *3Cs*.

Session number	Chance content	Appendix reference
Session 1	Language of Chance Notions of fair, luck	Activities 1-2, 1-4, 1-5 Activities 1-3, 1-6 Pages A-4 to 12
Session 2	Random generation	Activities 2-4, 2-5, 2-6 Pages A-22 to 27
Session 3	Outcomes of an event Combinations	Activities 3-3, 3-4, 3-5, 3-6 Pages A-35 to 38
Session 4	Ratio and probability of an outcome Stem & Leaf Plot	Activities 4-5, 4-6 Activity 4-4 Pages A-48 to 54
Session 5	Independent events and conditional probability	Activities 5-3, 5-4, 5-5 Pages A-62 to 66
Session 6	Sampling	Activities 6-2, 6-6 Pages A-76, A-86

Table 3.2: Listing of Chance content

COLLABORATIVE CLASSROOM STRATEGIES

Justification for inclusion as a topic in the *3Cs* program

> [Collaborative] learning is generally understood to be learning that takes place in an environment where students in small groups share ideas and work collaboratively to complete academic tasks. (Davidson & Kroll, 1991, page 362)

(Johnson & Johnson, 1989) contrast collaborative (or cooperative) learning to that of competitive and individualistic learning and state that most whole-class instruction has been traditionally competitive followed by individual practice. (Slavin, 1982) refers to cooperative learning as a set of instructional methods in which students work together in small groups toward a common goal. For successful implementation of collaborative techniques in the classroom researchers in this field and teachers who make use of such techniques note that teacher and pupil roles in the classroom are different to those of traditional approaches to teaching. For example, the teacher's role is no longer one of directing the lesson (Burns, 1990; Davidson, 1990-B) although teachers need to intervene to ensure that genuine argumentation takes place (Cobb, 1994). The notion of individual accountability within small groups of pupils is important (Davidson, 1990-B) and the notion that learning takes place when pupils discuss differences in views and move from controversy to consensus is paramount (Johnson & Johnson, 1989-90).

Research into the use of collaborative teaching strategies has demonstrated that there are many advantages in its use (***See footnote). It has been found that through the use of collaborative teaching strategies:

- more ideas and different solution approaches are generated (Davidson, 1990-B), including tentative suggestions that will help the individual and the group move closer to understanding (Reid, 1989);
- that academic achievement is enhanced (Davidson, 1990-A; Johnson & Johnson, 1989; Slavin, 1990; Johnson & Johnson, 1990), that groups can often solve a more challenging problem that would be beyond the capabilities of the individuals in the group (Davidson, 1990-B) and that higher achievement can be obtained in high-level and creative thinking (Good, 1990; Sharan and Hertz-Lazarowitz cited in Dees, 1991);

*** FOOTNOTE:
An initial list of advantages of collaborative teaching strategies was begun with prior research and reported in Smith (1990). This initial list was included in a project submitted as partial fulfillment for the degree of Master of Educational Studies. The initial list has been further developed with much additional information.

- greater pupil self-esteem is developed, that is, confidence in themselves as learners (Reid, Forrestal & Cook, 1989; Slavin, 1982; Slavin, 1990; Coats, Ogilvie & Strickland, 1989; Behounek, Rosenbaum, Brown & Burcalow, 1988; Davidson, 1990-A; Johnson & Johnson, 1990);
- a social support mechanism is established (Davidson, 1990-B) and hence an appreciation of the skills of others or a liking for each other develops, thus increasing motivation (Johnson & Johnson, 1990; Slavin, 1990)
- more time is spent on task (Behounek, Rosenbaum, Brown & Burcalow, 1988; Good, Grouws & Mason, 1990)
- students working in collaborative groups receive more attention from the teacher (Taylor, 1989);
- more group time is spent on conceptual understanding, as opposed to individual time which tends to be spent on products, and thus students may value shared academic work more because of the increased emphasis on understanding (Good,1990);
- children make more use of the spoken word of which they have more facility (Taylor, 1989) and that greater use is made of mathematical language - talking, listening, interpreting- and through this, intellect and curiosity are challenged and hence learning becomes an active process (Johnson & Johnson, 1989; Reid, Forrestal & Cook, 1989; Davidson, 1990-B) and through this communication and collaboration students come to see other ways of conceptualizing and solving problems (Good, 1990);
- greater confidence is gained in presenting findings to a critical audience because the pupils have the opportunity to sort the ideas out first (Reid, Forrestal & Cook, 1989);
- a more positive attitude of mathematics as a subject is developed (Johnson & Johnson, 1990; Slavin, 1990; Smith 1990);
- that even though some groups worked in an ineffective manner, effective groups succeed in creating cognitive conflict and grapple with misconceptions (Gooding & Stacey, 1993);
- teachers are able to introduce tasks that involve more thinking and challenge and that teachers often develop or adapt text-book lessons, frequently matching this lesson development to the real needs of students (Good, 1990).

Such a list of advantages associated with the learning of mathematics implies that teachers should give serious consideration to the incorporation of collaborative teaching strategies in their classroom practice. Many of the points listed by (Gervasoni, 1995) when she analysed Victorian documents pertaining to the improvement of quality mathematics learning and teaching (refer to Chapter 2, page 37) indicate that government initiatives were certainly encouraging teachers to adopt collaborative teaching strategies. The inclusion in the *3Cs* content of teaching strategies that promote collaborative learning is justified by the apparent researched advantages of their incorporation into classroom practice and by the encouragement for their use in current government initiatives.

Choosing strategies for the content of the *3Cs* program

(Mason, Reys & Good, 1990) in discussing small group work distinguish between the theoretical positions put forward by the 'developmental theorists' and the 'outcome theorists'. In citing the writing of Dewey, Piaget, Johnson & Johnson, Noddings, Burns, and Sharon & Sharon they suggest that the 'developmental theorists' would envisage that small group work would be used to encourage cognitive development. By encouraging cognitive development they mean 'active construction of insights, knowledge, and understanding through hands-on exploration, problem-solving, and investigation' (Mason, Reys & Good, 1990, page 4). In contrast they refer to the work of the 'outcome theorists' using Slavin as an example. They see that the 'outcome theorists' rationale for the use of small group work as increasing 'achievement, motivation, self-esteem, and pro-social behaviour' (Mason, Reys & Good, 1990, page 4).

When Mason, Reys & Good (1990) discuss the most effective approach for collaborative learning they align themselves with the 'developmental theorists' because their view of the use of small group work is that it contributes to:

> the development of higher-order thinking skills needed for problem solving through active involvement in the learner....... [and] to engage in academic discussions with peers (eg., explain their reasoning about problem solving and other higher-level math to peers and listen to and understand other students' reasoning about mathematical ideas. (Mason, Reys & Good, 1990, page 5)

The *3Cs* program will also take the 'developmental theorists' approach to collaborative teaching strategies because this approach can be closely linked with the content strand of constructivism. For this reason the five following organizational approaches to collaborative learning have been chosen for *3Cs*. The researcher has used each of these approaches in primary school situations where evidence of the above researched advantages has been informally noted. As well each of the selected strategies has been part of professional development activity and university courses taken by the researcher where participants have been able to appropriately trial and reflect on their use. It has been found that each of these collaborative approaches encourages discussion that in turn aids the development of mathematical thinking and presumably enhances mathematics learning.

- Role play (Dalton, 1985; Johnson & Johnson, 1990; Smith, 1990; Smith, 1995)

  This approach has pupils working in groups of two or more, although the preferred group size is four. Each pupil in the group takes on a role that is aimed at supporting the problem-solving process either from an organizational stance (roles include timekeeper, materials collector), or from an affective stance (roles include praiser, encourager), or covering both stances (roles include reporter, recorder). This teaching strategy is the collaborative approach that many Victorian teachers will have knowledge of and have attempted. It is commonly referred to as cooperative learning. (Smith, 1990) developed a 'mathematical' version of the role play situations in which 'mathematical' characters were used to model effective co-operative roles through the use of imaginative stories and drama activities.

- Clue cards (Erickson, 1989; Gould, 1993; Bellingham, 1994; Smith, 1994)

  In this approach each pupil in the group is given a clue that assists in the solution of a common group task. The pupils are only permitted to read their clue to the group and no one is allowed to take control over all of the clues.

- Jigsaw (Aronson, Blaney, Stephan, Sikes & Snapp, 1978; Dalton, 1985)

  In Jigsaw each group of students contains 'experts' that have previously worked together in 'expert groups', the 'expert groups' having only focussed on one aspect of the original group task. This approach can be used in conjunction with Clue cards, in that the 'expert groups' can be formed by those with common clues.

- Think-pair-share (Thorton, 1991)

  Individuals firstly tackle a problem on their own in this strategy. Then a pair of pupils share their problem-solving approaches and they attempt to come to consensus with a joint/common solution. They then share this solution with another pair and attempt to reach further consensus if possible.

- Group questioner (Smith, 1994)

  The organizational approach in this strategy involves each group having one pupil who is permitted to ask the teacher any questions that the group may have. They must be the group's questions and not the questions of individuals within the group and it is usually of benefit to limit the number of questions each group is allowed to ask.

One of these organizational approaches will be considered in each of the workshop sessions according to the list in Table 3.3.

Session number	Collaborative Strategy	Appendix reference
Session 1	Think-pair-share	Activity 1-5 Page A-11
Session 2	Jigsaw	Activity 2-5 Page A-24
Session 3	Clue cards Clue cards & Jigsaw	Activity 3-3 Page A-35 Activity 3-4 Page A-36
Session 4	Group questioner	Activity 4-5 Page A-50
Session 5	Role play	Activity 5-6 Page A-67
Session 6	(not applicable)	

Table 3.3: Listing of chosen collaborative teaching strategies

Because each strategy is to be the basis of between-sessions sharing the final workshop will not consider a collaborative teaching strategy although general discussion will be included on the relative merits and weaknesses of each specific strategy.

Constructivism

Justification for inclusion as a topic in the *3Cs* program

Proponents of constructivism see that children actively construct knowledge as that child adapts to their environment (Labinowicz, 1985). Although Malone & Ireland (1996) note that there are six 'forms of constructivism', the notions underpinning radical constructivism and social constructivism have had the most impact on teaching in mathematics. To distinguish between the two Cobb (1986) refers to the writing of von Glaserfeld (1983) for radical constructivism which he describes as a view where 'learning is a problem-solving process in which the learner attempts to overcome obstacles or contradictions that arise as he or she engages in purposeful activity' (Cobb, 1986, page 302). Cobb describes social constructivism, or 'empiricist-oriented constructivism' as he calls it, as the locating of 'knowledge in an external environment and sees it existing independent of the child's cognitive activity' (Cobb, 1986, page 302). The case studies of several teachers in Chapter 2, particularly those of the Grade 2 teacher (Wood, 1991) and of Jessica (Etchberger & Shaw, 1992), give examples of teachers who were beginning to adopt teaching strategies which promoted a constructivist approach to learning.

Davis, Maher & Noddings (1990) give some insights into what constructivist mathematics teaching and learning might include:

> Mathematical learning involves the active manipulation of meanings, not just numbers and formulas. ..... the notion that mathematics is learned in a cumulative, linear fashion [is rejected]. ..... Misconceptions may develop anywhere in the process, and constructivist teachers are continually watching for them and planning activities that will lead students to challenge their own faulty conceptions. Constructivists recommend providing learning environments in which students can acquire basic concepts, algorithmic skills, heuristic processes, and habits of cooperation and reflection. ..... The ideas which the student is learning become [the teachers'] main concern. (Davis, Maher & Noddings, pages 187-188)

Bishop & Goffree (1986) summarise the role of a constructivist teacher as:

> controlling the organization and dynamics of the classroom for the purposes of sharing and developing mathematical meaning. (Bishop & Goffree, 1986, page 314)

By 'mathematical meaning' they stress the 'personal' nature and the connections the individual makes with existing knowledge as essential components. However, constructivist philosophy does not provide a pattern or any particular vision for teaching approaches in mathematics but it does have the potential to inform change, where this change is a subtle and evolving process (Malone & Ireland, 1996).

In the list of points pertaining to improvement of quality mathematics learning and teaching from analysis of Victorian documents one of the points directly refers to 'utilising constructivist learning approaches' (Gervasoni, 1995). Thus the current government initiatives are directed towards encouraging teachers towards use of constructivist ideas in their teaching and it would thus be timely for the inclusion of this topic in the *3Cs* program.

As well the research literature suggests that activity-based professional development sessions involving the topic of Chance and Data along with strategies that promote meaningful discussion and sharing may be suited to the introduction and exploration of constructivist learning principles. Shaughnessy (1992) refers to Fischbein's writing on conceptual understanding in probability and in particular the notion of intuitions where Fischbein distinguishes between primary and secondary intuitions. Primary intuitions are those held before any intervention takes place and secondary intuitions are reconstructed thinking occurring after teaching or following an experience of some form. The move from primary to secondary intuitions, according to Fischbein, takes place in an instant, like a sudden thought, and is not a gradual process. Borovcnik & Peard (1996), when discussing the work of Fischbein and constructivist notions, make the following comments:

> For teaching, it is important that a direct link is established between the primary intuitions and the first mathematical model, and from there to those intuitions which should emerge from this mathematics. There is an ongoing revision of intuitions and mathematics, a dynamic interplay which should help one to understand the abstract theory in the end. (Borovcnik & Peard, 1996, page 12)

Good, McCaslin & Reys (1992) state that workshop tasks should evoke an idea that surprises the learner and that it is this element of surprise that accommodates justification of the new idea through additional exploration and discussion. Konold (1991) claims that because probability is a 'misconception-rich domain' that teaching the topic can be made more effective by the use of student discussion. Konold puts forward the following points to support this view:

> [Firstly class discussion] allows students to make explicit to themselves what they believe about a situation before they know what the 'expert' view is. Second, classroom discussion provides a motivation for further exploration of the question. The act of articulating one's beliefs in a public forum involves a personal investment in the question. Students who express their view are no longer indifferent to the final outcome of the discussion – in general they want to have been 'right' rather than 'wrong'. Third, discussion among students provides the opportunity for the instructor to gain further insights into how students are thinking about a particular topic. This information can be used to plan future interventions and to monitor conceptual development. Finally, the discussion communicates to the student the value that the instructor places on students' understanding and expression of ideas. (Konold, 1991, page 153)

This suggests that the topics of Chance and Data and strategies that promote collaborative learning can form the basis for modelling and appreciating a constructivist approach to teaching and learning.

Selecting constructivist content for the *3Cs* program

Both planned and unplanned opportunities exist for the inclusion of constructivist notions in the *3Cs* content with the planned activities summarised in Table 3.4.

Session number	Collaborative Strategy	Appendix reference
Session 1	Children's language constructions	Activities 1-2, 1-3, 1-6 Pages A-4 to 12
Session 2	Children's reaction to working together	Activities 2-2, 2-3, 2-5 Pages A-19 to 24
Session 3	Children's reaction to working together Children's thinking on combinations	Activities 3-2, 3-3, 3-4 Pages A-34 to 36 Activity 3-5 Page A-38
Session 4	Children's reaction to working together Children constructing notions of ratio	Activities 4-2, 4-5 Pages A-45 & 50 Activity 4-6 Page A-54
Session 5	Children's reaction to working together Children's ideas about independent events and conditional probability	Activities 5-2, 5-6 Pages A-60 & 67 Activities 5-4, 5-5 Pages A-63 to 66
Session 6	Children's reaction to working together Stochastic understanding Misconceptions	Activity 6-3 Page A-79 Activity 6-4 Page A-82

Table 3.4: Listing of constructivist content

The *3Cs* presenter, who is herself a teacher, subscribes to a constructivist approach in her own classroom will be encouraged to include connections to constructivist notions at every available opportunity. Although the between-sessions sharing is included as part of the program the discussion generated cannot be foreseen. Much of the between-sessions sharing is to be based upon classroom trialling of the teaching strategies which promote collaborative learning and it would be expected that in considering the advantages and the disadvantages of these strategies that constructivist notions will arise spontaneously and that the *3Cs* facilitator will have to run with this discussion in an unplanned or informal way. Some of the planned constructivist content is based on video snippets of children giving explanation of their stochastical thinking (refer to Activity 1-6 on page A-12, Activity 4-6 on page A-54).

3Cs: Overview and sample activities

The following presents a brief summary of each of the planned *3Cs* workshop sessions bringing together the separate consideration of each of the three topics already considered. The inclusion of several sample activities illustrates the hands-on nature of the workshop activities and how some workshop activities focus only on one topic whereas other workshop activities combine two or all three of the topics. A coding that is used in the summary introductory pages for each *3Cs* session (see Appendix A) is included. This coding will assist in the analysis of the content trialled by each teacher.

This overview represents what actually occurred in each of the six *3Cs* workshops and not necessarily what was originally planned. During each session the presenter needed to make decisions towards the end of the session about the remaining material and decide which activities she would continue to include. The omitted activities are not included in this overview as some of them were then used in a following workshop. At interview 3 several of the participants requested an overview of the CSF Chance content and some connections to evaluation. As a result of these comments the originally planned session 5 was substantially altered to cater for this request with the inclusion of Activities 5-3, 5-4 and 5-5 (pages A-62 to 65).

Session 1

The first workshop session (refer to pages A-2 to 15) covers the language of chance, beginning with informal language. Several workshop activities (1-2: Ordering / Four words and a biased die) will allow the participants to construct their own understanding of the spread of chance language and how percentages and fractions can be equated to this spread. Two activities using coloured dice (1-3: Dicetracks and 1-5: Rolling two yellows) will present situations were the initial participant response does not usually match the mathematics of the situation and the resulting conflict that is then set up leads to re-thinking of the initial responses. The first of these activities is at a pupil level whereas the second activity has a mathematics level more appropriate to adult construction of ideas (refer to the fourth sample activity below). Children's misconceptions about the luck of rolling dice (1-6: Lucky die) are considered with reference to Truran (1994) and a set of video snippets complement Truran's findings. The collaborative teaching strategy to be modelled in this session is Think-Pair-Share (1-5: Rolling two yellows).

Session 2

The second workshop session (refer to pages A-16 to 30) begins with the use of two-way charts as a way for solving chance problems (2-2: Rolling two yellows). The idea of random generation will be developed further through the between sessions sharing and the use of an activity (2-5: Jigsaw-Making a random generator) and a game (2-6: Toss of luck). Participants will share their reaction to trialling of the Think-pair-share strategy (2-3: Between sessions sharing). Jigsaw (2-5: Jigsaw-Making a random generator) will be the collaborative teaching strategy to be introduced in this session.

Session 3

Workshop Session Three (refer to pages A-31 to 41) considers the mathematics of combinations with a number of activities (3-3: Clue Cards – Finding combinations, 3-5: Ten green bottles, and 3-6: Hat, scarf and belt) addressing this theme. The collaborative teaching strategy for this session will be Clue Cards (3-3: Clue Cards – Finding combinations) as well as the possibility of combining this strategy with Jigsaw (3-4: Jigsaw and Clue Cards). Participant reflection on the trialling of the Jigsaw strategy will also be included (3-2: Between sessions sharing).

Session 4

The mathematics of combinations is further considered in session 4 (refer to pages A- 42 to 56) in a problem-solving situation (4-3: Writing your own clues) along with consideration of the connection of ratio to the topic of Chance (4-1: Game – Remove, 4-6: Green and white containers). The 'Green and white containers' activity involves video snippets of children giving explanations of a ratio problem and in one of the snippets the child actually changes his initial response and gradually constructs a mathematically correct explanation. As well some simple statistics are introduced and their relevance to chance is discussed (4-4: Some connections to statistics). The previous session will be followed up with an activity were participants consider the writing of their own clues for use in the Clue Cards strategy (4-3: Writing your own clues) as well as sharing reflections on Clue Cards trialling (4-2: Between sessions sharing). As well the Questioner Tag collaborative strategy will be modelled (4-5: Questioner tag strategy).

Session 5

Workshop Session Five (refer to pages A-57 to 72) begins with a consideration of the distinction between independent events and conditional probability (5-3: Conditional probability and independence, 5-4: Scenarios) and then makes a connection from this distinction to pedagogical issues developed by Jones, Langril, Thorton & Mogill, 1997) (5-

5: Sequencing activities). The collaborative teaching strategy for this session is Role Play (5-6: Role Play).

Session 6

The last workshop session (refer to pages A-74 to 90) concentrates on the notion of sampling (6-2: M & M's) and also briefly considers how chance can be linked to other mathematics topics (6-1: The paper clip game, 6-6: Family Feud). Teacher reactions to each of the collaborative teaching strategies will be gauged and each strategy will be compared for advantages and disadvantages for its use in the classroom.

Sample activities

Mathematics discipline and constructivist focus: Activity 4-6, Green & white containers, page A-54

This activity involves the showing of a set of video snippets where the researcher interviews three children. The children are shown two containers. The green container has in it four blue counters and two red counters. The white container has two blue counters and one red counter. The children are told that they are playing a game and if they pick a blue counter they will win. They are asked which container they would prefer to use and to explain why. The younger child immediately selects the green container because there are more blue counters. The older two children also select the green container but in trying to explain their reasoning they both change their minds and say that both containers give the same chance. During their explanations they construct new knowledge. Following the showing of the video the *3Cs* participants discuss various points about the children's knowledge and how the children came to construct their new knowledge. Activities like this one will be labelled as 'M' for their mathematics discipline focus and 'C' for their constructivist focus.

Mathematics discipline and collaborative strategies focus: Activity 2-5, Jigsaw - Making a random generator, page A-24

In this activity pairs of participants are asked to construct a random generator that could give 4 selections that theoretically could result in chances of 10%, 20%, 30% and 40%. Each pair designated one person as '1' and the other as '2'. Each of the ones met together to ensure that everyone in their group understood percentage and in particular how to convert vulgar fractions to percentages and vice versa. The twos met together to brainstorm possible ideas for random generators. The two groups are referred to as 'expert groups'. Then each pair meets together to construct their random generator. Discussion concerning the strengths and weaknesses of this collaborative strategy follows. This discussion may lead into notions of constructivism, although this will most likely arise in the discussion in the following session after the participants have trialled the strategy (refer page A-34). Activities like this one will be labelled as 'M' for their mathematics discipline focus and 'T" for their collaborative strategies focus.

Mathematics discipline focus only: Activity 1-4, Applying number to the continuum, page A-10

In this activity a continuum is drawn and one end is labelled as 'NEVER' and the other end as 'CERTAIN'. 'MAYBE' and 'LIKELY' are placed on the continuum in the appropriate positions. Discussion then centres on numerical arrangements for this continuum including percentage, vulgar fractions from 0 to 1, and rating scales from 0 to 10. The continuum is put to practical use by plotting the possibility for rolling various results using a coloured die (sides are 3 yellow, 2 red and 1 black). Activities like this one that have a chance only focus will be labelled as 'M'. This particular activity is not considered to present new mathematics knowledge to the *3Cs* participants, but some of the activities do and will be labelled 'M*'.

Combined foci: Activity 1-5 & 2-2, Think-pair-share - Rolling two yellows, pages A-11 & A-19

In this activity participants are set the problem: What is the chance of rolling two yellows, with one die that has 3 yellow, 2 red and 1 black sides and the other die having 4 yellow and 2 purple sides? Firstly, the participants work individually on the problem. Secondly, they share their ideas with a partner with the aim being to come to some consensus, and lastly two pairs join together to discuss the problem and where possible come to one solution. This collaborative strategy is referred to as Think-pair-share and naturally involves participant's ideas and understanding being challenged, confirmed and/or changed, that is, constructivist components of learning. Once everyone or group has given an answer and their reasoning the problem is modelled by pairs rolling a die and recording the result noting the percentage of double yellows rolled. This result (usually about 30%) surprises most people because they expect the answer to be closer to 60% based on the fact that there are a total of 7 yellow sides out of 12. Ideas and understanding are further challenged and normally much discussion occurs and a theoretical solution is sought. If one of the participants does not suggest the use of a two-way chart (cartesian graph) then the presenter is to demonstrate this solution. For many primary teachers the idea of a two-way chart will be new knowledge. Activities like this one that have a combined foci will be labelled as 'C' for their constructivist strand, 'T' for their collaborative strategy strand, and in this particular example 'M*' because the Chance content most likely presents new knowledge to some of the participants.

SUMMARY

Chapter 3 has outlined the context in which this study will take place, both in terms of how the features of effective professional development are played out in the *3Cs: Chance, Constructivism, & Collaboration* program and the three content topics that make up the subject matter of the workshops. The *3Cs* context also provides some direction for the research methodology and this will be described in Chapter 4. In particular, interviews of *3Cs* participants will assess their reaction to each of the professional development features, especially those features that are significantly present in *3Cs*. Interviews and post-*3Cs* classroom observations will gauge participant reaction to the *3Cs* workshop content.

CHAPTER 4

METHODOLOGY

INTRODUCTION

This chapter outlines the research approach to be used for this study. Firstly the research questions are listed and then considered in terms of the use of a case study approach. It is noted that interviews will provide the main source of data but be supported by classroom observations as well as observations and transcripts made of the *3Cs*: *Chance, Constructivism, & Collaboration* (*3Cs*) workshops. The use of a classroom observation schedule is detailed including notes on modifications made while piloting the schedule. The organizational structure for the interview schedules is described and sample interview questions are listed under the major topic components for this study. The use of the NUD•IST software program for categorization of interview comments is briefly described. Participant selection and the role of the researcher are briefly considered followed by comments on data analysis and how this relates to the following four chapters.

ABOUT THE STUDY

Research questions

As noted in Chapter 1 (see page 12) this study aims to investigate:

- the classroom practice and beliefs of a group of primary teachers who are engaged in a short course professional development program in order to classify the teachers;
- the attitudes the group of teachers have towards organizational features of short course professional development and the extent to which these attitudes impact on the short course example which is to be part of this study;
- the extent of implementation of the specific short course content offered as part of this study;
- any connections which may exist between teacher beliefs and practice and their attitudes towards the organizational features and content of short course professional development.

This leads to the following research questions:

- How are the attitudes of primary teachers towards recognized features of effective professional development influenced by their beliefs about the nature of mathematics, the role of the teacher, and/or how children learn mathematics?
- How are the attitudes of primary teachers towards recognized features of effective professional development influenced by their classroom practice?
- Is the reaction to and classroom implementation of the content of a short course professional development experience by primary teachers influenced by their beliefs about the nature of mathematics, the role of the teacher, and/or how children learn mathematics?
- Is the reaction to and classroom implementation of the content of a short course professional development experience by primary teachers influenced by their classroom practice?

Case Study approach

This study intends to investigate the reactions of a group of primary teachers to a short course professional development experience and how their reactions are played out in their classrooms and school setting as well as in the general context of their views on professional development. So the following general research questions listed by Erickson (1986) are applicable to this study:

> What is happening, specifically, in social action that takes place in this particular setting?
>
> What do these actions mean to the actors involved in them, at the moment the actions take place?
>
> How are the happenings organized in patterns of social organization and learned cultural principles for the conduct of everyday life. (Erickson, 1986, page 121)

Erickson (1986) claims that these questions are best answered by fieldwork and in regard to data collection he describes fieldwork as:

> intensive, long-term participation in a field setting [along with] careful consideration of what happens in the setting by writing field notes and collecting other kinds of documentary evidence. (Erickson, 1986, page 121)

Stenhouse (1981) suggests that because of time constraints the balance of field observations becomes limited and can be supplemented with interviews. The downside of this, according to Stenhouse, is that the data maybe more limited in penetration,however, he adds that many researchers regard interviewing as more spontaneously revealing.

Fieldwork and interviews can lead to an in-depth qualitative study of the participants involved, as well as give a global view of the situation. This approach allows the researcher to give a comprehensive account of the situation, to develop categories and make generalizations and to allow for judgements to be made. Merriam (1988) would describe this approach as an evaluative case study. This study which aims to give recommendations for future approaches to professional development requires a detailed account of the experiences of a group of teachers involved in professional development along with consideration of the resulting findings and implications. An evaluative case study would appear an appropriate way to achieve this aim.

To respond to the research questions for this study the following information for each participating teacher needs to be collected:

- their beliefs about the nature of mathematics, the role of the teacher, and how children learn mathematics;
- their approach to lesson planning, what happens in a mathematics lesson, and the place they put on classroom discussion in a mathematics lesson;
- their attitudes towards the features of effective professional development and the impact these had in their *3Cs* experience; and
- their reaction to the content material of the *3Cs* program and the extent to which they implemented the content.

It would be possible for all of this information to be collected through interviewing. However, it is imperative that interview data, where possible, is validated by other data sources. Classroom observations and transcripts from the *3Cs* workshop sessions will assist with this validation process as well as provide further information to support the study.

Role of the researcher

The researcher will have a number of roles including:

- organiser and facilitator of the *3Cs* program;
- author of the *3C*s workshop notes;
- interviewer of the *3Cs* participants;
- observer of lessons in the 3Cs participant's classrooms; and
- observer at the *3Cs* workshop.

Where possible the researcher will act in a non-participatory way in the two observer roles. However, if a teacher asks a question or suggests involvement in any way this opportunity will be taken. If the teacher shows signs of nervousness because of the researcher's presence an appropriate action will be taken in order to alleviate the situation, for example, by roving around the room to assist pupils and to correct their work.

Timeline

Table 4.1 gives a timeline for the *3Cs* workshops and how the classroom observations and teacher interviews complement this timing. The interviews are to be in three stages: pre-*3Cs* (interviews 1 and 2), mid-*3Cs* (interview 3), and post-*3Cs* (interviews 4 and 5). The major foci of the pre-*3Cs* interviews will be to ascertain the beliefs and approach to classroom practice for each *3Cs* participant. The pre-*3Cs* classroom observations will provide some of the context for this interviewing. Initial reaction to the *3Cs* program, both

Time	Classroom Observation	Interview	*3Cs* workshop
April	1 2		
May		1 2	
May 29			1
June 12			2
June 19			3
June/July		3	
August 7			4
August 21			5
September 4			6
September/October	3 4		
October/November		4 5	

Table 4.1: Timeline showing placement of classroom observations, interviews, and *3Cs* workshops. Arrows indicate the context for some of the interview questions.

on content and on professional development features, will be the major focus of interview 3 with workshop sessions 1, 2 and 3 providing the context for interview questions and discussion. It would also be expected that interview 3 will provide some feedback on *3Cs*, particularly on content, and that this will assist in the planning of the remaining three sessions. The major foci for the post-*3Cs* interviews will again be on participant reaction to the *3Cs* program. Further insights into teacher beliefs and classroom practice are also likely to result from interviews 3, 4 and 5.

Table 4.2 summarises the major sources of data for this study.

	Pre-*3Cs* interviews	Mid- & Post-*3Cs* interviews	Pre-*3Cs* classroom observation	Post-*3Cs* classroom observation	*3Cs* workshop transcripts
Teacher beliefs	√				
Classroom practice	√		√		
Attitudes towards features of effective professional development	√	√			
Reaction to *3Cs* content		√		√	√

Table 4.2: Summary of the major sources of data for this study.

CLASSROOM OBSERVATION

As already noted there are to be two facets of classroom observation for this study: pre-*3Cs* and post-*3Cs*. The pre-*3Cs* observations will be made in order to gain a 'picture' of each *3Cs* participant's classroom practice particularly in regard to how they act out their role in the classroom and the extent to which they make use of pupil discussion and use the ideas generated by the pupils. The post-*3Cs* observations are aimed at observing lessons that result from the *3Cs* experience. Both the pre-*3Cs* and the post-*3Cs* observations will provide the researcher with a context in which to frame some of the interview questions and also enable validation of the comments made in interviews. Visiting and observing classrooms will also allow the researcher to gauge any possible constraints that may be in the way of the teacher fully implementing their espoused beliefs.

Recording of classroom observations could take the form of quite structured notation or as fairly open-ended field notes. It seems important to have both forms of record, firstly to provide results that can be compared in a quantitative way and secondly to provide data of a qualitative nature in order to describe 'classroom episodes'. To meet the first provision an observation schedule will be developed, piloted and modified if necessary. To meet the second provision informal notes will be taken by the researcher and audio-recording of observed lessons will also enable transcripts to be produced for more in-depth analysis.

Observation schedules

There are numerous observation schedules that have been developed to record actions in classrooms. The one chosen for use in this study was based upon one developed by Beeby, Burkhardt, & Fraser (1980). They developed the Systematic Classroom Analysis Notation (SCAN) in order to provide for more systematic feed-back in the development of curriculum materials. Specifically under test was the impact of the use of micro-computers as a resource for teachers and whether their use impacted positively or negatively on individual teaching styles. Their purpose had some parallels to the intentions of this study, that is, the impact on teaching style following the introduction of various innovative classroom practices.

Beeby, Burkhardt, & Fraser (1980) firstly developed a mathematics version of the Science Teaching Observation Schedule (Eggleston & Galton, (1976) cited in Beeby et al.). Because the time-slicing approach did not sufficiently detail the classroom dialogue, Beeby et al. found that the data resulted in 'a more strategic analysis of the lesson than was [their] main concern' (page 19). After much discussion, trialling and validation SCAN was developed to describe the teaching which pupils received.

SCAN involves an analysis of a lesson into three levels - Events, Episodes and Activities. Events are the exchanges that take place in the classroom and include procedural dialogue, such as those pertaining to managerial statements and questions for checking, as well as dialogue associated with the content of the lesson, such as explanations, suggestions, and instructions. A series of Events forms an Episode, that is, a noticeable segment within a lesson. Classification of Episodes is an attempt to summarise the intent of the related Events and categories used include Coaching, Revising, Initiating Activity and Explaining. The major components of a lesson, Activities, refers to the form of the dialogue, such as dialogue between the teacher and individual pupils, pupil-to-pupil discussion, and exposition by the teacher to the whole class. SCAN also records within the coding process the nature of the activity, the level of guidance given, the fate of questions, and the resources being used. If needed other brief un-coded jottings can also be included, along with other support material such as lesson plans, samples of pupils work, and follow-up discussion.

Sullivan (1989-A) in his investigation of beginning teachers and the impact of their pre-service training and other professional support on their actual classroom practice used a modified version of SCAN for collection of data from classroom observation. On trialling the instrument Sullivan found that for his study which concentrated more on the actions of the teacher than general classroom activity that not all of the codes were necessary, that episodes did not reveal additional information already gained from the event coding, that there was a need to categorise the types of explanations, and that a naturalistic summary was also needed to produce an accurate picture of the lesson. Post-lesson discussions were also part of Sullivan's data collection and for this purpose more detail was needed to allow for reviewing of key events. As a result of these decisions and findings Sullivan decided 'to supplement SCAN data with an audio-recording, a verb[illegible] rec[illegible]ling of major events such as key questions, a brief naturalistic summary of the [illegible] d some quantifying scales for key behaviours' (page 123).

Piloting SCAN

Because Sullivan's research focussed upon the actions of the teacher, which was also the intent of this research, it was decided to trial this version as a starting point. Five mathematics classes were observed - two triallings each with two teachers (Teacher A and Teacher B) and one trialling with a third teacher (Teacher C). The third teacher was included as I anticipated that she operated in a very different mode to the other two and it seemed worthwhile checking whether the modified SCAN would also work in a fairly open-ended classroom. Slight alterations were made to the SCAN schedule between each trialling. Some of this process of piloting and modification have been reported in Smith (1998).

Events

Events categorize the teacher commentary and include explanations, instructions, observation, disciplining, and types of questions asked. It was felt that coding the types of explanations as 'facts', 'instrumental', 'relational', 'general' or 'by giving examples' would give data in relation to the level of an individual teacher's mathematical understanding, and also their beliefs on how children learn best. Although it was initially difficult to do this classification 'on the run', by the end of the trialling the researcher felt confident that it was possible. Skemp (1976) assists in distinguishing between 'relational' and 'instrumental'. For 'relational' he refers to 'what' and 'why', whereas for 'instrumental he refers to 'rules without reason'.

For similar reasons, the classification of types of questions asked also seemed relevant for this research. It could, for example, be expected that a teacher with greater confidence in mathematics would ask more probing questions; that a teacher who taught for instrumental understanding as the optimum would most likely only ask questions that involved simple recall. However, the original SCAN and Sullivan's modification classified teacher questioning with level quantifiers resulting in at least five categories. For this research it was decided to simplify this and have only two classifications of questioning, that is, 'qs' to indicate a question that only required simple recall of a fact, and 'q+' for a question that required more than simple recall. This simpler classification would also allow the addition to SCAN for recording the extent of wait time used by teachers. Wait time was classified on three levels, that is, 'wtx' to indicate no wait time given, 'wtr' to indicate a reasonable length of wait time given (up to 4-5 seconds), and 'wt+' for extended wait time given. Coding wait time was considered to be useful for adding to the data in relation to teacher beliefs on how children learn. It could be assumed that a teacher who makes use of wait time values listening to children's ideas and sees them as important. Perhaps this type of teacher may adhere to constructivist principles of learning.

When coding events, the only coding relates to the teacher and not the pupils. To indicate pupil comments during teacher exposition 'ch' was used to indicate pupil's speaking. During trialling this was refined to be 'ch_n' to indicate the number of children speaking at once, with 'ch+' if the whole class responded.

Following the first two trials it was found that there was some teacher dialogue not covered by either the original SCAN nor the Sullivan modification. These were a teacher confirming or repeating what a pupil had said (code added: 'con'), and a teacher giving praise (code added: 'p'). Table 4.3 (refer to page 93) lists the coding of Events.

It became obvious after the first four trials of SCAN that it would be useful if the teaching was audio-taped. In some instances it was impossible to keep up with the speed of the discourse and having access to a tape of the session would be useful to fill out any gaps in coding if it was thought relevant. As well, a record of the actual words used by the teacher would be useful data for qualitative reporting. So a small tape recorder was purchased, one that would be as inconspicuous as possible in the classroom, and hence the fifth trialling was audio-taped. A transcript was produced of this session, coded and then checked against the original coding. There was sufficient similarity between the two sets of coding to feel that coding being attempted while a class was in action would produce a fairly reliable account of that lesson. Sections of the transcribed tape are reproduced below (Table 4.4 – refer to pages 94 and 95) with accompanying coding of Events completed to demonstrate how SCAN was applied. In between the sections of transcription, field notes complete the scenario that took place in the classroom.

Code	Explanation	Example
er	explaning, relational	"Area is the amount of two-dimensional space taken up."
ei	explaining, instrumental	"To work out area of a rectangle you multiply the length by the width."
ef	explaining, facts	"The area of the MCG is just greater than one Hectare."
eg	explaining, general	Any explanation not covered by the above categories.
x	explaining, by using an example	"When you measure area it is as if you are covering with carpet or tiling the space."
con	confirming or repeating what a child had said	"OK, so John you think that the area is 20 square centimetres."
i	instructing	'We are going to use square centimetre grid paper to measure the area of the various tiles. First trace around the outline of the tile."
m	managing	"Susan will you please hand out the sheets of grid paper."
c	correcting	"Yes, folding the piece of paper around is the right way to do that."
o	observing	When the teacher purposefully observes the class and there is no teacher dialogue with pupils.
d	disciplining	"Alex, do not throw crumpled up bits of grid paper at Sally!!"
p	giving praise	"Well done Allison, you have correctly measured the area of all of those tiles."
qs	asking a question only requiring simple recall	"What is the area of a rectangle 3cm by 4cm?"
q+	asking a question requiring more than simple recall	"What is the area of a rectangle if the perimeter is 20cm?"
wtx	wait time, none or little	When the teacher offers no time following a question for a pupil to consider their response.
wtr	wait time, reasonable	When the teacher offers a reasonable amount of time following a question for a pupil to consider their response, up to 5 seconds.
wt+	wait time, extended	When the teacher offers extended time following a question for a pupil to consider their response, more than 5 seconds.

Table 4.3: List of SCAN codes, giving their meaning and an example.

[During a language session just prior to this mathematics session the pupils had followed oral instructions to make a simple spinner with the numbers 1, 2, 3 and 4. After they had all made their spinners the class worked as a group to compile written instructions that the class teacher wrote on the board. Then the mathematics session started.]

TEACHER:	OK listen please. Has everybody got a partner?	m
CLASS:	[various comments]	ch+
TEACHER:	What you need ... is you need two spinners between you and you need one of your sheets of paper with the numbers 1 to 8 where they are spread out along the bottom of the sheet. OK.	i
	You need to be listening please or you'll not know what to do.	m
	Right girls? Sit down.	d
	With your counters	i
	- excuse me -	d
	with your counters you put them 3, 4, 5, 6, 7, 8, anywhere above the numbers so you might put one counter on a 2 and you might put one counter on a 5 and you might put two counters above 6. Whatever. So you spread your counters out. Now, before you put them on you need to know what the game is. So don't put them on yet. Right. When you spin your spinner and your partner's spinner you're going to add the numbers up. If the total is 3, then if you have a counter on 3 you can take that counter off.	i
	So If you spin a 1 and a 4, What's the total of 1 and 4?	qs wtx
CLASS:	5	ch+

The class began to work enthusiastically on this game. The teacher roamed around the room making sure that all the pupils knew what to do. She commented to them about various things but little of this was to do with the real mathematics of the situation. The class played their games until the teacher noticed something interesting and called for silence. What she had noticed was briefly discussed.

TEACHER:	Stop and listen please.	m
	These boys over here have put every single counter on number 6.	ef
	Anybody who has an opinion on that?	q+ wtx
	Do you think that it is a good idea or a bad idea Maedie?	qs wtr
MAEDIE:	I think that it's a bad idea.	chl
TEACHER:	Why do you think that it's a bad idea?	q+ wtr
MAEDIE:	You won't always roll a 6.	chl
TEACHER:	You won't always roll a 6. No that's true.	con
	Anybody else with anything? Matthew (what do you want to share)?	qs wtx
MATTHEW:	Well I think that you can put it on 5.	chl
TEACHER:	Why do you think they need to put it on 5?	q+ wtr

MATTHEW:	Because that would be coming up ...... I think that there are more ways to get 5 than anything else.	ch1
TEACHER:	OK	con
MATTHEW:	2 and 3, you can have 1 and 4, you can have	ch1
TEACHER:	So you think there are most ways of rolling a 5.	con
	Why did you put them all on 6 boys?	q+ wtx
BOYS:	So we can come a draw.	ch2

The class and the teacher chuckled at this response, and all went on playing. Several other observations made by the teacher were discussed as a whole class at various intervals during the playing. The teacher asked if they could think about which number or numbers came up the most by doing twenty spins and keeping a tally of the totals. After a few minutes she asked the class to stop and to sit on the carpet in front of the blackboard.

TEACHER:	Glen (what was your number that came up the most)?	qs wtx
GLEN:	We did a bar graph and we ticked them off as we got it and 4 came up the most. We rolled thirteen times.	ch1
TEACHER:	OK. So 4 was the most but you only rolled thirteen times.	con
	Do you think that the 4 would have stayed the most if you'd done twenty?	q+ wtr
GLEN:	The 3 might have catched on.	ch1

The rest of the data was collected and written on the blackboard. There was some discussion about how many trials had been made. Unfortunately the bell rang and the teacher said that discussion on which were the best numbers to play on would continue at another time.

Table 4.4: Transcript from part of the 5th observed lesson with SCAN Events coding

Episodes

Episodes were used by Beeby, Burkhardt, & Fraser (980) to summarise a series of events. Categories for these included 'explaining', 'introducing', and 'revising'. Sullivan (1989-A) stated that he did not see these as relevant for his research and the same applies for this study.

Mode

Beeby, Burkhardt, & Fraser (1980) and Sullivan (1989-A) classified the classroom working structure under the heading 'Activities' and this included 'teaching the entire class', 'dialogue with 5 or less pupils' and 'pupil-pupil discussion'. I decided to call this classification 'Mode' as it relates to the mode or structural organization of the classroom. This aspect is important as one of the content areas for the *3Cs* sessions will focus on the use of collaborative or small group work strategies. Table 4.5 lists the classifications and codes for Mode.

Mode	Code
Teacher dialogue with the whole class	T
Teacher dialogue with n pupils	D_n
Pupils working in groups of n	W_n
Pupil-pupil discussion	p-p

Table 4.5: Listing of 'Mode' aspects and their coding

In the above scenario the codes used would be 'T' in the introductory, brief discussion times and final discussion; while $D_{1/2}$, W_2 and p-p would have been used for the coding during pupil working times.

Additional information

It was decided that an approximate record of time would be useful. One very basic reason for this was to be able to locate particular instances of a lesson on the audio-tape that was made. It also seemed appropriate to note the materials being used during the session. An increase in the use of materials, or a shift from teacher demonstration only to pupil use, may indicate a change in the teacher's philosophy on how children learn. To denote who was using the material a 'p' denoted pupil use and 't' denoted teacher use. Table 4.6 lists the coding that was used.

Resource	Code
Teacher produced worksheet	TM
Produced from Blackline Masters	BLM
Textbook	PM
Overhead projector	OH
Blackboard or whiteboard	BB
Calculator	CALC
Computer	COMP
Mathematics manipulatives	Individually named, eg MAB, Wainwright, Attribute Blocks, dice, play money.

Table 4.6: Listing of classroom resources and the codes used for each one

For the above scenario few resources were used. The pupils used spinners during their working time and in the final discussion the teacher made use of the blackboard to record the pupil's data.

It was also decided to plot where the teacher and the pupils were in the classroom. For this purpose a rough classroom sketch was needed with various sections of the room labelled with a capital letter. Sections of the room could be blackboard area, carpet area for the pupils to sit, tables working area, teacher table, quiet area. The 'p' and 't' coding was used in conjunction with this aspect as well.

Has the piloting of the modified SCAN resulted in worthwhile data?

The purpose of piloting SCAN was to see if it was workable and resulted in data that would assist to broadly categorise the teachers as either 'mainly instrumental' or 'mainly relational' in their classroom approach. It has already been noted that it was workable. When considering the latter point it must be remembered that data obtained from both classroom observation and interview are intended to support, confirm and supplement each other. Since interviews were not part of the SCAN piloting it is difficult to take any interpretation too far and inferences or judgement are certainly not made. Some brief examples follow.

Example 1

Extent of use of collaborative teaching strategies - from field notes and classroom plans

Teacher A had classroom seating arrangements that encouraged children to talk to each other, although there was little structure in the teaching approach that encouraged this talk to be on mathematics. The only instance in which this occurred was when the teacher asked for them to put their hand up to tell if they could see someone on their table who had remembered to include cm^2 in their answers. The seating arrangement in Teacher B's classroom was five rows of tables and chairs along one side of each row with all children facing the blackboard. The structure of the two lessons observed did not give any hint that the children ever talked or worked collaboratively in mathematics. Teacher C actively encouraged the class to work in pairs by asking the children to play a game and then to discuss together the mathematics that underlay the game. Seating arrangements were also appropriate for children to work and talk together. The teachers could be roughly placed on the following continuum:

No collaborative ____ B ________ A ______________________________ C ________ Collaborative talk
talk or work   encouraged

Example 2

Level of questions asked - from modified SCAN and lesson transcript for Teacher C

Most of the questions that Teacher A asked only required simple recall, whereas Teacher B asked more questions that required more than just recall. In consequence to this the pupil responses in Teacher A's class were shorter where the pupils in Teacher B's class gave quite long answers - some of them very complex. The majority of the questions asked by Teacher C were of the simple recall type. It is difficult to draw tight conclusions from this as the lesson content could have much to do with the types of questions asked. However, excluding this factor the following continuum could show approximate positions for each teacher:

Questions ____ A ____ C ____________________________________ B __________ Questions
simple recall — more than simple recall

Example 3

Extent of wait time - from modified SCAN

Teacher A, even though questions were only of a simple recall type, gave reasonable and in many cases extended wait time associated with questioning. Teacher B gave little or no wait time and after awhile the observer noticed that the majority of the questions were aimed at the two front row of pupils. Teacher C did not give any wait time at all, partly because most of the questions were directed at individual pupils and the answers were generally straight forward. When teacher C asked a question that involved more than just simple recall no wait time was offered and the question was usually reworded and directed at a particular pupil. Teacher use of wait time is noted on the following continuum:

Wait time ____ C __ B __________________ Wait time ______ A ______________________ Wait time
none — reasonable — extended

Example 4

Level of explanations - from modified SCAN

Teacher A's explanations were nearly all at an instrumental level, particularly when compared to the explanations given by Teacher B. Teacher B's explanations were factual (and of complex content) and a few were relational. The few explanations given by Teacher C were either instrumental or factual (and of simple content). The following continuum could be developed to show the relative differences between the three teachers' explanations:

Explanations ____ C ____ A __________________________________ B ____________ Explanations
instrumental — relational

In the above examples it appears that by using the modified-SCAN observation schedule in conjunction with other general observations and lesson transcripts comparisons can be made between teachers. For the above comments on each teacher the SCAN results were used in two quite distinct ways – quantitatively and qualitatively. The quantitative use involved counting the actual number of times each code was recorded. For instance, with example 3 above the extent of 'extended wait time' used by teachers A, B and C was ascertained by tallying the number of times that code appeared for each teacher in their SCAN schedule. A qualitative approach involves in-depth analysis of the lesson transcript along with the SCAN coding. Such analysis can reveal how the teacher makes use of pupil responses and whether there are any patterns in the flow of the classroom discussion. The teacher description for Teacher C in example 2 above made use of transcript analysis.

It is interesting to note, however, that making overall judgement about a teacher's classroom approach will not be clear-cut. In the above examples Teacher B for instance is rated as 'mainly relational' in two of the examples but 'mainly instrumental' in the other two examples. In Chapter 5 a SCAN analysis will be used to make comparison between each of the *3Cs* participants and this pilot study suggests that as many variables as possible will be needed in order to result in a reliable and useful indicator of each participant's classroom practice.

INTERVIEWS

The interview questions and discussion will need to cover the four major components of this study: teacher beliefs, classroom practice, attitudes towards features of effective professional development, and reaction to *3Cs* content.

Sullivan (1989-A) expresses some concern about producing biased results when using interviews. He cites Borg & Gall (1974) who claimed biased interview data can be achieved because of the influence of the researcher on the subjects, and Sullivan further notes that because he had known the subjects for nearly three years that this familiarity had the potential to increase the tendency for subjects attempting to give the 'right' answers. In the case of the teacher participants in this study, they will not be influenced in this way as the researcher is unlikely to know any of them prior to the beginning of the study. They will also not be under any pressure to supply 'right' answers because the researcher does not have any influence over decisions made within their schools or by their employing authorities. As well the idea of anonymity of any published reports will be stressed. Monitoring and limiting any potential interview bias will be achieved by consistency of responses over successive interviews, in conjunction with comments made in the professional development sessions, comments made by fellow teachers, and classroom observations.

Interviews can take many forms, from quite open-ended through to totally structured. Semi-structured interviews were chosen for this study because they allow for the intervention to be less threatening to the interviewees and allow for greater flexibility in further probes by the interviewer and responses by the interviewees. Instances from classroom observations and the *3Cs* workshops will be recalled and probed. The interview schedules are divided into major questions (MQ) and for each of these there are a selection of suggested possible probes (PP) where MQ1-3 denotes that this is the third major question in Interview 1 and PP1-3 denotes a possible probe that belongs to the third major question. For example,

> Do you encourage your pupils to work together and talk about the mathematics they are doing? (MQ1-3)
>
> What teaching strategies do you use to achieve effective pupil to pupil discussion? (PP1-3)
>
> Do you make use of small groups for mathematics? What criteria do you use when deciding whether to use small groups or not? When wouldn't you use small groups in mathematics sessions? Do you make use of small groups in any other subject areas? (PP1-3)

The following section gives a sampling of interview questions as they relate to the four major components of this study. As well a number of questions were planned that did not directly relate to the four major components but appeared to be useful for this study. A sample of these questions is also included.

Interview questions – teacher beliefs

On beliefs about the nature of mathematics

> Someone said to me one day that learning mathematics was like learning to ride a bike. What do you think? (PP2-1)
>
> Has teaching mathematics to young children changed your attitude towards mathematics? (MQ2-4)
>
> What do you see as the purpose for teaching mathematics/chance? (PP2-4)

On beliefs about the role of the teacher in the mathematics classroom

> Do you allow your pupils to work together and talk about the mathematics they are doing? (MQ1-4)
>
> What teaching strategies do you use to achieve effective classroom discussion? (PP1-4)
>
> What criteria do you use when deciding whether to use small groups or not? When wouldn't you use small groups in mathematics? (PP1-4)

On beliefs about how children learn mathematics

> How do you think children best learn mathematics? (MQ2-1)
>
> Do you think that children learn other subjects in the same way as mathematics? Take language, or science for example. (PP2-1)

Do children learn all mathematics topics in the same way, consider learning measurement compared to learning chance? (PP2-1)

Interview questions – classroom practice

On lesson planning

Tell me about the typical mathematics class that you take? What are its main components? (MQ1-1)

From where do you get your lesson ideas? (PP1-1)

Do you find that you cover many aspects of mathematics in one lesson, or just concentrate on one aspect? Can you give an example? (PP1-1)

Do you link your mathematics sessions into other subject areas? How do you do this? (PP1-1)

On what happens in a mathematics lesson

When you took "xxxxxx" lesson the other day you "xxxxxx". Can you tell me why you chose to take that course of action? (PP1-1)

If you were doing that part of the activity again would you take the same action? (PP1-1)

On the place of classroom discussion in a mathematics lesson

One boy asked you "xxxxxxx" and you replied by saying "xxxxxxx". Why did you chose to say that rather than "xxxxxxx"? (PP1-1)

You made use of groups of children working together in this lesson, but not in the lesson last week that was on the topic of "xxxxxxx". Can you explain how you make choices of when to use group work and when not to use it? (PP1-1)

Interview questions – attitudes towards features of effective professional development

Do you feel that professional development in mathematics needs to be done in a different way to professional development in other curriculum areas? Explain. (PP2-2)

What do you think characterises good professional development in mathematics? Why have you chosen xxxxxx as an effective aspect? (PP2-2)

Have you ever been to an ineffective in-service? What made it ineffective for you? Did other participants feel the same way? (PP2-2)

Tell me about your initial reactions to the professional development program. (MQ3-2)

How does this program compare with the program XXXXXX that you told me about in the first interview? Which professional development features are similar? In the first interview you said that being able to trial activities between sessions worked well for you, is this also the case in this professional development? (PP3-2)

In addition to the semi-structured interview questions a card-sorting procedure was also used in order to ascertain each interviewee's attitude to the features of effective professional development. Eight of the features were listed on cards and participants were asked to select the two features most significant to them and the two features that were of least significance. This procedure also meant that participants were not relying on their own recall of features. The interviewer gave explanation of any of the features when this was requested. Sullivan (1989-A) used a card-sorting technique for similar reasons in his interviewing. Sullivan cited the interview techniques of Sax (1979), Best & Kahn (1986), Pelto (1970) and Clarke (1989) to reinforce the viability of such a technique.

Interview questions - reaction to *3Cs* content

So far has the professional development approach to classroom practice matched the way you like to teach mathematics. (MQ3-1)

In what ways? Give me an example where the match has/has not been consistent with the way in which you like to teach mathematics. (PP3-1)

Have you changed any of your approaches to the teaching of mathematics as a result of this professional development? (MQ4-1)

So far, two collaborative teaching strategies have been modelled in the professional development sessions. Do you feel that you will be able to make use of these strategies in your mathematics teaching? Why/why not? (MQ3-3)

What do you see as the value of these strategies for learning mathematics? (PP3-3)

Has the professional development encouraged you to reflect upon or re-think your views on how children learn mathematics? (MQ5-1)

In what way has it changed your opinion? (PP5-1)

Can you relate an instance from the professional development that encouraged you to reflect on these views? (PP5-1)

Interview questions – other topics

On personal learning processes

It seemed important to include some questions directed at seeking each participant's views on how they thought they learnt new mathematics concepts and how they felt about accepting and implementing new teaching strategies. It was of interest to see if these beliefs corresponded with those they held for how children learn. The responses to these questions could also be correlated with observations made at the *3Cs* workshops.

> Do you think that adults learn new •mathematics concepts (PP2-1) •chance concepts (PP2-1) in the same way as children do?
>
> How did you acquire your knowledge of chance concepts? Would this have been the same for other adults? (PP2-1)

On personal mathematics knowledge

It was decided to include several questions that may ascertain some level of competence in the topic of Chance and Data for each *3Cs* participant. So that they were not threatening to the interviewees these questions were framed either in a context where the focus was placed on classroom use or as planning for the workshops. These questions were left until the second interview so that each interviewee would be familiar with the style of the interview.

> Interviewees are shown the handout related to the 'Tennis Clothes Problem' (refer to page A1-30). What year level would this task be suitable for? Is it appropriate for the pupils in your class? How do think children would solve this problem? What do you see as the solution? What would be the connection of this problem to the topic of Chance? (MQ2-10)

On attitude and confidence with mathematics

> Have you felt confident with the mathematics tasks set so far during *3Cs*? (MQ3-5)
>
> When you have trialled a Chance and data activity in your classroom have you felt confident/not confident with the mathematics involved? Gave an example. (PP3-5)

On teacher collaboration

Information on this topic corresponds to the feature 'attending as groups of teachers'. Questions on this topic were included to gauge whether there was any change in the extent of teacher collaboration resulting from the *3Cs* program.

> To what extent and in what way do you work with the colleagues at your year level? (MQ2-3)
>
> Does this collaboration cover all subject areas? (PP2-3)
>
> Who initiates this collaboration? Why is it this person? (PP2-3)

On teaching Chance and Data

It appeared that it might be useful to have some guide as to how the teachers included the three major *3Cs* topics in their teaching. Examples included here are for Chance and Data.

Similar questions were included for collaborative strategies and constructivist teaching approaches.

> What place does the topic of Chance have in your curriculum? (MQ1-2)
>
> How often do you teach chance concepts.... once a week?....once a fortnight?.....only when it rises incidentally? How does this compare to your approach for teaching other mathematics topics such as measurement? (PP1-2)
>
> Why do/don't you teach more measurement/chance than chance/measurement? (PP1-2)
>
> From where do you get your ideas for teaching chance? (PP1-2)

Using NUD*IST

NUD•IST (Qualitative Solutions Research, 1995) is a computer package that allows Non-numerical, Unstructured Data to be Indexed, Searched and Theorised. NUD•IST is thus most suitable for using with qualitative data, although it can be used in a quantitative manner. Use of the NUD•IST software for a project results in two parts, a document system for managing documents and an index system for developing and exploring ideas. NUD•IST has the ability to organise index categories into trees. Index categories can have sub-categories and sub-sub-categories and so on producing an indexing system that 'can be thought of as a collection of trees of categories and the categories as nodes in the trees, linked by branches' (Qualitative Solutions Research, 1995, page 10). The indexing tree begins with a single root node and spreads downwards. Indexing occurs at nodes and dated memos can be kept of decisions made at each node. NUD•IST has been designed so that the tree structure can be built upon, further explored, and altered as the project develops. Once the text data has been coded and placed at various nodes NUD•IST can then explore the relationships between the various nodes using nearly twenty node-building operations including Boolean operators such as 'intersection' or 'union', non-Boolean ones such as 'just-one', or relational ones such as 'near', or any combination of these operators.

It is not intended that detailed case studies will be prepared for all participants in this study. Perhaps 4 to 6 case studies will be developed. The implication of this decision is that NUD•IST will be useful for categorising interview comments to assist with sorting similar comments into categories. Some of the basic operators will be used, but with a small number of cases this particular use of NUD•IST would be limiting and possibly not produce anything that could be considered significant or reliable.

3CS WORKSHOP TRANSCRIPTS

It is intended that each *3Cs* workshop will be audio-taped so that transcripts of the discussion can be made. These transcripts could add useful additional information about participant beliefs, classroom practice, and reaction to *3Cs* content.

It was anticipated that up to 20 teachers will be involved in the *3Cs* program. The intention is that participants will sit in small groups around tables to work in a hands-on way with some of the activities and to engage in small group discussion and sharing. If four table groups are established then 4 to 6 participants can sit at each table. A tape recorder will be set up for each table in such a way to be as inconspicuous as possible. As well a tape recorder will also be set up at the front of the room to capture what is said by the presenter and by participants that give explanations from the whiteboard.

3CS PARTICIPANTS

Selecting participating schools

It was decided by the researcher to conduct the study in an outlying suburb/geographic area of Melbourne. From personal observations and anecdotal comments made by colleagues the researcher expected that this geographic area would have teachers representing a wider age range, higher ratio of males and greater percentage of beginning teachers than suburban areas closer to the city centre. It was then possible that a group of teachers drawn from this area would be more diverse than that expected from other geographic areas, allowing for a wider spectrum of classroom experience, and possibly more diverse attitudes and beliefs.

Choosing schools within the one geographic area will enable the researcher's time to be better managed and also put into easy reach the venue for the *3Cs* workshops of all the teachers. It was also hoped that teachers from neighbouring schools may communicate with each other more than if they were some distance apart.

The following procedure for locating participants is to be put in place.

Step 1: Send letters to schools outlining the 3Cs program and asking for a volunteer school or volunteer teachers. The geographic area chosen has sixteen primary schools representing both the State and Catholic education systems.

Step 2: Make telephone contact with each of the mailed schools within a fortnight of sending the letters. Speak to the principal of each school to determine interest and if there are any possible participants.

Step 3: As soon as possible the researcher will visit those schools indicating possible participants to further outline the program, explain the research intentions, and the commitment required by the teachers. Compile list of potential participants.

Step 4: Send letters to individual participants to confirm their place in the program, advise of workshop dates and venue.

Although not expected, preference would be given to a school if the whole staff was prepared to be involved. Other than this, preference will be given to groups of teachers from a school. It is hoped to have between 15 and 20 participants.

DATA ANALYSIS

The data collected from the pre-*3Cs* classroom observation using the modified SCAN schedule will enable the *3Cs* participants to be placed into the categories of 'mainly instrumental' and 'mainly relational'. As stated earlier the schedule will be used in both quantitative and qualitative ways. A number of quantitative dimensions will be devised and then combined to rate each teacher. This rating will then be compared to a separate rating resulting from an analysis of the patterns apparent in their SCAN-coded lesson transcripts. As well, the teachers will be divided into two groups based upon experience, with possible experience dimensions being years of teaching, dealing with mathematics, and extent of professional development. From this it is anticipated that the majority of the teachers should be able to be placed in one of the cells of the following matrix (Table 4.7):

	Mainly instrumental	Mainly relational
Higher level of experienced		
Lower level of experience		

Table 4.7: Matrix showing categories for teacher groupings

From this categorization one teacher from each matrix category will be selected as representative of that category to be further studied in detail. This first phase of the data analysis will be reported in Chapter 5.

The four chosen case study teachers will then be considered in detail and this will be reported in Chapters 6 and 7. Chapter 6 will report on further analysis of each case study teacher's classroom practice and beliefs. Pre-*3Cs* classroom observations, interview comments and *3Cs* workshop transcripts will be drawn upon to undertake this analysis. Where appropriate this analysis will be used to summarise each case study teacher's classroom approach and beliefs using the classifications developed Tables 2.2, 2.5, 2.6, 2.7 & 2.8 in Chapter 2 (see pages 19, 33 to 36) as well as an interpretative diagrammatic summary. The analysis reported in Chapter 7 covers the case study teacher's reactions to the *3Cs* program and their attitudes towards the features of effective professional development. To undertake this analysis the data from the post-*3Cs* classroom observations, interview comments, and the *3Cs* workshop transcripts will be used. At the end of Chapter 7 there will be analysis of any possible connections that may exist between the classroom practice and the beliefs held by the case study teachers and their attitudes to the professional development features and to their reactions to the *3Cs* content.

In Chapter 8 the case study findings will be compared to the more generalized findings for the group of participants as a whole. The focus of the analysis in Chapter 8 will be on investigation of the relationships as listed in the research questions.

Table 4.8 summarises the objectives for chapters 5, 6, 7 and 8 and notes which data is the most relevant.

	Objective	Pre-*3Cs* interviews	Mid- & Post-*3Cs* interviews	Pre-*3Cs* classroom observation	Post-*3Cs* classroom observation	*3Cs* workshop transcripts
Chapter 5	All teachers: •classification of teachers based on classroom practice. *** Selection of case study teachers.			√		
Chapter 6	Case study teachers: • in-depth analysis of practice and beliefs.	√	√	√		√
Chapter 7	Case study teachers: • in-depth analysis of attitudes to pd features & reaction to *3Cs* content.	√	√		√	√
Chapter 8	All teachers: • further analysis and discussion	√	√	√	√	√

Table 4.8: Summary of objectives and data sources for chapters 5, 6, 7 and 8.

SUMMARY

This chapter has described and justified the research methodology to be used in this study. A timeline shows how the various components of the study fit together and provide context for the interviews. Selection of participants and the contents of the following chapters are both outlined.

CHAPTER 5

PROFILING THE PARTICIPANTS

INTRODUCTION

The purpose of this chapter is to classify the *3Cs* (*3Cs: Chance, Constructivism, & Collaboration*) participants and to then select a representative sample to be chosen as case studies for more detailed analysis in Chapters 6 and 7. This classification involves analysis in two readily identifiable dimensions – participant experience and teaching style.

The experience dimension considers years of teaching, mathematics background and professional development involvement. The dimension relating to teaching style is based on the data collected by SCAN (Systematic Classroom Analysis Notation) and lesson transcripts and is limited to the way in which the teachers handle discussion with their class. The basis for the resulting classification involved in this second dimension is the instrumental/relational dichotomies developed for discussion and questioning in Chapter 2. The resulting groupings based on teaching style are then linked to the teacher groupings based on the experience dimension. The end result of this process is that the *3Cs* participants are categorised into distinct classifications.

The eighteen *3Cs* participants were drawn from five schools in neighbouring suburbs in the outer south-eastern metropolitan area of Melbourne. Two of the schools had two participants each, one school had three participants, one school had five participants and the remaining school had six participants. They represented the full range of primary year levels, but the majority (15 out of 18) came from the middle and upper primary years. Further details of the schools and the participants are contained in Appendix B. Because of tape-recorder difficulties one of the teachers has not been included in the data and analysis for this study. The data for another teacher has been used in this chapter, but because of interview transcription difficulties any data pertaining to this teacher has not been used in the general analysis of Chapter 8.

DIMENSION 1: PARTICIPANT EXPERIENCE

There are three aspects of experience considered relevant to this study - years of teaching, mathematics background, and professional development experiences especially in mathematics.

Years of teaching

Noted in Chapter 2 is the notion that beliefs change over time depending on the knowledge base on which the beliefs are founded [Scheffler, 1992 cited in Thompson (1992)]. However, also noted is that this knowledge base changes with the accumulated experiences that arise from activity such as day-to-day classroom practice and involvement in professional development programs (Fennema & Franke, 1992). It would thus be expected that a longer-serving teacher would have a greater breadth of experience-based knowledge on which to establish their beliefs. It is more likely that longer-serving teachers will have deep-level beliefs as opposed to surface-level beliefs (Raymond, 1997), or implemented-beliefs (values) as opposed to held beliefs (Southwell, 1995). Teachers' beliefs generate the approach taken in their classroom (Ernest, 1989; Baroody, 1987). It is most likely that the deep-level beliefs or values are the ones that underpin what is implemented by the classroom teacher (Raymond, 1997; Southwell, 1995). Thus it would be assumed that a teacher's pedagogical and discipline knowledge base developed over time is an important factor in making decisions about how to implement mathematics curriculum. Seeing that teacher beliefs are pivotal to the research questions for this study, it would appear plausible that a 'years of teaching' measure would be a suitable initial indicator of the possible nature of teacher beliefs.

Years of teaching experience is relatively easy to quantify from the interview data collected and varies from less than a full year of teaching through to those that have been teaching for up to at least thirty years. Table 5.1 summarises the full years of teaching for each teacher prior to the year the classroom observations, interviews and professional development program were completed.

Full years of teaching	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15 +
	•	•	•	•					•		•				•	•
			•	•												•
Numbers of participants																•
																•
																•
																•
																•
																•

Table 5.1: Summary of full years of teaching

There were six teachers who had three years or less of full time teaching experience prior to the start of this study and this group of teachers could be referred to as beginning teachers. The remaining teachers had had eight or more years of experience and could be referred to as experienced teachers. Some of these teachers had taken extensive family leave at some stage in their career but, except for one, had had more than five years teaching since returning from leave. The exception to the family leave is the teacher who had been teaching for ten years. She had taken just one year of family leave in the year prior to the study being undertaken and should still be considered as an experienced teacher. Several of the participants had recently had positions as library or subject specialists, but this should be relevant to any experience with working with young children whether it is mathematics or not. Table 5.2 records how the teachers are classified as either beginning or experienced teachers.

	3Cs participants			
Experienced teachers	Karen	Gail	Nora	Malcolm
	Teresa	Dianna	Kaye	Bianca
	Helen	Gerry	Neva	
Beginning teachers	Deidre	Tasha	Olivia	Trevor
	Megan	Sally		

Table 5.2: List of *3Cs* participants classified as either beginning or experienced teachers

Mathematics experience

(Fennema & Franke, 1992) considers that beliefs in the nature of mathematics are initially derived from school experiences. Both beginning and experienced teachers base their beliefs on the nature of mathematics on their past school experiences, but the more experienced teachers also have a wealth of other experiences to inform such beliefs (Fennema & Franke, 1992). This is an important consideration because beliefs in the nature of mathematics also generate the classroom approach that is likely to be taken by a teacher. The teacher that has a problem-solving view of mathematics is more likely to act as a facilitator of learning rather than act as instructor or explainer (Ernest, 1989). Therefore the extent or depth of teacher content knowledge in mathematics (ie mathematics experience) is closely related to teaching style and thus a measure of teacher content knowledge could be useful in the classification of the teachers in this study.

The most obvious measure of mathematics experience would probably be to consider each participant's academic mathematics background. For example, whether the teacher took mathematics through to year 10 or year 12 of secondary school or whether any tertiary mathematics has been undertaken. However, it is going to be difficult to equate the academic mathematics experience pertaining to specific teachers to what this experience really means in terms of their beliefs on the nature of mathematics. For example, taking mathematics through to Year 12 does not necessarily mean that you have an instrumental, Platonist or a problem-solving view of mathematics. Each individual's primary and secondary experiences would be different and would also be dependent on the varying views of mathematics and mathematics teaching held by their respective teachers.

Such a measure could be quite problematic in other ways. Many of the participants took mathematics through to year 12 of their secondary schooling but for some this was twenty years ago. Other participants could not remember at what year level they finished taking secondary school mathematics or whether they had completed any mathematics discipline studies in their teaching qualification. At least three participants had completed their teacher training as mature-aged students and had previously worked as accountant, bank teller, and baker. How could this real-world experience in mathematics be included as a measure of mathematics background? It would appear that a measure involving mathematics experience is too problematic to be included in any reasonable manner in which to classify the participating teachers.

However, the range of mathematics experiences should be noted. The teachers' interviews reveal that at least four took mathematics through to Year 12, three to Year 11 and one to Year 10. Only one of the teachers mentioned that they completed a mathematics discipline major in their teacher training. For those that had updated their initial teacher training with further study only two indicated that they had completed any studies in either mathematics and/or mathematics education. One teacher had completed a Bachelor of Science degree with a major in mathematics and another teacher was currently undertaking a Graduate Diploma in Mathematics Education.

Professional development experience

Numbers of teachers mentioning either specific programs or one--off sessions are listed in Table 5.3. Other professional development experiences that were mentioned included attending the Annual Conference of the Mathematical Association of Victoria (MAV), FAMPA (Family Maths) Training, and Families Count. The two teachers from Wattlebird Rise Primary School had obtained a grant from the MAV that gave them teacher release time for curriculum development and to work with a mentor. The six teachers from Honeyeater Hills Primary School had all been involved in a series of school-based professional development sessions that had as its focus the *Mathematics Frameworks* (Ministry of Education, Victoria, 1988). One of the teachers from Wattlebird Rise Primary School had been a workshop presenter for a series of mathematics sessions for the parents at her school.

EMIC	Continuing Maths	Maths Making Links	Maths in Schools	One-off sessions
5	1	4	2	9

Table 5.3: Numbers of teachers reporting their participation in specific professional development programs

Making comparison between the teachers in the study based on a measure of professional development experience is problematic for a number of reasons. The open-ended structure of the interviews meant that participants only raised the professional development activities that they could remember unless prompted. So the professional development record for each individual teacher may not be complete. Professional development experiences in areas other than mathematics, such as language, information technology, and behaviour modification were also mentioned and should possibly be included as part of a total experience. It would be expected that all professional development activity would probably have considered pedagogical issues transferable to mathematics teaching. The quality of each professional development activity would vary. How could participation in EMIC for example, be matched to attending a one-off session? Individual teacher effort and input into professional development activities would also vary and a measure of this should not be gained from only knowing that they attended. Thus because of the way the information was gained for this study and for other factors the development of a measure of experience in mathematics professional development is problematic and needs to be dismissed as a way for categorisation of the teachers participating in this study.

It would be expected that the number of years of teaching experience would positively correspond to the amount of professional development attended. The teacher that was in their first full time year as a classroom teacher, i.e. about two months worth, had not yet attended any professional development activity other than those included in the weekly staff meeting. This compares to one of the longer serving teachers who had participated in *EMIC* and several MAV Annual Conferences as well as being the co-ordinator for the Maths in Schools Program at her school over a two-year period. The years of teaching measure is generally a measure of the amount of professional development involvement.

In conclusion

Of the three aspects considered for experience, the only viable classifier seems to be that of years of teaching. Both the mathematics experience and the professional development aspects appear to be too problematic to develop any meaningful measure in which to gauge differences between the teachers. The two 'years of teaching' groups - beginning and experienced teachers - listed in Table 5.1 will be used later in this chapter and matched to the groupings to be developed in the other dimension based on teaching style.

DIMENSION TWO: TEACHING STYLE

This dimension is to be considered in two ways: one using the SCAN data and the other relying on the transcripts of observed lessons. Both ways will develop classification instruments that will be used to categorise the teachers as either instrumental or relational in their teaching style. Some of this discussion has been reported in a symposium paper (Smith, 1998).

SCAN and teaching style

SCAN results and limitations

The Systematic Classroom Analysis Notation (SCAN) developed by (Beeby, Burkhardt & Fraser, 1980) which was discussed in Chapter 4 was used to code events during classroom observations. These codes recorded what the teacher did: classroom events such as giving instrumental explanations, observing, or confirming what a pupil had said. Table 5.4 lists the coding for particular classroom events and also includes the overall data for this study. The content of the two observed lessons following the completion of the professional development was, for most teachers, generally based on activities and/or strategies from the professional development sessions and thus not a reliable record of their usual practice. Therefore the data presented in Table 5.4 relates to the two observed lessons for each teacher prior to the professional development taking place (for Nora, because of the nature of the first observed lesson only one coded session is available). The range, mean and median for each event are expressed as a percentage of the total events for an individual teacher (to the nearest whole number for range and median, and to one decimal place for mean). Some additional data for groups of events are included as they will be referred to in later analysis.

CODE	EXPLANATION	Minimum	Maximum	Mean	Median
er	explaining, relational	0	12	4.7	4
ei	explaining, instrumental	2	16	8.9	9
ef	explaining, facts	0	1	0.1	0
eg	explaining, general	0	9	3.9	3
x	explaining, by using an example	0	1	0.3	0
(er + x)		0	12	5.0	4
(er + ei + ef + eg + x)		9	27	17.4	17
qs	asking a question only requiring simple recall	6	30	17.0	18
q+	asking a question requiring more than simple recall	4	36	21.5	23
(qs + q+)		24	60	38.5	36
i	instructing	1	22	10.7	9
wtr	wait time, reasonable	0	8	2.9	2
wt+	wait time, extended	0	4	0.8	1
(wtr + wt+)		0	10	3.8	3
m	managing	1	13	5.6	4
d	disciplining	0	9	4.9	5
(m + d)		2	21	10.5	8
o	observing	0	6	0.8	0
c	correcting	0	5	0.8	1
con	confirming or repeating what a child had said	4	23	11.4	11
p	giving praise	0	10	4.6	4

Table 5.4: SCAN coding for classroom events

As can be seen in table 5.4 the range in data for total questions varies from a teacher whose questioning events (qs + q+) were 24% of all classroom events through to a teacher whose questioning events were 60% of their total events. Such high percentages were quite unexpected, but they parallel the findings made by Sullivan (1989-A). A wide percentage range for questioning events may prove useful in distinguishing groups of teachers. This also applies to explaining events where the range is 18% and to confirming events where the range is 19%. The high percentage of confirming events was also unexpected. The inclusion of the coding of confirming events was a modification of the version of SCAN used by Sullivan, so no comparison can be made to his study. Where the percentage range is small such as with observing and correcting it may be more difficult to distinguish any differences in teacher style. For some events where the range might be reasonable, such as with wait time or giving praise, the majority of teachers are bunched together with very low percentages and this lack of separation also makes it difficult to distinguish varying teacher styles. In fact, the coding of wait time and observing events proved to be quite difficult to do. During the piloting of SCAN it seemed useful, appropriate and manageable to include both of these events for coding. However, as it eventuated it proved difficult to code a silence! Was the teacher really giving wait time? Was the teacher really observing the class with any real purpose? Only the teacher can answer these. Instructing events have a wide range in the overall data (1-22%). During the coding and reflecting on the types of statements that were coded as instructing events it became clear that there were at least two very different reasons for giving instructions. (Sullivan, 1989-A) classes instructing as a similar event to questioning because he claimed that in the educational context they produced the same outcome, that is, pupils acting or responding in a cognitive way. In this study it was observed that some teachers used instructing in a step-by-step fashion to keep the class together and avoid management problems. This style of instructing did little to engage the pupils in any active thought. On the other hand there were teachers who used instructing more in the way suggested by Sullivan. The SCAN results do not distinguish between these two styles in instructing and thus the use of instructing percentages may shed little light on classification of teacher style.

SCAN data for individual teachers suggests that lesson content appears to impact on the teaching approach that might be taken. For example, Tasha had 27 events recorded in the first observation compared to 121 events recorded for the second observation. Although some of the events are represented in similar proportions (19% and 22% for instructing) some events have very differing proportions (7% and 22% for asking questions requiring simple recall). In Tasha's lesson 1, which was part of an integrated unit on media, Tasha set the class the task of cutting out of a newspaper as many advertisements as they could find and then they were to sort and group their collection of advertisements in some way. Tasha established a working rule that children were only to come to her for assistance if they could not find an answer to their problem from others in the class. This meant that Tasha's role was as facilitator and there were very few upfront comments made. In fact she spent much of her time tidying up her own working space. In a later lesson the class discussed their groupings, but the researcher did not observe this. Lesson 2 involved paper-folding activities to investigate fractional relationships. Tasha took a very different role in this lesson by giving a large number of instructions and asking many questions.

A second example can be given to illustrate that lesson content may impact on type and proportions of particular events. In Deidre's lesson 1 the proportion of questions involving simple recall as opposed to questions needing more than just recall is reversed in lesson 2 (14% and 28% for questions needing simple recall; 24% and 11% for questions requiring more than simple recall). Lesson 1 also has far more 'confirming' events than lesson 2 (18% and 8%). Lesson 1 involved group work where Deidre worked with a small group on telling the time. In lesson 2 Deidre worked with a group of pupils who were unsure as to how to do the vertical set out for subtraction. She treated this in a very instrumental way asking quite straightforward questions and giving instrumental explanations as the lesson proceeded. Thus this contradiction with the proportion of question types may also be explained by the content of each lesson and the teaching approach taken.

However, there may also be explanations other than lesson content for differing SCAN results between two lessons. When a difference of 5% is noted between Karen's lesson 1 and lesson 2, there were less relational explanations given in lesson 2, and as well only half the proportion of questions requiring simple recall were asked, some wait time was used and twice the number of instructions were given. Lesson 1 involved the children locating themselves on a grid (like that of a street directory) set up in the classroom. Karen did this with just her own class, whereas lesson 2 was taken with a combined class of about 60 pupils. Lesson 2 involved finding a way to create a doubling pattern on a calculator. Thus, in lesson 2, when each pupil was trying out a suggested doubling method on their calculator, Karen attempted to keep the group together by giving step-by-step instructions. Lesson 2 was a revision lesson and it could be assumed that the basic doubling notions had already been covered previously, whereas the notions inherent in lesson 1 were 'new' to the pupils. This may be the reason as to why there were less relational explanations in lesson 2. As well, the open-ended way in which Karen approached lesson 1 meant that the incidents that occurred spontaneously required meaningful explanations to be given. As well the children's interest was much higher in lesson 1 probably because of the nature of the content and this may have meant that less questions only requiring simple recall were needed to keep the class on task. So the size of the group being taken and whether the content is revision or not may also have some bearing on the proportions of classroom events.

(Beeby, Burkhardt & Fraser, 1980) confirm these limitations and noted that SCAN results could vary depending on the content of the lesson as well as the age and ability of the pupils. Other limitations with the SCAN events coding could relate to the coder, the pupils, school organisation, or to extraneous events on the day. Limitations relating to the coder include being able to judge the ability of the pupils particularly with decisions on coding of questions, the ability of the researcher to record at the pace at which some lessons moved, the time spent by the coder with any particular teacher and the point of time of arrival or of leaving, assumptions made by the coder about the prior teaching and learning experiences of the pupils, and the impact that the presence of the coder has on the teacher. Limitations relating to the pupils could include the year level being observed or prior classroom approaches and their ability to be involved in discussion. School organisation limits to SCAN coding include the nature of school policy and its impact on teacher style, or the use of team planning where the observed teacher is implementing a session prepared by a colleague. Limitations caused by extraneous events could include teacher mood or well being on the day, the occurrence of special events such as a visit by the school doctor to give injections, and even 'everyday' occurrences such as a bird flying into the room.

For this study the number of lessons per participant is much lower than that for the teachers involved in Sullivan's study. Reliance on only two lessons places a limit on any judgements made from the events coding. In order to accommodate the various limitations referred to, the SCAN events data were used to develop a classification instrument, but another instrument has also been developed using lesson transcripts. For the SCAN instrument a number of indicators will be developed and their combined result will be used to form an 'instrumental-to-relational' continuum of the *3Cs* participants.

Linking SCAN and teaching style

The SCAN events data codes the up-front action being taken by the teacher, that is, what the teacher says to the class or to individual pupils (as well as a code for when the teacher observes the class while they are working). On the whole most of the SCAN events data relates to whole class instruction because whenever a teacher moved into working with a small group much of what was said was inaudible. This data is then quite relevant to the instrumental/relational dichotomies for 'the place of discussion and questioning' developed in Chapter 2. These dichotomies are reproduced in Table 5.5.

CLASSROOM PRACTICE		
	In regard to the place of classroom discussion teachers	
Classroom layout	• arrange pupil seating arrangements that are not conducive to pupil-pupil discussion	• allow flexible seating arrangements to match lesson intentions and planning
Handling pupil discussion	• in discussion judge whether the pupil's responses are worthy of consideration and impose own solution method	• facilitate a 'discourse community' where the children's ideas are accepted and built upon
Dialogue directions	• generally include teacher-pupil dialogue and not pupil-pupil dialogue	• include pupil-pupil interactions and teacher-pupil interactions
Questioning approach	• use questioning to ascertain whether pupils understand the procedure that they have presented	• listen to the ideas that children have and then use questioning techniques that allow children to further develop their thoughts by asking why- and how-type questions
Type of questioning	• use questioning that does not allow for open-ended responses	• use questioning techniques that allow for opened-ended situations
Giving explanations	• sole giver of explanations / rule bound explanations that lack contexts	• both pupils and teacher involved in giving explanations / meaningfully covered using contexts such as real world applications, illustration and manipulatives

Table 5.5: Comparison between beliefs about classroom practice – in regard to the place of discussion (copy of Table 2.8, page 36)

The SCAN events directly relate to the dichotomies of 'Explanations' (er, ei, ef, eg & x) and 'Type of questioning' (qs & q+). Other SCAN events (con; m & d) indirectly relate to several of the dichotomies. As well the SCAN recording sheet included notation for whether the classroom dialogue was either teacher-pupil or pupil-pupil. Sketch plans of classrooms were also made. A SCAN classification instrument based on the connections or implications of the dichotomies and SCAN coding will be devised. This instrument is a compilation of seven indicators.

SCAN analysis

Explaining events

It would be expected that a 'relational teacher' should be explaining both how (ei) and why (er and x) whereas a teacher whose classroom practice is instrumental is more likely to only give instrumental explanations (ei). One measure that uses explaining events could be a ranking of the teacher's ability to be able to give er-type explanations (er + x). Thus ordering the percentages (TEr) for such explanations could be used. If a 'relational teacher' is defined as being equal to or above the median for (er + x) of 4 and an 'instrumental teacher' defined as being below the median of 4 then Table 5.6 lists the resulting division.

Instrumental ('er + x' explanations for less than 4% of total events)	Relational ('er + x' explanations equal to or more than 4% of total events)
Olivia (0)	Neva (4)
Sally (1)	Nora (4)
Bianca (2)	Karen (4)
Dianna (2)	Teresa (4)
Trevor (3)	Kaye (4)
	Deidre (5)
	Megan (6)
	Tasha (7)
	Malcolm (8)
	Helen (9)
	Gerry (10)
	Gail (12)

Table 5.6: Division of the sample into relational or instrumental based upon total percentage of 'er + x'-type explanations (TEr) given

(NOTE: Even though the median was used as a mechanism to divide the group of teachers into approximately equal groups, this has not happened in this case as there were five teachers scoring the median. Taking those equal to the median to be relational has been consistent practice throughout the development of the SCAN instrument)

The five teachers that gave 4% of 'er + x'-type explanations (of total events) all had varying levels of both total explanations and instrumental explanations. For example, 40% of Teresa's total explanations were coded as relational compared to 17% for Nora. Although each teacher was capable of giving relational explanations the proportion of relational explanations out of total explanations varies widely. Thus the balance of instrumental and relational explanations needs to be further explored. This balance or quality of explanation (QE), the ratio $^{[er\,+\,x]}/_{ei}$ results in the listing in Table 5.7 where the instrumental teacher is defined as having a ratio of less than one and the relational teacher a ratio of more than one (ratios are rounded to the first decimal place).

Instrumental ($^{[er + x]}/_{ei}$ ratio less than 1)	Relational ($^{[er + x]}/_{ei}$ ratio greater than 1)
Olivia (0.0)	Gerry (1.1)
Sally (0.1)	Tasha (1.2)
Trevor (0.2)	Neva (1.3)
Nora (0.3)	Teresa (1.3)
Dianna (0.3)	Helen (1.8)
Deidre (0.3)	Gail (6.0)
Bianca (0.3)	
Megan (0.4)	
Karen (0.4)	
Malcolm (0.7)	
Kaye (0.8)	

Table 5.7: Instrumental/relational listing of teachers based on QE

These two indicators (TEr & QE) divide the group of teachers between instrumental and relational teaching styles in quite different proportions. With TEr, just over 70% of the teachers were classified as relational, whereas with QE only 35% of the teachers were classified as relational. The actual ordering of the teachers is also very different. Gerry, who was the second highest TEr scorer for having a relational style, has only a marginal QE score which places him in the relational category. Malcolm and Megan who both had reasonably strong TEr relational scores are quite clearly in the instrumental category using QE. Because the giving of explanations is extremely important in making decisions about a teacher's classroom approach it seems appropriate to have two different indicators based on explanations, especially when they have discriminated between the teachers in varying ways. However, neither of these indicators (TEr & QE) take into account how the explanations arose or where they fitted into the sequence of classroom discussion. Nor do these indicators consider the relational notion of teacher encouragement for pupils giving explanations. This will be addressed in the alternative instrument based on lesson transcripts.

Questioning events

Teachers asking q+ type questions are clearly relational in their classroom approach because these are the types of questions that encourage children to develop or construct their own thinking. All teachers in the study were capable of asking q+ questions, but some were more capable than others. So if the teachers are arranged in order of their ability to include q+ questions in their classroom practice a ranking is established which may indicate an instrumental/relational distinction. Thus from such a ranking the teachers can be divided into two groups based around the median - those equal to or above the median to be 'relational' and those below the median to be 'instrumental'. The two groups of teachers resulting from this division based on the criteria of percentage of events that were q+ questions (TQ+) are listed in table 5.8.

Instrumental (q+ questions for less than 23% of total events)	Relational (q+ questions equal to or more than 23% of total events)
Sally (4)	Kaye (23)
Olivia (6)	Gerry (23)
Trevor (14)	Gail (23)
Karen (15)	Tasha (26)
Malcolm (15)	Nora (27)
Deidre (18)	Teresa (30)
Dianna (19)	Megan (30)
	Helen (30)
	Neva (34)
	Bianca (36)

Table 5.8: Division of the teachers into relational or instrumental based upon total percentage of q+ questions (TQ+) asked

Table 5.8 notes that all teachers were able to ask questions that required more than just simple recall and they are divided into two groups based on their apparent ability to do this. However, a further measure, as for explanations, needs to be considered. Table 5.8 lists Tasha and Nora as virtually having the same percentage of q+ questions. However, when their total questioning approach is considered Nora asked q+ questions on a basis of more than four to one compared to qs questions whereas Tasha's balance of q+ and qs questions is close to fifty-fifty. Thus the study includes two teachers that had virtually the same percentage of q+ questions but the proportion of q+ questions to qs questions varies enormously. Considering a ratio of q+ questions to qs questions ($^{q+}/_{qs}$) might provide a further useful indicator based on question quality (QQ). A 'relational teacher' is defined as asking a greater proportion of q+ questions and an 'instrumental teacher' is defined as asking a lower proportion of q+ questions. Table 5.9 classifies all teachers using the q+/qs ratio (ratios rounded to the first decimal place).

Instrumental ($^{q+}/_{qs}$ ratio less than 1)	Relational ($^{q+}/_{qs}$ ratio greater than 1)
Sally (0.2)	Dianna (1.1)
Olivia (0.2)	Gerry (1.2)
Karen (0.8)	Tasha (1.3)
Trevor (0.8)	Neva (1.3)
Deidre (0.9)	Megan (1.6)
	Malcolm (1.7)
	Bianca (1.9)
	Kaye (1.9)
	Helen (2.1)
	Teresa (2.5)
	Gail (3.3)
	Nora (4.5)

Table 5.9: Instrumental/relational listing of teachers based on QQ

Like the two indicators for explanations, TQ+ and QQ have also resulted in differing instrumental/relational lists for the same group of teachers. As with explaining, the asking of questions is also a crucial factor in categorising teachers as either instrumental or relational and the use of two differing indicators would appear to be appropriate. However, the SCAN coding does not deal with the way in which questioning was used to develop pupil discussion. This aspect will be considered in the instrument based on using transcripts of lessons.

Management and discipline events

Management and discipline events relate to classroom organisation and control and in several instances seriously impacted on the outcomes for the particular lesson being observed. Sullivan (1989-A) also noted that management and discipline events compromised the flow of lessons.

> It was a pleasant experience to observe and code the lessons with very low proportions of discipline and management statements. These student teachers seemed able to pursue the objectives of the lesson freely. It was much less comfortable to observe the lessons where up to one third of all events, and an even greater amount of time, were related to management and discipline. (Sullivan, 1989-A, page 202).

Hill (1994) suggests that an instrumental teaching style requires external reinforcement for its maintenance and hence could be characterised by more management and discipline events than the usual norm. This contrasts to the relational style where encouragement is required but learning is basically naturally driven. This possibly suggests that discipline and management statements are more likely to be used by the teacher with an instrumental approach. Thus the teachers could be categorised into two groups based on their percentage of management and discipline events - those above the median to be 'instrumental' and those equal to or below the median to be 'relational'. This categorisation (M/D) appears in Table 5.10.

Instrumental (management and discipline events more than 8% of total events)	Relational (management and discipline events equal to or less than 8% of total events)
Teresa (21)	Deidre (8)
Sally (20)	Gerry (8)
Dianna (19)	Megan (8)
Karen (17)	Nora (7)
Kaye (14)	Helen (7)
Trevor (13)	Bianca (5)
Malcolm (11)	Olivia (4)
Gail (10)	Neva (4)
	Tasha (2)

Table 5.10: Division of the sample into relational or instrumental based upon total percentage of M/D

Confirming events

The 'con' (confirming or repeating what a child said) event is an important factor in 'Dialogue direction'. A teacher who wants to maintain a dialogue direction that is predominantly teacher-pupil will repeat what pupils say which means that pupils have no need to listen to each other as they have come to realise that the teacher says everything anyway. The teacher who wants to encourage pupil-pupil dialogue must also encourage the pupils to listen to each other. This also relates to the 'Handling pupil discussion' dimension where the relational teacher facilitates a 'discourse community'. The wide range and high percentages for some teachers was most unexpected. If the teachers with a percentage lower than or equal to the median are classified as relational and those with a percentage higher than the median are classified as instrumental the lists in Table 5.11 result. The criteria for this categorisation is based on percentage of confirming events (CF).

Instrumental (confirming events more than 11% of total events)	Relational (confirming events equal to or less than 11% of total events)
Gerry (23)	Kaye (11)
Helen (16)	Teresa (11)
Malcolm (16)	Bianca (10)
Neva (14)	Megan (9)
Deidre (14)	Tasha (9)
Nora (13)	Gail (9)
Sally (12)	Dianna (7)
Karen (12)	Trevor (7)
	Olivia (4)

Table 5.11: Division of the sample into relational or instrumental based upon total percentage of confirming events (CF)

Classroom layout and teacher provision for pupil-pupil discussion

Although not recorded as a SCAN event, the researcher made sketches of each teacher's classroom layout. Some classrooms had seating arranged in rows facing the front of the room which is not overly conducive to pupil-pupil interaction. Other teachers had arranged the furniture so that pupils worked in small groups around several tables pushed together. This arrangement is far more suitable for encouraging the use of pupil-pupil discussion. The first-described arrangement will be referred to as 'instrumental' and the second arrangement as 'relational'. The data for this indicator (CL) is recorded in Table 5.12. However, having a classroom layout appropriate for pupil-pupil discussion does not necessarily mean that this form of discussion occurs, so an additional component needs to be explored. As well, Classroom Layout by itself has not proved to be a distinguishing feature as 14 out of the 17 teachers rated as relational on this indicator. For observation 1 (Obs1) and observation 2 (Obs2) a classification has been made on the basis of the organisational structure provided by the teacher as to whether pupil-pupil discussion had been planned or took place. An activity that had pupils playing a game with each other where discussion about the game was encouraged, a problem-solving task collaboratively tackled by two or more pupils, and a situation where other pupils were actively encouraged by the teacher to assist those experiencing difficulties are examples that would be counted as lessons involving pupil-pupil discussion. Where this occurs the lesson will be described as relational (R), where it does not occur the lesson will be described as instrumental (I). The criteria of pupil-pupil discussion (P-P) for observations 1 and 2 are listed in Table 5.12. The final P-P indicator for inclusion in Table 5.12 is then an amalgamation of the three components - CL, P-P Obs1, and P-P Obs2.

	CL	P-P Obs1	P-P Obs2	P-P Indicator
Bianca	R	I	R	R
Deidre	R	I	I	I
Dianna	R	R	R	R
Gail	R	R	I	R
Gerry	I	I	R	I
Helen	I	R	I	I
Karen	R	I	R	R
Kaye	I	R	I	I
Malcolm	R	I	R	R
Megan	R	I	I	I
Neva	R	I	I	I
Nora	R	I	I	I
Olivia	R	R	I	R
Sally	R	R	R	R
Tasha	R	R	R	R
Teresa	R	R	R	R
Trevor	I	I	I	I

Table 5.12: Amalgamation of results for CL and P-P Obs1&2 to produce a P-P indicator

Compilation of the seven indicators

Table 5.13 takes the seven indicators devised for the SCAN instrument and summarises the findings. The findings for each teacher are then tallied and presented as a score or ratio (I/R). The teachers are listed, from top down, in the order of their scores from most instrumental through to most relational.

	Indicators	TQ+	QQ	TEr	QE	CF	M/D	P-P	I/R
Trevor		I	I	I	I	R	I	I	6/1
Sally		I	I	I	I	I	I	R	6/1
Deidre		I	I	R	I	I	R	I	5/2
Karen		I	I	R	I	I	I	R	5/2
Olivia		I	I	I	I	R	R	R	4/3
Dianna		I	R	I	I	R	I	R	4/3
Malcolm		I	R	R	I	I	I	R	4/3
Nora		R	R	R	I	I	R	I	3/4
Kaye		R	R	R	I	R	I	I	3/4
Gerry		R	R	R	R	I	R	I	2/5
Bianca		R	R	I	I	R	R	R	2/5
Megan		R	R	R	I	R	R	I	2/5
Neva		R	R	R	R	I	R	I	2/5
Helen		R	R	R	R	I	R	I	2/5
Teresa		R	R	R	R	R	I	R	1/6
Gail		R	R	R	R	R	I	R	1/6
Tasha		R	R	R	R	R	R	R	0/7

Table 5.13: Summary of participant's indicators
(KEY: I = instrumental; R = relational)

This SCAN analysis can be used to order the participants along a continuum. Table 5.14 displays the ordering of the teachers from instrumental through to relational.

I							R
7/0	6/1	5/2	4/3	3/4	2/5	1/6	0/7
	Sally	Deidre	Malcolm	Nora	Gerry	Teresa	Tasha
	Trevor	Karen	Dianna	Kaye	Megan	Gail	
			Olivia		Neva		
					Bianca		
					Helen		

Table 5.14: Continuum of teachers based upon their I/R score from the SCAN analysis
(KEY: I = instrumental; R = relational)

Lesson transcripts and teaching style

Using transcripts

Beeby, Burkhardt & Fraser (1980) refer to the 'characteristic rhythms' of a teacher's style and suggest that there is evidence that teachers vary rarely alter their style. This is quite evident in the SCAN reports for this study. For example, a number of teachers had a classroom discussion style that could be generally labelled as 'question - pupil response - question - pupil response - question - .....'. However, it was observed that the nature of the discussion of some of these lessons where teachers exhibited similar lesson styles was quite different and that recourse to the transcripts of the lessons might reveal further insights into teaching styles. Percentages and proportions of questioning and explaining styles have been the basis for the SCAN analysis but the underlying intent of teacher questioning and explaining has not yet been considered. Analysis of this could be gained from a study of lesson transcripts.

For each teacher a lesson transcript of at least one pre-*3Cs* program is available and it was found that extracts could be taken from lesson transcripts that illustrate the typical approach by a specific teacher. Of course some of the limitations noted for the use of SCAN, such as lesson content, may apply equally to any analysis using lesson transcripts. In order to develop a classification based on discussion structure noted in lesson transcripts various extracts will be taken that typify some of the teachers. These will be analysed and the resulting generalisations used to classify the total group of teachers.

Discussion extracts

Discussion extract 1: Deidre

Deidre's discussion style was generally one of 'question - pupil response - question - pupil response - question - .....'. The extract taken from Deidre's second lesson and recorded in Table 5.15 typifies the approach that she took in much of her classroom discussion. In this lesson about half of the class who felt that they were unsure as to how to do the formal process for subtraction were seated on the carpet space in front of the blackboard. Manipulatives such as MAB blocks were not available. The 'confident' half of the class practised the process using a set of subtraction problems that were written up on the chalkboard. They worked quietly on these at their tables.

		SCAN coding
Deidre:	Now I want you to set them out like this. [Deidre wrote on the board a vertical format for 38 - 26] I've done it like this. It makes it easy. You can see which column's in which.	e_i
	Sharryn what do I have to do first?	qs
Sharryn:	Take the 2 away from the 3.	ch
Deidre:	Do I?	c
	If you're doing any sort of maths which column do you always start with, Trixie?	qs
Trixie:	Units.	ch
Deidre	Always start from the units column	con
	and work that way. If you go back from this way to that way ..... [pupil interjection] that's right you can't go carry.	e_i
	So what do I do first? [silence]	qs
	You had your hand up. I thought you must have known.	m
	What do I do?	qs
Pupil:	Take the 6 away from the 8.	ch
Deidre:	Take the 6 away from the 8.	con
	I don't take the 6 away from the 8. I take the bottom number from the top number.	e_i
	What's the answer, Tom?	qs
Tom:	Two.	ch

Table 5.15: Extract taken from transcript of Deidre's lesson 2

This discussion extract suggests that Deidre likes to have very tight control over the direction of classroom discussion. A strict teacher-pupil direction is maintained throughout by asking questions that need little more than simple recall along with explanations and corrections mainly given by Deidre. The discussion generated does follow on from the pupil's responses but is characterised by correcting what was said or by moving on to what Deidre saw as the next step in achieving a specific outcome. In fact the questions appear to be directed at specific pupils suggesting that a smooth lesson flow is important to Deidre. Pupil responses are dealt with rapidly in both positive and negative ways and Deidre quickly moves on to the next point that she wants to make. It suggests a step-by-step approach where the ultimate goal for Deidre is to ensure that the class could perform or repeat a particular routine following her explanation. There is no sense of pupils sharing possible methods or ideas with each other or being probed for further explanation. This approach would suggest that Deidre's teaching style is instrumental.

Discussion extract 2: Karen

The extract taken from Karen's first lesson and recorded in Table 5.16 typifies the approach that she took in much of her classroom discussion. Like Deidre's overall style, Karen's approach is also generally 'question - pupil response - question - pupil response - question - .....'. The class had considered describing where they were sitting in the room ("Next to the teacher", "At the top right corner of the room", "Close to the door"). Karen then set up a reference grid by placing numbers along one wall and letters along another wall so that they could be read like map references. The children were sharing their grid references when Karen picked up on an apparent contradiction.

		SCAN coding
Karen	Looking at Brendan and looking at Gerry is there anyone else who we think might be at number 13? Along the line of 13?	q+
Pupil	Yep Annie.	ch
Karen	Annie ..... and who else?	q+
Pupil	Jenny.	ch
Karen	What number did you say you were Jenny?	qs
Jenny	12	ch
Karen	12. OK we have a problem here. It looks like they're at the same number ..... Jenny said she was at ..... what number Jenny ..... 12 and Brendan and Jerry thought they were at 13. Why is that different?	con q+
Pupil	Jenny might have moved.	ch
Karen	She could have moved her chair a little bit. How could we be more accurate? How could we be exact? To know if she is exactly in the right spot.	con q+
Pupil	Get a big ruler.	ch
Karen	We could actually get ..... that's a very good idea ..... we could get a big ruler and rule lines ..... across the carpet ..... How else do you think we could do it? If we didn't rule it what else might we be able to do. Yes Roma?	con p con & er q+
Roma	Walk there.	ch
Karen	Walk there. Walk in a straight line. Anyone else? Any other ideas? Yes Annie?	con q+
Annie	Lie down.	ch

Table 5.16: Extract taken from transcript of Karen's lesson 2

Already noted is that Karen and Deidre had a very similar SCAN pattern (q - ch - q - ch - q ....) in their discussion style. As well the SCAN results for Deidre and Karen are very similar. It was noted in Table 5.8 that of total events Karen had 15% as 'q+ questions compared to Deidre's 18%, and both had a $^{q+}/_{qs}$ ratio of 0.8 (refer Table 5.9). This is almost where the similarity stops because analysis of the transcript gives a very different impression. Karen by picking up on the pupils' comments, found an incident on which to base some incidental teaching. The problem was introduced to the class through a series of q+ type questions, questions that were aimed at getting as many different solutions as possible. Karen took on board these varying solutions that she either elaborated on further or probed the pupil's ideas further with more questioning. The questions were directed at the whole class and not just specific pupils. This use of questioning where the pupil responses are sought and valued is close to the teaching approach that the teacher described by Wood, Cobb & Yackel (1991) was moving towards. Karen's use of questioning corresponds to the comparisons of teaching styles made by Ernest (1989) and by Kuhs and Ball's [cited in Thompson (1992)] where her style is more that of the facilitator. Karen's questioning and explaining style makes her very much a facilitator or instigator for the pupils to put forward or construct their own ideas. Karen's approach using this analysis is thus more in line with being relational.

Discussion extract 3: Teresa

The extract taken from Teresa's first lesson and recorded in Table 5.17 typifies the approach that she took in much of her classroom discussion. The SCAN coding for Teresa's approach indicates that she generally uses the same 'question - pupil response - question - pupil response - question - .....' pattern used by Deidre and Karen. However,just as Deidre's and Karen's approaches were found on further investigation to be different, so to is Teresa's approach. Teresa's lesson fitted into an integrated unit on leaves and seeds. The class had already collected various leaves during a walk on the previous day and Teresa had supplemented this collection with some that she had personally collected. She had also brought along a number of different seeds that had been purchased from the supermarket.

Teresa asks open-ended questions and directs these to the whole class, not to individual pupils. A range of responses is encouraged. Pupil's ideas are accepted, sometimes repeated or rephrased but the ideas are not further elaborated on by Teresa. Extension to the pupil's ideas are gained by further questioning of the class or of the pupil who supplied the idea. Explanations are only given by the pupils. Teresa's style is along relational lines.

		SCAN coding
Teresa	Listen.	m
	I also went and found lots more different types of leaves than you have around here.	eg
	What we're going to do today is to have a look at the seeds. Some people will be looking at leaves and some people will be looking at the seeds. And I want to see if you can sort them for me.	i
	What if you had some leaves .... Who's got some ideas as to how we might sort leaves?	q+
Pupil	[Put the same sort of leaves together]	ch
Teresa	The same sort of leaves together.	con
	What sort of things would make them the same?	q+
	How would they be the same?	q+
Pupil	[The same shape]	ch
Teresa	So leaves can have the same shape.	con
	Right, so you might put all the same ones in the same group ..... the same sorts of leaves.	eg
	Who's got another idea?	q+
Pupil	[Put them together if they are the same kind and colour]	ch
Teresa	Kind and colour.	con
	What do you mean by kind of leaves?	q+
Pupil	[The shape and the colour]	ch
Teresa	So you're talking about the shape and the colour. Ohhh that could be very interesting.	con

Table 5.17: Extract taken from transcript of Teresa's lesson 1 (Note that pupil's responses were difficult to pick up on the audio-tape and may not be verbatim - hence they are placed in square brackets)

Discussion extract 4: Gerry

The extract taken from Gerry's first lesson and recorded in Table 5.18 typifies the approach that he took in much of his classroom discussion. The SCAN coding shows that Gerry began a discussion sequence with a question but that there were a number of pupil responses or interjections and teacher explanations before the next question was put to the class. Gerry's lesson was in preparation for an exercise in calculating various distances on a map where the class were considering the notion of scale. Gerry had drawn a rough sketch map on the chalkboard.

		SCAN coding
Gerry	Well what we're after is what the word scale means. When I say that it's either to scale or not to scale	q+
Pupil	It's a balance.	ch
Gerry	Yes we're balancing with scale.	er
Pupil	Measuring.	ch
Gerry	Measuring, right. When you actually look at a map. The map is not the same size as the actual area, is it? You're not going to have a map that's 32km thick otherwise it would take 32km to lay it out. We'd never be able to have a map like that and if we did it would be very difficult to follow. So we draw maps to scale. So for example. Yes.	con/p er
Pupil	It's smaller.	ch
Gerry	You make it smaller don't you. You make everything relatively the same but smaller. So we squash the map down. It's like putting it on a photocopier and you just make it smaller but much much smaller.	con er

Table 5.18: Extract taken from transcript of Gerry's lesson 1

Gerry's style allows for a flow of pupil comment and input that was initiated by his original question. This question was generally directed to the whole class. It is interesting to note that Gerry gained a number of pupil ideas without having to ask the question again. This gives an impression that the class discussion was more of a dialogue between Gerry and the class. Although Gerry does gain many ideas from the class and is very accepting of the ideas he then takes control of each one and gives further detailed explanation rather than encourage the pupils to give further elaboration. Gerry's approach is generally relational.

Discussion extract 5: Trevor

The extract taken from Trevor's second lesson and recorded in Table 5.19 typifies the approach that he took in much of his classroom discussion. The SCAN coding shows a pattern where lengthy explanations are given by the teacher and the questioning comes at the end of these explanations. This lesson was part of a series of lessons that Trevor had been giving on transformations.

		SCAN coding
Trevor	I need to explain what you are going to do first and then you can start on it straight away.	m
	So Len and Mike pay attention thanks.	d
	Today we are going on with some more transformation type stuff and it's actually a different name and we're looking at things that ..... the exact shape of them. And that's got a special name. It's called congruent shapes. And we use that name and I'll give you some worksheets to do with that. You have to remember that a congruent shape is a shape that is still exactly the same size. Same shape no matter what you do with it. OK you can turn it around, flip it over or slide it along and it still stays the same.	ei
	So for example, I'll just use this shape up here. (Using a diamond cut from coloured paper). It could be any shape.	er
	So if I did a translation on it ..... which is what Haydn?	qs
Pupils	Slide it. (Haydn was meant to reply but a group of pupils called out the answer)	
Trevor	Slide it.	con
	So this is a translation. I could go across there and it's still the same. (Using the cut out shape)	er
	Shane, don't push your luck.	d
	Right. Even if I slide it downwards it still stays the same. Right.	er
	If I use the terms, flip, turn or slide and reflection, rotation or translation what would a flip be?	qs
	Hands up. Haydn again.	m
Haydn	If you move it.	
Trevor	What would a flip be? No.	c
	Is it a reflection or a rotation?	qs
Pupils	Reflection. (Directed at Haydn but others called it out)	
Trevor	OK. That's right. That's all you need to say. Right, a reflection is also a flip.	con
	So if I flip this over or I move it down there it stays the same. If I flip it over that way it stays the same. OK It's still a congruent shape. It stays exactly the same no matter what I do with it.	ei
	Is there still anyone who doesn't understand what a congruent shape is? Right. Well we'll leave that one there. OK.	qs
	This [worksheet] is a double-sided piece of paper and the first side is easy. What you need to do up the top ..... you've got a lot of pear shapes, different shapes. When you get down to the second one you need to draw the congruent shapes so that they are the replica of these shapes.	m
	What's a congruent shape Sam?	qs
Sam	It stays the same.	

Table 5.19: Extract taken from transcript of Trevor's lesson 2

It is easy to see that Trevor dominates the time spent on classroom discussion with lengthy instrumental explanations. Questioning, using simple recall questions, is not used to gain ideas from the children but to assess whether they have understood what he has been explaining. Pupils are not asked for their own ideas or explanations. This discussion style clearly suggests that Trevor sees himself as the holder of knowledge that needs to be shared with the class. The explanations are directed at the completion of the worksheet rather than the children gaining any meaningful understanding of concepts that could be applied to other situations. There are a number of management and discipline comments spread through Trevor's discourse. Trevor's questions were often directed at Haydn possibly as a control mechanism as he was a fairly disruptive student. Trevor's classroom style is instrumental.

Discussion extract 6: Dianna

The extract taken from Dianna's first observed lesson and recorded in Table 5.20 typifies the approach that she took in much of her classroom discussion. The SCAN coding suggests a number of similarities between Dianna's approach and that of Trevor's. Firstly, questions generally come at the end of Dianna's explanations, and secondly these are the first two extracts where there have been a large number of management and discipline events.

Dianna's lesson had started off with a tables game which was followed by a game of Greedy Pig. Greedy Pig involves throwing a die, individual players keeping a tally and making a decision on when to withdraw from the game. If a 2 is rolled the game finishes and the player/s who quit the game just prior to the two being rolled become the winners. Dianna then wanted the pupils to work in pairs and to tally the number rolled each time for 100 rolls of a die. This task had been attempted before but the pupils had had difficulty knowing when to stop at 100 rolls of the die. The extract picks the lesson up at this point.

Dianna tends to give an explanation, usually of a general or instrumental nature, and then follows this up with a question. The questions asked are generally not aimed at getting the pupil's original thoughts but are used in a way to confirm what she has been explaining. She continues to ask a question until either she has gained the response she wanted or gives up and gives the answer or explanation herself. The questions are usually directed to specific pupils. She often does not appear to listen to what the pupils have said or misinterprets their response. If she does pick up on a pupil response she tends to repeat it and continue with her own explanation. There is no recourse to probing for further pupil explanation. At the end of this extract the question asked was either used to discipline a pupil or to assess whether s/he understood. This tactic was used from time to time throughout the two observed lessons. Like Trevor's style, Dianna's classroom approach is instrumental.

		SCAN coding
Dianna	What we're going to do now is put each other ..... go into pairs. We've done this before.	m
	We had a problem last time. Who had problems last time? We had a problem. One main problem that we did. We have to roll the dice 100 times. But what was the problem when we actually recorded this ..... when we actually wrote down our answers. There was one main problem that we all had. Yes Brian?	eg/q+
Various pupils	[How many times we rolled it]	ch+
Dianna	You mean when we played the game [of Greedy Pig]? At a guess 40. The first game we played had taken about 20 rolls before we got a 2 but last time was twice as long. ..... Now. Mitchell can you remember the problem	eg
	that we actually had?	q+
Mitchell	No.	ch
Dianna	No.	con
	Anyone? Do you remember the problem we had?	q+
Pupils	(many inaudible comments)	ch+
Dianna	The problem we had	-
	and we talked about this before Brendan	d
	When we record numbers	-
	Brendan stand up please. Sit down the front thanks.	d
	We've got ..... [drawing 4 tallies on board] how many do we have here Ricky?	qs
Ricky	Four.	ch
Dianna	Four.	con
	When we go to our fifth one instead of doing another line we cross this way.	ei
	Jamie why do we put the line across here?	qs/+
Jamie	So that it's easy to count.	ch
Dianna	So that it's easy to count.	con
	Boys and girls if you have to have 24 little lines	ei
	looking at me please	d
	it's a lot easier to put them into groups of 5 than putting lines everywhere. That takes far too long.	ei
	Just like the jelly bean jar. We had groups of 5 and we put them into groups	x
	and so Graham when you do this you put five little ..... four lines and one line through it to make a group of five.	d/ei
	Now the one problem that we had ..... the one problem we did have was we forgot how many times we rolled the dice.	eg
Pupil	We didn't.	ch

Dianna	You didn't but everyone else did.	c
	Everyone forgot to actually ..... because the person who throws the dice and you throw 2 you put a little line for 2 you throw a 4 you put a little line for 4. But this person also had to record every time they threw the dice. Because both of you have to be involved in actually recording the information.	eg
	Brendan stand up please. You can tell the class what I have just said.	d
	Stand up and turn around. It's very important. Now can you tell me what was the mistake last time?	qs

Table 5.20: Extract taken from transcript of Dianna's lesson 1

Instrumental/relational styles for using questioning and explaining

The analysis of lesson transcripts suggests a number of commonalities in the discussion approaches used by teachers. These commonalities are listed in Table 5.21 (page 139) with the relevant discussion extract/s being noted. The commonalities have been listed in order from most instrumental through to most relational and a comments section is included in the table. A code for each commonality is included.

If the group of teachers in the study are checked against the instrumental/relational uses of questioning and explaining then Table 5.22 results. If the commonality was not strongly noticeable but still evident it is indicated by using brackets. The table clearly shows a group of teachers that are instrumental - Dianna, Trevor, Deidre, Sally, Malcolm and Olivia. It also clearly delineates a group of teachers that are relational - Kaye, Tasha, Gerry, Teresa, Neva, Bianca, Helen and Karen. There are three teachers (shaded area) - Megan, Gail and Nora - where the analysis of the transcripts shows that they make use of both instrumental and relational approaches.

Seeing that each commonality can be considered to have a different weighting according to the continuum produced in Table 5.21 then the teachers can be placed in order from most relational through to most instrumental. For example, Dianna is the only teacher for which all of the instrumental commonalities are checked and she would, according to the analysis of the lesson transcripts, have to be the most instrumental teacher in this group. Likewise, Helen and Karen both exhibited all the relational commonalities in the analysis of their lesson transcripts and would thus be considered the most relational. These are the two most obvious conclusions.

	Commonality	Evidence	Comments	Code
I	Pupil's ideas not sought or when given they are not taken on board as part of the discussion	Trevor Dianna	This implies that the teacher sees themselves as the holder of all knowledge. For a relational approach to occur the teacher needs to find out what the pupils already know to be able to build upon their existing knowledge and to include their ideas in the discussion.	PIN
	The teacher is mainly the provider of explanations	Trevor Dianna Deidre	This follows on from 'PIN'. It is included as a separate category because it is possible to gain minimal input by questioning the class but still be the main provider of explanations.	ESP
	Questioning often used to ascertain pupil comprehension of teacher explanation	Trevor Dianna Deidre	This use of questioning appears to be associated more with the completion of a task or worksheet rather than aimed at any meaningful understanding. It also seems to be associated with management and discipline events and thus used to maintain lesson flow.	QPU
	Questioning and responsiveness to pupil comments used in a limited way with the main objective being to reach a specific outcome or agenda	Dianna Deidre	Limited questioning is associated with only wanting one response rather than a range of ideas. Teachers using this approach only deal with what they see as the one correct response. The main objective for these teachers is for their class to be able to complete a task or to perform some set of rules or procedures.	QEL
	Mainly addresses questions to particular pupils	Dianna Trevor Deidre	There are situations where both instrumental and relational teachers would use this approach but if it is used as the dominant approach it suggests that maintaining a smooth lesson flow is more important than gaining a range of ideas. Maintaining a smooth lesson flow can be achieved by directing questions to the pupils who you know are more likely to have the correct response.	QPP
	Mainly addresses questions to the whole class	Gerry Teresa Karen	This is the corollary of 'QPP'. Teachers wanting to obtain as many ideas as possible from the class are more likely to include the whole class in their questioning and discussion.	QWC
	Teacher uses questioning to seek pupil's ideas	Gerry Teresa Karen	Although this is the corollary to 'PIN' it is not placed at the most relational part of this continuum as it then depends on how the teacher follows up the responses.	PIS
	Questioning is used to gain a range of responses	Gerry Teresa Karen	This follows on from both 'QWC' and 'PIS' where the teacher does actually encourage and accept a range of responses.	QRR
	Teacher accepts pupil's ideas and builds upon them with further explanation	Gerry Karen	This follows on from 'PIS' where the teacher is accepting of the ideas and suggestions given by the pupils and expands the ideas with their own explanation.	PIE
R	Teacher accepts pupil's ideas and probes the particular pupil or the class for further elaboration	Teresa Karen	This also follows on from 'PIS' where the teacher is accepting of the ideas from the pupils but rather than them becoming the explainer takes on a facilitating role to gain further comment from the class through follow-up questioning. This is seen as a more relational approach than 'PIE'.	PIQ

Table 5.21: I-R Continuum of discussion commonalities generated from analysis of classroom discussion extracts

However, the rest of the teachers can also be arranged in order. For example, Trevor did not exhibit the commonality 'QEL' and for Deidre the only missing commonality missing was 'PIN'. Since 'PIN' is considered to be more instrumental than 'QEL', Trevor is the most instrumental of the two. Table 5.22 thus shows that within the instrumental group of teachers Dianna and Olivia are the least representative of the group whereas Trevor, Deidre, Sally and Malcolm are the most representative.

For the relational group of teachers, Table 5.22 shows that Kaye and Tasha are at one extremity of this group and that Helen and Karen are at the other extremity. This leaves Gerry, Teresa, Neva and Bianca as the most representative of the relational teachers.

	I					R				
	PIN	ESP	QPU	QEL	QPP	QWC	PIS	QRR	PIE	PIQ
Dianna	•	•	•	•	•					
Trevor	•	•	•		•					
Deidre		•	•	•	•					
Sally		•	•	•	•		(•)			
Malcolm	(•)	•		•	(•)					
Olivia		(•)		•	•		(•)			
Megan				•		•	(•)			
Gail		(•)	(•)	(•)	•		•	•	•	
Nora		(•)		•		•	•	(•)	(•)	(•)
Kaye					•		•	•	•	
Tasha						•	•	•		(•)
Gerry						•	•	•	•	
Teresa						•	•	•		•
Neva						•	•	•		•
Bianca					(•)		•	•	•	•
Helen						•	•	•	•	•
Karen						•	•	•	•	•

Table 5.22: Summary of data based on transcripts analysis

The conclusions made from Table 5.22 can be used to group the teachers as either instrumental or relational in the use of questioning and explaining and Table 5.23 contains the resulting lists. The most representative instrumental and relational teachers are listed in bold.

Instrumental		Relational
Dianna	Megan	Kaye
Trevor	Gail	Tasha
Deidre	Nora	**Gerry**
Sally		**Teresa**
Malcolm		**Neva**
Olivia		**Bianca**
		Helen
		Karen

Table 5.23: Grouping of participants according to analysis of lesson transcripts

Combining the two analyses

When the two sets of analysis are combined the matrix in table 5.24 results.

		Transcript analysis		
		I		R
Most instrumental	7/0			
	6/1	Sally Trevor		
	5/2	Deidre		Karen
SCAN	4/3	Malcolm Dianna Olivia		
Analysis	3/4		Nora	Kaye
	2/5		Megan	Gerry Neva Bianca Helen
	1/6		Gail	Teresa
Most relational	0/7			Tasha

Table 5.24: Matrix showing the results of the two sets of analysis

(Key: I = instrumental; R = relational)

Combining of the sets of analysis - from SCAN and from lesson transcripts - clearly divides the group of teachers into three classifications. The result of both analyses indicates that there are a group of teachers who are essentially instrumental in their classroom practice - Sally, Trevor, Deidre, Malcolm, Dianna and Olivia. Secondly there are a group of teachers that were found to be relational as a result of both analyses - Kaye, Gerry, Helen, Neva, Bianca, Teresa and Tasha. For the third group - Karen, Nora, Megan and Gail - the analyses either showed a contradiction or a classification that was not clear.

SELECTING THE CASE STUDIES

The instrumental section of Table 5.24 is reproduced in Table 5.25 but with the extremes and the representative group from the transcripts analysis noted. The SCAN analysis scores of 7/0 and 4/3 are extremities for this analysis leaving the teachers scored as 6/1 or 5/2 as the most representative based on the SCAN analysis.

	Instrumental (Transcripts analysis)		
SCAN analysis	Extreme	Representative	Extreme
7/0			
6/1		Sally Trevor	
5/2		Deidre	
4/3	Dianna	Malcolm	Olivia

Table 5.25: Instrumental section of Table 5.24 showing extremities

Table 5.25 shows that Sally, Trevor and Deidre are representative using both analyses, that Malcolm is representative only using the Transcripts analysis, and that Dianna and Olivia are the least representative according to both analyses. Sally, Trevor and Deidre are all beginning teachers (refer to Table 5.2) so to be able to select one of this group as a case study a further criteria needs to be considered. Since attendance at the *3Cs* workshops was crucial to Interviews 3, 4 and 5 as well as trialling classroom activities presented in the workshops, attendance could be used for final selection. Sally attended four of the six workshops, Trevor attended three workshops, and Deidre attended the whole six workshops. Because Deidre attended all workshops she would be the most suitable beginning teacher for further study. Dianna and Malcolm are the only two experienced teachers in the instrumental group. Malcolm is more representative of the group than Dianna, so Malcolm would be the most suitable experienced teacher for further study.

By repeating this process for the relational section of Table 5.24 a further Table 5.26 shows the extremes and the representative group from the transcripts analysis noted. The SCAN analysis scores of 3/4 and 0/7 are extremities for this analysis leaving the teachers scored as 2/5 or 1/6 as the most representative based on the SCAN analysis.

	Relational (Transcripts analysis)		
SCAN analysis	Extreme	Representative	Extreme
3/4	Kaye		
2/5		Gerry Neva Bianca	Helen
1/6		Teresa	
0/7	Tasha		

Table 5.26: Relational section of Table 5.24 showing extremities

Table 5.26 shows that Gerry, Neva, Bianca and Teresa are representative using both analyses, that Helen is representative only using the SCAN analysis, and that Kaye and Tasha are the least representative according to both analyses. However, Tasha is the only beginning teacher in this group and for that reason will be studied further. Gerry, Neva, Bianca and Teresa, as the most representative of the relational teachers and all experienced need to be considered for case studies. Gerry and Teresa both attended six workshops, Bianca five, and Neva four. On the basis of attendance it would seem reasonable to exclude Neva and Bianca from the case study choice. Teresa has worked closely on several other projects with the researcher and it is possible that interviews with her may be influenced by this relationship. Thus for the experienced relational teacher case study Gerry will be chosen.

Of the remaining group of teachers - Karen, Nora, Megan and Gail - that did not solely belong to either the instrumental or relational group it has been decided not to make any further study of these teachers, but to concentrate on detailed analysis of those four teachers that can be clearly classified as either instrumental or as relational – refer to Table 5.27.

	Classification according to SCAN and transcripts analyses	
	Instrumental	Relational
Experienced Teachers	Malcolm	Gerry
Beginning Teachers	Deidre	Tasha

Table 5.27: Matrix showing profile of case study teachers

INSIGHTS AND SUMMARY

Insights: Instrumental and relational teachers

Table 2.8 in Chapter 2 (page 36) gives descriptors for both instrumental and relational approaches to classroom practice in regard to the place of discussion. Through the SCAN and Transcripts analyses some of these descriptors are strongly endorsed and further insights can be made. In his study of children's constructions of informal science conceptions Tytler (1998) developed a series of insights explaining his analysis of observations. He only included those insights that 'were demonstrably supported by a number of incidents' (Tytler, 1998, page 906). He was able to group like insights together to construct a set of principles concerning the nature of children's science conceptions. For each chapter that analyses the data for this study, insights that can be generally supported will be listed in the concluding section of those chapters. These insights will then be grouped and used to provide the starting points for general analysis discussion in Chapter 8.

Insight 5.1: Teachers do not fit into neat boxes

It is clear from the SCAN and Transcript analyses that each teacher's classroom practice is unique. For example, in comparing two of the 'relational' teachers – Gerry and Teresa. The following summary profiles could be developed for each of these teachers.

	TQ+	QQ	TEr	QE	CF	M/D	P-P	QWC	PIS	QRR	PIE	PIQ
Gerry	R	R	R	R	I	R	I	•	•	•	•	
Teresa	R	R	R	R	R	I	R	•	•	•		•

Table 5.28: Summary profiles for Gerry and Teresa – the first seven columns being SCAN analysis, the remaining columns being Transcript analysis

The SCAN analysis summary in Table 5.28 shows that Gerry and Teresa both display differing 'instrumental' characteristics. And the Transcript analysis shows that although three characteristics were the same Gerry gives explanations based on pupil's comments whereas Teresa further probes pupil's ideas. In fact of the seventeen teachers studied there are only two pairs of teachers that have the same overall SCAN analysis but the Transcript analysis for each of these pairs differs. Again there are two pairs of teachers that have the same Transcript analysis profile but their SCAN analysis differs.

Insight 5.2: Analysis of classroom discussion transcripts is an appropriate means for classifying teachers

With the combined use of the SCAN and Transcript analysis there is a good correlation of results – thirteen teachers out of seventeen having the same 'instrumental' or 'relational' classification from both of the analyses. The Transcript analysis has been the more definitive, with six teachers clearly described as 'instrumental' and eight teachers clearly described as 'relational', whereas only three teachers do not have a clear classification (refer to Table 5.22). On the other hand because the overall Scan analysis (refer to Table 5.14) has teachers clustered more towards the middle of the I/R continuum discernible differences are not as obvious. Detailed study of the lesson transcript can also be quite revealing. For example, Deidre and Karen had the same SCAN analysis result of 5/2 (I/R). They also had a very similar overall pattern in their SCAN coding but on further analysis using the commonalities established in Table 5.21 Deidre remained as 'instrumental' whereas Karen was noted as being the most 'relational' of all the teachers.

Insight 5.3: 'Instrumental' and 'relational' teachers can be distinguished in the way they perceive the role that pupils can play in the learning process

The descriptions of 'instrumental' and 'relational' teachers developed in Chapter 2 (see Table 2.8, page 36) stated that 'relational' teachers facilitated a discourse community and built upon the ideas given by pupils. This descriptor, from the Transcript analysis, seems to be more prominent than might have been expected. Karen was able to make use of a classroom incident and subsequent questioning and comment for enhancing pupil's understanding in some key mathematical concepts. The flow of Gerry's explanations appeared to be completely generated from the comments made by his pupils. This is in stark contrast to the 'instrumental' teachers who used pupil's comments in a very different way. Both Dianna and Trevor gave lengthy explanations with little or no input from pupils and then questioned in order to ascertain whether certain pupils had understood what they had been told. The relational teachers addressed their questioning to the whole class whereas the instrumental teachers specifically nominated particular children to answer their questions and was in large part a management mechanism.

Insight 5.4: 'Instrumental' and 'relational' teachers classroom practice indicates that they have different views on the purpose of learning mathematics

It was noted in Insight 5.3 that the direction of Karen's and Gerry's lessons resulted from classroom incidents or pupils comments. The learning that took place could be seen as an exploration of mathematics concepts collaboratively attempted between pupils and teacher. Whereas Dianna and Trevor saw themselves as the holders of knowledge and their objective was to impart this knowledge to their pupils. The 'relational' teachers saw the purpose of teaching mathematics as an opened-ended exploration of concepts whereas the 'instrumental' teachers saw the purpose of teaching mathematics as transmission of knowledge.

Insight 5.5: Perceived or actual 'Relational' beliefs on pedagogy may not necessarily translate into relational practice in teaching mathematics

It was interesting to note that the majority of teachers had classroom layouts that were conducive to pupil-pupil discussion, a 'relational' indicator of classroom practice. However,many of these teachers did not include in lesson planning opportunities for pupils to work in collaboration or to discuss their mathematics. Why did these teachers have 'relational' classroom layouts but not 'relational' practice in regard to pupil-pupil discussion? One scenario could be peer group pressure where the perception held by teachers is that having 'relational' classroom layouts is the norm and/or expectation. Because most teachers work in isolation the way they handle classroom discussion is not readily assessed by their peers but the seating arrangement in the classroom is easily observed. A second scenario is that teachers may have a 'relational' classroom layout for the teaching of other subject areas such as language or SOSE and actually put into place 'relational' classroom practice for these subjects but not for mathematics. Both of these scenarios suggest a mismatch between beliefs and practice. In the first scenario the teachers implement an easily observable innovative practice but cannot match this with the way they implement classroom discussion in mathematics, a more difficult task and less observable. In the second scenario the teachers have 'relational' beliefs on the role of the teacher and how children best learn in subjects other than mathematics.

Summary

Chapter 5 has established a process where the *3Cs: Chance, Constructivism & Collaboration* participants have been classified under the two dimensions of experience and teaching style. This has generated four groupings of teachers – experienced/instrumental, experienced/relational, beginning/instrumental, and beginning/relational. One teacher has been selected from each grouping as representative and will be further studied in Chapters 6 and 7. Chapter 6 will concentrate on description and analysis of each case study teacher's classroom practice and their beliefs making use of Insights 5.3, 5.4 and 5.5 as a basis for discussion. Chapter 7 will focus on each case study teacher's reaction to the *3Cs* content and their attitudes towards the features of effective professional development.

CHAPTER 6

CASE STUDIES – BELIEFS AND CLASSROOM PRACTICE

INTRODUCTION

This chapter presents the case studies of the four teachers selected at the conclusion of Chapter 5. These four teachers were seen as representative of the four distinct groups generated by analysis of classroom discussion and years of experience of teaching. The case studies will include a description of each teacher's classroom practice by referring to the two pre-*3Cs* classroom observations as well as interview comments, especially those comments related to lesson planning. Using Insights 5.3, 5.4 and 5.5 developed at the end of Chapter 5 as a focus for discussion each teacher's classroom practice will be further analysed in order to explore the beliefs they might hold along with any influences and constraints that come together to shape their classroom practice. Data taken mainly from the pre-*3Cs* interviews will be used for this discussion and analysis. From this discussion and anlaysis a profile for each teacher will be developed in order to establish a possible scenario that predicts each case study teacher's likely reaction to the *3Cs* content and to features of effective professional development. The predictions will be based on possible connections for where teacher beliefs and practice might give reason for their reaction to workshop content and their attitudes to features of professional development. In Chapter 7 these predictions will be compared to what actually occurred either at the *3Cs* workshops, in classroom trialling or comments made in the mid-*3Cs* and post-*3Cs* interviews. The purpose for doing this is to use the basis for each prediction as a starting point for analysis related to considering the research questions for this study.

The summary made of each teacher's beliefs and practice is completed in several ways. Initially the three sets of beliefs - the nature of mathematics, the role of the teacher in the classroom and about how children learn mathematics – are described. This text description is then summarised in a table that was developed in the Literature Review. Following this there is a scenario that explains the possible influences on each set of beliefs, the connections between each set of beliefs, and how they have then influenced classroom practice along with any constraints to practice. A diagram summarises these conclusions.

This analysis and construction of possible scenarios as explanation have led to further insights into differences between instrumental and relational notions about beliefs and classroom practice. These are briefly listed.

DEIDRE

Classroom practice

Deidre: Background and current situation

As noted in Chapter 5 Deidre was a beginning teacher. Her classroom was part of the main school building and housed a year 3/4 class of nearly thirty pupils. Three other teachers worked at the same year level as Deidre and they co-operated very closely as a supportive team especially in planning the weekly classroom activities (all took part in *3Cs*).

A large piece of netting was suspended from the ceiling of Deidre's classroom and hanging from this were pupil-constructed mobiles and cubes, teacher-prepared word lists, a story plan chart and a list of room rules. Many other charts were displayed on the classroom walls including graphing work completed by the class. A reading corner had been set up with library books on display and lounge chairs for the pupils. A trolley containing mathematics equipment such as Pattern Blocks and MAB materials was kept in a corner of the room. An area was set up to one side of the room with several computers. Returning to the room at the end of the year little had been changed.

The pupils' tables were pushed together so that there were four working groups and this layout was conducive for possible pupil interaction and discussion. The carpet space in front of the blackboard was large enough for all of the class to sit together and Deidre would sit on a lounge chair at one end of this space. During the observed lessons these 'working spaces' were used in a variety of ways: whole class discussion as well as teacher-directed small group instruction on the carpet space, pupils working individually at their tables and activity groups based at tables.

Deidre: Lesson planning

It appears that Deidre may probably draw classroom activities from a number of sources as during interview 1 she made reference to the *Course Advice* (Directorate of School Education, 1995), blackline masters, an in-service booklet on Chance, a set of books kept in the staffroom, as well as activities presented at Maths Making Links. She made use of a store of activities that she may have at her fingertips because she said:

> They're just things that must have come from somewhere originally but you just do them because you know you've got the resources. You've done them before because someone else has probably passed it onto you. (Interview 1)

Deidre justified her selection of activities for mathematics by claiming that:

> You'll decide what the kids really don't need ..... they need more of this ..... you'll make up your own sheets on what they need to do or you'll just sit down and talk about it [with the 3/4 teachers] ..... what you've done previously I guess and what the kids need. (Interview 1)

The 3/4 teachers had an overview of the year's mathematics instruction based on completing broad topics at certain times of the year.

> We do Nnumber all of the way through [the year]. We do Tools and Pprocedures all of the way through but the others we've picked up. First term we didn't have a focus, second term Mmeasurement and then Chance and then [in Term 4] we are doing mostly division and revision and weight and volume. (Interview 4)

They would take it in turns to prepare the week's mathematics tasks especially a set of small group work activities used on a rotation basis for one session (refer to observation 1 on this page). Deidre described one of the benefits of team planning.

> The activities you might teach in a different way but basically the kids are all covering the same stuff. (Interview 1)

Deidre: Observation one

The first observed lesson involved the pupils working in five groups with five or six in each group. The five activities had been prepared by one of the other teachers in the year 3/4 team. At the start of the session there were many management statements and sticky orange dots placed on a chart were used to reward the best working group. One group played a game that involved subtracting the total of two rolled dice away from a starting point of 99 with the winner being the first player to reach zero. A calculator was available for checking answers and a parent helped this group. A second group completed a colouring-in sheet titled 'Chinese Puzzle'. The spaces with incorrect multiplication facts were to be coloured. A third group were given free choice with a variety of construction materials that were placed on the carpet space at the front of the room. The fourth group, either working in pairs or individually, had to roll a die fifty times and tally the numbers rolled and then show the results on a graph. Deidre asked if the die rollers would get the same result if they did it again and to write why/why not on the back of their sheet.

Deidre worked with the remaining group on the floor at the front of the room on telling the time on an analogue clockface. There was only one manipulable clockface available and Deidre used this most of the time. Several teacher-prepared worksheets were used and the times included were o'clock, half past, quarter to and quarter past. There was some oral work on counting by fives and connecting this to the numbers 1 to 12. Deidre stayed with this group the whole time. After about thirty minutes the pupils wrote their names on their worksheets and handed them to Deidre and they moved on to a new activity.

Deidre: Observation two

This lesson exemplifies what Deidre saw as her typical mathematics lesson.

> What I usually do is, because there's such a wide range of kids in here the ones that can do it or think they can they'll go off and have a go themselves at doing some addition practice or subtraction. I'll work with the ones on the floor that still want to do it. Then we try to get time, we don't always, to go through, correct it, see where they've got as a class and then I usually take their work home and have a look and see where they've made the mistakes if they've made mistakes. (Interview 1)

The second observed lesson started with all the pupils sitting on the carpet space at the front of the room. The lesson began with Deidre revising what the pupils could remember about subtraction from a previous lesson. At one point there was discussion about the notion of difference between and Deidre posed the problem of "What was the difference between Karyn's 20 and Benny's 10?" One pupil replied, "Ten because ten plus ten is 20." Deidre noted this but asked how else it could be done. A pupil came to the board and showed a vertical written method. Deidre praised this child and said:

> Excellent. Who thinks she's right? [Most hands went up] Who thinks she's wrong? [Some hands went up] ..... Actually she's right. If I want to work out the difference between the 20 Karyn had and the 10 Benny had that's how I'd write it. I'd say 20 take away 10 equals 10. Not only did she do it right she got the sum right.

Note that there is some mismatch now as to whether this problem is a 'difference between' or a 'take away' subtraction. Deidre did not ask the class for any other methods. The lesson continued with Deidre making the following comment:

> I don't like big numbers. I just like little numbers. One number at a time so I'm going to think of a way to work it out, set it out, so I only have to take away little numbers at a time. Big

> numbers are sometimes scary. People see big numbers and they think, "No can't do". And there's a really easy way that you can do it but you only take away little numbers.

A pupil worked this out on the board as a typical subtraction process with vertical setting out with Deidre pointing out such things as, "all I have to do now is one column at a time", "so you only had to take the three away from the six to start with" and "the biggest number goes on the top". Deidre had the class work through two more examples and stressed that they must start with the units column (refer to discussion extract 1 in Chapter 5). The children then used grid books and Deidre talked about setting out comparing it to when they had completed addition sums in this way. Those that felt comfortable with doing the 'take aways' returned to their tables to work out those written on the board. Those who weren't sure stayed with Deidre on the floor. About half worked at their tables and half worked with Deidre on the floor. The floor group were instructed in a very step-by-step manner, that is, "draw a line down four spaces, put one in the top corner, the first number is 27 so put the 2 under the T, ...". At some stage she noted that some children were ahead of her and congratulated them. There were no manipulative materials used in this lesson, although Deidre stated several times that there would be counters available to those that needed them.

Deidre: Summary and conclusion - Classroom practice

It appears that Deidre uses a number of resources and the ideas from her teaching team to prepare her lessons and may possibly rely on children's perceived needs rather than 'good activities' as a starting point. However, from the two observed lessons, her planning did not cater for individual differences, set a pace which did not allow for pupil reflection or time to assist those with lack of understanding, and seemed to be constrained by having pupils able to accomplish set tasks as the major goal.

To reach these major goals Deidre had a teaching style that was directive, relied on her explanations, and had pupils being taken through the lesson content in a step-by-step manner. Although Deidre spoke about pupils using manipulatives, their use was limited or did not eventuate. Those pupils that did not understand were given the same sort of explanations rather than alternative approaches.

The layout of Deidre's classroom suggests that she likes to have a flexible space for teaching although the P-P indicator from Table 5.13 shows that she did not make use of this arrangement for meaningful pupil-pupil discussion in the observed lessons. Most of the classroom dialogue was teacher-pupil with Deidre imposing her own methods. Both the SCAN and Transcript analyses (Tables 5.13 & 5.22) show that Deidre's approach to classroom discussion and questioning was most likely to be instrumental. Deidre used pupil comments from questions in a limited way with her ultimate goal being the overriding factor. She was the main provider of explanations with questions being mainly directed to individual pupils. Table 6.1 summarises Deidre's classroom practice.

		Instrumental	Relational	Contradictory Evidence	Lack of Evidence
	Lesson source		*		
	Individual differences	*			
Lesson	Innovation				*
Planning	External factors	*			
	Assessment				*
	Lesson pace	*			
	Lesson initiation		•		*
	Teaching style	*			
	Pupil mode	*			
	Deviation	•			*
Classroom	Manipulatives	*			
Implementation	Lack of understanding	*			
	Pupil working time	*			
	Struggling pupils				*
	Making connections	*			
	Classroom layout		*		
Discussion	Handling discussion	*			
and	Dialogue directions	*			
Questioning	Questioning approaches	*			
	Type of questioning	*			
	Explanations	*			

Table 6.1: Summary of classroom practice indicators for Deidre.

(* indicators readily noticeable; •possible indicator)

It is clear from Table 6.1 that Deidre's classroom practice is mainly instrumental, particularly in the 'Classroom Implementation' and 'Discussion and Questioning' sections.

Explaining classroom practice

Deidre: Perceptions of the role that pupils play in the learning process

From the observations it appeared that the pupils in Deidre's class were given little role to play in their learning. The group work in the first observed lesson did not have activities where pupils were encouraged to talk with each other about their mathematics. This group work arrangement was more for organisation and ensuring that the teacher had a small focus group for instruction while the other groups worked alone. In the second observed lesson some pupils worked alone. This was also most likely an organisational arrangement to allow Deidre to focus on the group of pupils that needed most assistance. Deidre commented during Interview 1 that her comments to children talking in class were focused more on management and on them being on task. The idea of using co-operative group work strategies were dismissed on organisational grounds rather than on anything linked to effective practice for pupil's learning.

> No I find [co-operative group work strategies] too structured. I have done it before. But on the whole it just seemed too structured, too organised, too contrived to do something ..... it just doesn't fit in with how I think about doing things. I've tried it and it just doesn't work for me. I mean I know they say that's the way your supposed to do things and that but no I don't. (Interview 1)

Deidre made a comment about the use of group work at *3Cs* and referred to the notion of 'comfort zone'.

> I mean some people aren't comfortable mixing with other people and that's personality. But you find it in kids. I think that is a human trait and I don't think it is something just to do with teachers. (Interview 5)

Perhaps this is a possible explanation for her not using collaborative strategies in her classroom.

The second observed lesson had the pupils working through a step-by-step process to complete subtraction problems where Deidre gave most of the explanations and missed many opportunities for building upon pupil misunderstandings or alternative ideas presented by the class.

However, when Deidre was asked which of the three major content areas from the *3Cs* program was fulfilling her most immediate professional need she selected the teaching strategies one on encouraging children to talk about their mathematics.

> I think that is the most important for the kids, encourage children to talk about how they learn things. ..... Because I think that's how children, most people, learn ..... is to talk about how

> they think about things. How they feel about things. How they worked it out. Strategies that they used. If you talked to one of them ,"How did you work that out?". The children that don't have those strategies then pick up on that. "Ohh, he did it like this, I'll try it like that next time". So, I think talk about all of your learning whether it's maths or anything else. It's really valuable. (Interview 3)

This was supported by earlier comments she made about how children learn best:

> I think if you talk to someone else about how you're thinking then that clarifies not only how you're thinking about it but it gives you other ideas as well. [Other people] might think about it differently and if you don't talk about it you don't know how you're thinking about it until you try to explain it to someone else. (Interview 1)

These beliefs on the importance of children's discussion were confirmed when Deidre was asked how she would tell if a classroom activity was successful or not successful.

> The discussion probably that comes up afterwards. ..... The kids learn to articulate what they are thinking about by talking about it. (Interview 3)

And the beliefs are further confirmed when Deidre commented on her preferred learning style when participating in professional development.

> Ah, I think that people learn better in groups than on their own. Generally I think people learn more from the discussion you gain out of things. (Interview 3)

Deidre appears to have strong relational beliefs about the role that children play in the learning process. However these beliefs are not put into practice in the classroom. There is thus an apparent mis-match between Deidre's beliefs and practice.

Deidre: Perceptions on the purpose for teaching mathematics

From the analysis of the two observed lessons it seems clear that Deidre's overall approach to teaching mathematics is quite clearly one where she acts as explainer imparting knowledge to her pupils. Deidre explains the way to do something and the role the pupils have is to practice what Deidre has shown them. When Deidre was asked if learning mathematics was like learning to ride a bike she replied:

> I guess you give them the basic skills to start with. Like you put them on the bike and put their feet on the pedals and get them going. But then they've got to learn and we have to teach them to adapt that to different situations. Like once you can ride a bike you still need to practise a lot and you practise and you have to practise until you've got it right. (Interview 1)

Deidre did make comments which suggested that she recognised that there were children who needed alternative tasks rather than the idea of 'Practise'.

> You know everybody pushes the bottom end and so they should, but I think the gifted kids are ignored a lot. I mean I have a few in here that pick up maths concepts just like that. And you

think well what's the point in getting them to do subtraction over and over and over again when they know how to do it. (Interview 2)

However, the planned 'extension activity' for those that understood the subtraction process was actually no different to doing more subtraction problems.

I've actually made up some crossword puzzles with numbers and I'm going to get them to put the answers in, work out what the sum is and write the clues across and down and things like that. (Interview 2)

Deidre relies on rules, procedures or formulas for her own personal mathematics problem solving, and she is prepared to admit that she does not understand why she uses such rules. There were many examples from the *3Cs* workshops where this occurred. One example was when the problem about the chance of rolling two yellows was being discussed (refer to page A-11 & A-19). The presenter asked Deidre to outline her method of solution as she was one of the only ones to have the correct answer.

Deidre: I worked it out if I had three yellow sides out of six. So it's three in 6 chance or a half. Fifty-fifty, I worked it out as a fraction. And I multiplied it by the other one which was 4 in 6 chance which was two-thirds so I multiplied a half by two-thirds and got a third.

Presenter: And why did you do that?

Deidre: I've got no idea. I must have learnt it at school and remembered ..... as soon as we did it I thought that's how you work it out. (*3Cs* Session 2 transcript)

It was very important for Deidre to know that she was using the recognised procedures. This came out when she was asked how she learnt new mathematics as an adult. To answer this she referred back to her learning mathematics at school.

You mean something like I couldn't do, like in algebra. Well I used to get the text books, read through, see all the examples, work all the examples through one step at a time, try it out myself, see if I can do it, and then check the back of the book to see if I got the right answer. OK I got the right answer so I must be doing it the right way. So I keep doing it that way until I get the wrong answer then I think, "Oh gone wrong somewhere". So I get back to the beginning and work out where it was I went wrong. (Interview 1)

Deidre is however prepared to accept that others may have differing ways of solving problems other than by the rule or formula. She suggests that these alternative solution paths are possible but not legitimate. This came out in a comment on something that she had gained from the *3Cs* program.

I tend to stick to ..... well I know the formula. But I found it interesting to see the way other people work things out. They probably gave me more ways to think about it instead of just

> thinking well I know how to do that so I'll just do it. And I thought well other people, yeah I can see how they are thinking. They're wrong but I can see how they're thinking. (Interview 3)

Deidre appears to have a fixed and narrow view of the nature of mathematics.

> Maths is very closed. You're either right or you're wrong. There's not different possibilities. I don't find it's just you're right or you're wrong but you know how to do it or you don't. (Interview 2)

Deidre's reasons for needing a set of practised rules and procedures was probably given when she was asked what was the purpose of teaching mathematics.

> To be able to learn how to apply it in everyday life. Some things ..... for example my son says, "Why do I learn how to do '2x plus y equals whatever' and plot the line on the graph and all that sort of thing". Simply because you need to have a broad knowledge of different areas in maths. [You might not now be able to think of someone] that actually uses that but there must be some sort of career that would be applicable. So you have to give them a broad knowledge of it so that they can apply it when they need to. (Interview 2)

However when Deidre compared the learning of Chance to the learning of other mathematics topics a very different view was given.

> Chance isn't necessarily a skill. It's more a knowledge, a knowledge about how things work. Whereas to learn how to add and carry and decomposition subtraction is a skill that they need practice at. And they really have to practise it and be shown and shown and shown and some pick it up really quickly and others don't and they have to have practise at it. Whereas Chance I don't think practice is what they need ..... well something like throwing the dice and proving to themselves but it is not practicing a skill. It's learning a concept ..... more of a way of thinking. (Interview 4)

This is an important comment because it suggests that she possibly has different beliefs about Chance compared to other mathematics topics. These different beliefs could be due to a number of reasons. Perhaps her beliefs about the learning and teaching of Chance at primary school level are not yet established because Chance is a topic that has only recently been introduced into the primary mathematics curriculum. And most likely her past schooling experiences do not involve the study of Chance which could mean that she has not any pre-conceived notions about how it is best learnt and taught nor about the nature of Chance as a discipline.

When comparing learning mathematics to learning language Deidre said:

> Language you just seem to pick up more naturally than maths. With maths kids seem to have to work at it more than [language] ..... No you probably don't learn [mathematics] in the same way but in theory you should. (Interview 1)

This is a very interesting comment because it suggests that Deidre possibly believes that mathematics and language should be learnt in a 'natural' way but in practice for Deidre, for some reason, it is not possible to implement that approach for mathematics. But interestingly she sees that learning Chance is more like learning language.

> Chance I think is experience. You know you have to give them an experience of language and what it means so it is as much a language lesson as anything else. So they have got a concept on what it means in their head. (Interview 4)

Because of Deidre's narrow and fixed view of mathematics she sees that the end result of teaching is to convey a set process to the pupils so that they can practice until mastery is successful. This certainly mirrors the way in which Deidre has been successful in her own 'school mathematics'.

Deidre: Dealing with mathematics and pedagogy

Deidre dealt with the presentation of the mathematics content in her lessons in a very confident manner. She knew exactly what she wanted to achieve and the steps in the presentation led to the desired outcome. There appeared to be little deviation on Deidre's part from what she had planned for the lesson.

Deidre was asked directly whether she felt confident in mathematics. A very forthright reply was given in the affirmative although with an interesting qualification that she did not regard herself as a mathematical person.

> Yes I do. And I don't have any, and I don't mean that I can do everything but I usually know if I am right. Yeah maths, do you know how some people think maths, I don't. (Interview 4)

There are a number of examples where Deidre discusses mathematical concepts in a confident manner. The following example was as a result of discussion about the number of combinations of clothing you could get with two pairs of shorts and three shirts.

> Well you could do ..... well if you just picked up one top from one pair of pants what's the likelihood of him picking up the same top and the same pair of pants everyday. We know there's six different combinations. Now is he likely to if he had his eyes closed pick out the same ..... well the shorts is fifty fifty chance. He's going to get one or either pair of the shorts and there's a one in three chance that he's going to pick the same top. (Interview 1)

However Deidre is quite prepared to acknowledge that there are gaps in her mathematical knowledge.

> Median and average I still get confused. I mean if I stop and think about it I had to really concentrate on the difference between median and average because I tend to think the middle is the average. I had to really concentrate and think now what is she [the PD presenter] talking about, the average or median because it's not always the same. (Interview 4)

Deidre suggests that she lacks the mathematics expertise, knowledge or ability to plan for individual differences in mathematics although she does not have the same difficulties in the language area.

> I mean language isn't as difficult. I don't find with maths that it is easy to extend them. Maths seems harder to give them. Like if you're working on subtraction to give them things that would challenge them that are totally different to what you're are actually doing. (Interview 2)

In the two observed lessons Deidre did not have the children using manipulative materials even though there appeared to be good reasons for the use of MAB, counters, and manipulable clock faces. During Interview 1 Deidre was questioned as to why she did not use MAB materials for explaining the subtraction process and she explained that she had used them on the day when the process was introduced. Even though Deidre made a decision that most of the class understood the process most teachers would expect to use manipulatives for much longer than this especially when there was still such a substantial group still indicating that they did not fully understand what to do.

At one point I made a comment to Deidre about how the *3Cs* participants had mainly trialled activities that had been workshopped in the sessions rather than those activities included in the handouts and she replied:

> That's the same with kids. We all learn things by doing them. We don't learn by ..... I mean if you are standing up the front telling me about something you are only taking bits and pieces. (Interview 5)

This indicates a mis-match between Deidre's beliefs about learning and what she actually puts into practice in her mathematics teaching. This mis-match may be tied to her beliefs on mathematics because when Deidre compared the learning of science to the learning of mathematics she made a comment which suggests that she sees science as being hands-on, but not mathematics.

> [My pupils] love science. For some reason most kids don't love maths and I don't know why ..... it's the hands on stuff again in science they love because they're making rainbows and doing things like that and they love to see how things work. Maths for some reason they see as a necessity, not something that is fun. (Interview 1)

The possible inference here is that if Deidre taught mathematics in the same hands-on way that she teaches science then her pupils may also 'love mathematics'. It is possible that it is Deidre that sees maths 'as a necessity', that is a set of rules and procedures that have to be learnt. It has already been noted that she has these beliefs about mathematics. Perhaps for Deidre, using manipulatives either gets in the way of or slows down progress towards achieving mastery of mathematical rules or procedures.

Neither of the two observed lessons had any of the mathematics embedded in a context. The times that the children had to complete on a worksheet were devoid of any context, as were the practice subtraction sums in the second lesson. This does not mean that Deidre does not place some of the mathematics instruction into context because she mentioned in an interview that she made a mathematics connection to the current class theme on weather. However she does believe that it is difficult to always provide a context for mathematics instruction.

> Well yes, like for example sometimes maths is a bit harder to link in only because ..... not that maths doesn't happen in all other things it does ..... but there's certain things you just have to cover so it's often harder. (Interview 1)

Deidre's reason for not connecting mathematics lessons to a context comes back to her belief that mathematics contains certain rules and procedures that must be mastered. The constraint of having to cover a large number of learning outcomes from the CSF would reinforce Deidre's approach on this aspect.

Deidre was asked how children best learn mathematics and replied:

> How they best learn? Because they can see reason for doing it. That's probably why I talked about, you know, well why do you do it. Because I don't think they realise how often you use maths, all the time everyday, in every day business like shopping and things you do at home, trying to work out if you want to go and buy something, working out how much of something you need. And they just don't realise how often they use it. They think maths is for school. (Interview 1)

Although this is essentially a comment which might suggest that Deidre values putting her planned mathematics activities into context, it is more likely to be related to Deidre's view of mathematics where she sees the main outcome of teaching mathematics is to be able to apply set procedures to everyday problems.

Deidre deals with classroom mathematics in a confident way, a way that reflects her instrumental beliefs about the nature of mathematics.

Deidre: Summary and conclusion - beliefs

Deidre sees mathematics as a collection of rules and skills to be practised and learnt and as a fixed body of knowledge. Deidre acknowledges that there may be many ways to solve a problem but that there is usually only one 'correct way'. Mastery of these 'correct ways' is important for Deidre. These are instrumental views on the nature of mathematics.

Although Deidre made no direct comments as to whether she believed that the teacher or the pupils should be the main source of information, Deidre's actions in the classroom certainly indicate that she sees herself as the main source of information and authority. Similarly she does not provide comment on whether she believes that lessons should be teacher-directed or teacher-facilitated but as her lessons contain much teacher-directed activity it would suggest that she probably believes that the teacher-directed approach is effective. For Deidre the important outcome of her teaching is for the pupils to successfully master specific processes and to get the correct answers. She believes that it is possible to learn mathematics when the content is devoid of any context. These beliefs on the role of the teacher are instrumental.

In interview Deidre says that she believes that children learn best in collaborative situations and that manipulatives and active participation were important. Deidre saw that children needed to demonstrate mastery of specific methods as a measure of learning taking place.

Table 6.2 summarises Deidre's beliefs.

		Instrumental	Relational	Contradictory Evidence	Lack of Evidence
Beliefs	Rules or process	*			
about	Fixed or developing	*			
the nature of	One or multiple solutions	*			
mathematics	Mastery or developing inquiry	*			
Beliefs	Knowledge source	•			*
about	Lesson format	•			*
the role of	Lesson outcome	*			
the teacher	Context provision	*			
Beliefs	Pupil working mode		*		
about	Pointers to success				*
how	Use of manipulatives		*		
children	Measure of learning	*			
learn maths	Rewards				*

Table 6.2: Summary of beliefs indicators for Deidre.

(* indicators readily noticeable; • possible indicator)

Deidre's instrumental beliefs on the nature of mathematics may have been largely shaped by her own past school experiences. The perceived successes which resulted from her past school experiences have developed a preferred way in which she does mathematics. This preferred way relies on applying formulas and set processes in order to achieve a definitive result, that is, an instrumental approach. Instrumental views of the nature of mathematics may have in turn developed a lack of interest in mathematics as a discipline. Deidre's contrasting views on the nature of Chance reinforce this possible scenario.

Deidre's relational beliefs in how children best learn mathematics may have been influenced by her beliefs on learning in other curriculum areas. Comments made about the learning of language and science are examples. Her 'CSF-focussed' approach to lesson planning most likely influences it in a way that encourages instrumental procedures although on the other hand planning with colleagues and the resources diversity that results gives a relational facet to planning. Deidre is very confident in mathematics knowledge and the instrumental way in which she tackles it and this has probably influenced the instrumental nature of her classroom approach. Deidre's relational beliefs on the value of pupil collaboration have influenced her in the way she prefers to set out her classroom, but this has not lead to the implementation of collaborative teaching strategies. Her instrumental beliefs on the nature of mathematics and the role of the teacher must outweigh her relational beliefs on how children best learn.

These connections and contradictions between Deidre's beliefs, practice and influences are summarised in Figure 6.1.

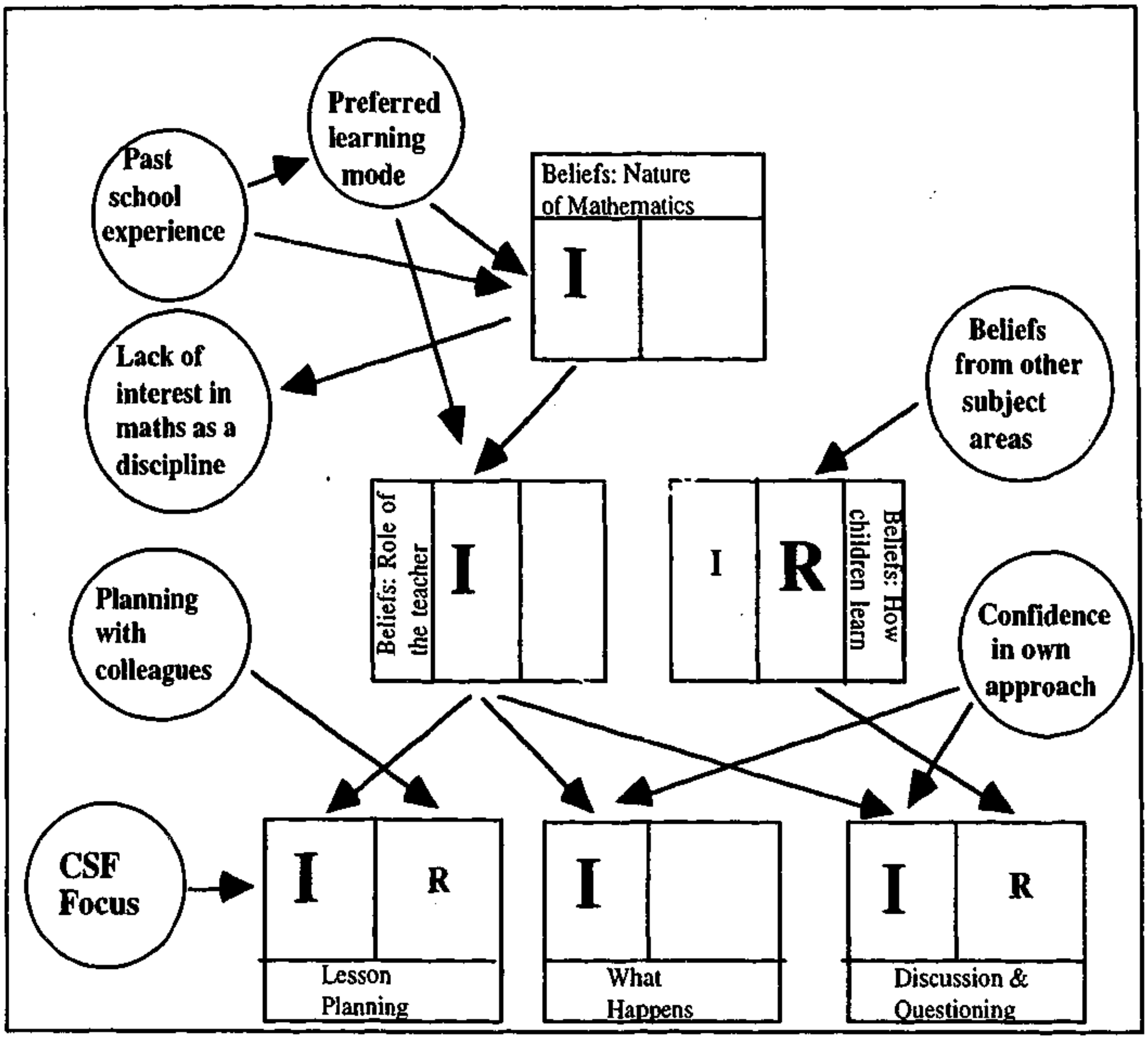


Figure 6.1: Summary of Deidre's beliefs and practice and the influences that act upon them.

Notes about these diagrams:
The diagram includes an indication as to whether each teacher's beliefs and practice (contained within rectangles) were found to be either instrumental (I) or relational (R). In some cases teachers demonstrated both instrumental and relational dimensions and for this varying type size has been used to indicate where the emphasis lay. Arrows are used to show the possible connections between the beliefs and practice. As well any influences (contained within circles) on the beliefs and practice that have been noted during the case study are included and arrows have also been used to indicate where they have had the most impact.

MALCOLM

Classroom practice

Malcolm: Background and current situation

Malcolm's class, a year 6, was situated in the main school building. Malcolm worked closely in planning and organisation with the other two year 6 teachers. One section of the room had two computers set up and information technology appeared to be of special interest to Malcolm. A library shelf containing mainly non-fiction was in one corner of the room. There was a large display of children's work around the room, both on the walls and hanging from the ceiling. This work included research projects and student colouring of black-line master tessellation patterns along with some student produced tessellations. There was little mathematics equipment visible in the room, the only obvious one being a set of rocker scales. The tables were set out so that four pupils were sitting at each arrangement. This allowed pupils to talk readily to each other but also allowed them to easily see the blackboard and movable whiteboard which Malcolm used frequently during whole class discussion. The classroom arrangement was the same, at both the first two observations and the latter two observations.

Malcolm: Lesson planning

Malcolm suggests that his teaching style involves planning for a variety of approaches including group work, chalkboard application and hands-on work.

> Normally a typical maths session would be I guess group work discussion. Quite often I will let the kids discuss what they are doing with ...... I do put maths on the board, not a great deal, but I will now and then to see how they're going with their basic skills. But most of their maths is a hands on style maths. (Interview 1)

He noted that this was a change in style partly resulting from completing the professional development workshops *Maths Making Links.*

> [*Maths Making Links*] probably made me try to challenge the way I was seeing maths as being on the board. I started doing a lot more of the hands on or the group work or the activity-based maths rather than the 'here's a board full of sums go for it'. (Interview 2)

When asked if he ever planned to use co-operative group roles Malcolm said:

> Not all the time. It depends on the activity. If we have an activity where a result is needed from the group and the group needs to come back and report well yes I have recorder, reporter and timekeeper. (Interview 1)

Malcolm relies mainly on one resource for planning lessons.

> At the moment I'm using the *Course Advice* which is quite a handy document because I find it is very open ended. I used the *Course Advice* last year. Before that when I first started I really had no idea. We had *Young Australia* maths books in the classrooms and I just followed them as much as possible and text books but now mainly *Course Advice*. (Interview 1)

The *Mathematics Course Advice* (Directorate of School Education, 1995) is compiled to be compatible with the *Curriculum and Standards Framework: Mathematics (CSF)* (Board of Studies, 1995). Malcolm noted that the outcomes from the *CSF* were a perceived constraint to a more freer approach in teaching.

> This is the first year we have actually reported on the outcomes. Last year we had the outcomes but we didn't report to parents on them. So we are in a great area of large change at the moment and yeah it's a bit sad that it is taking away our time in the classroom. It will come back, once we become more familiar and once we know where we are going. Now at the moment it's difficult. (Interview 5)

And one of the justifications given by Malcolm for not trialling a *3Cs* activity using the materials as suggested in the workshop reinforced Malcolm's feelings of restraint caused by being CSF-focussed.

> I don't have time to make things. In the good old days where there wasn't CSF outcomes and interviews and all of this I used to be able to make little things. (Interview 4)

Malcolm: Observation one

This lesson was part of an integrated unit on flight and the aim was to compare modes of flight. Malcolm had been reading *Around the World in Eighty Days* to the class as a serial story. This lesson was to be an introductory lesson for planning a world trip using various means of transport.

The outline of a table was established on the blackboard. Down one side of the table were listed each mode of flight in order of speed - for example, balloon, bi-plane, helicopter, Jumbo jet. The names of the capital cities were written across the top of the table according to their distance from Melbourne. Flight speeds and distances from Melbourne were on a chart on the whiteboard. Malcolm asked if someone could explain how to calculate how long it would take to travel from Melbourne to Canberra by hot air balloon.

> Ronny: Do 23 divided by 653 ..... no 653 divided by 23.
>
> Malcolm: OK what would that tell me? What would that tell me?
>
> Ronny: How many hours.

Malcolm: So if I said Canberra is 653 kms away, the balloon travels at 23 so I divide that by 23 kms and I can get an equals and once I've worked that out it will tell me. What will it tell me?

Pupils: How many hours.

Malcolm: How many hours.

Pupil: How many hours and it will have a point?

Malcolm: If I use the calculator it will give a decimal point. Will that tell me how many minutes or only in hours?

Pupils: Hours and minutes.

Malcolm then performed the calculation on a calculator and obtained the result 28.391304. One girl said that the answer was 28 hours and 39 minutes. Malcolm replied:

> Ahhhhhh No because remember that there are 60 minutes in an hour so be careful not to call it minutes. Point 3 of an hour or point 4 of an hour which is not necessarily minutes. Don't fall for that trap. If we were rounding this down to one decimal place there it would be 28 point what? (Classroom Observation Transcript 1)

The answer of 28.4 was established and Malcolm showed the class one further example.

The task was then for the pupils to complete the table so that they knew how long it would take to arrive at each destination for each mode of transport. The class were to complete a rough copy of their table which would then be copied into their workbook and also into a computer database. In the staff room later Malcolm expressed concern about the pupil's skills in rounding off decimal numbers and said that he would need to teach that topic again even though he had taught it at the start of the year and that it was really year 5 work. In the first interview Malcolm noted that this had happened using a formal lesson and giving practice at a number of examples.

Because this lesson fitted into the theme of flight Malcolm was asked a number of questions about his use of integrating mathematics into class themes.

> This is the only time that we [Malcolm and his Year 6 colleagues] have actually tried to blend maths into the theme. In first term maths was more stand alone where we actually used the *Course Advice* and we did two weeks of Space, two weeks of Chance and Data, three weeks of Number and a couple of weeks of Measurement. And inter-dispersed with all that we did automatic response games and things like that. But when we started flight we looked at the topic of flight and we thought there is a lot of maths which blends it to the topic. This is actually probably the first and I don't think we will be doing it again this year. We've looked at our themes for this year and felt that this was the only one that really blended itself well to maths. If there's a link we will make it. But there will be a lot of stand alone maths. (Interview 1)

The theme on flight was to be completed within a week of the first two observations and the next class theme was to be centred around a visit to the school by the Life Education van. Malcolm commented that this next theme did not relate very well to mathematics, although he pointed out that there would be data related to Life Education that might be of use in a mathematics lesson.

Malcolm: Observation two

This lesson, adapted from the *Course Advice*, also fitted in with the integrated unit on flight. Malcolm compiled on the board a list of ways to travel to Sydney using suggestions given by the class. These included plane, train, motorbike, horse and cart, and swimming. Malcolm made a comment on each one and rejected some such as go-kart. There was some whole class discussion on which was the safest way to travel to Sydney. One pupil suggested that they needed information on the number of accidents and another pupil claimed that the weather could be a factor. Malcolm nearly always paraphrased each pupil's comments.

The class were then set the task of individually writing the list of transport modes in order from safest through to most dangerous. Malcolm moved around the room talking to groups of pupils and listening to what they had to say. He then asked one of the girls how the class' opinion could be collected. She suggested that a survey needed to be taken and was invited to the board to conduct the survey. She asked pupils to raise their hands if they thought that particular modes of transport were on the top of their list for being the safest. She collected the following data: plane - 4, train - 19, car -1, motorbike - 1, and horse and cart - 1. Then the same approach was taken to collect the class' opinion of the most dangerous way to travel to Sydney. The following data was collected: horse and cart - 2, hot air balloon - 1, bicycle - 19, motorbike - 2, train - 1, plane - 1.

Each student was then asked to show this information on a graph. Malcolm reminded the pupils that graphs needed to be labelled. He also noted that the information could be either on one or two graphs, but the majority of pupils chose to show the information on two separate graphs.

Malcolm: Summary and conclusion - Classroom practice

Malcolm mainly relied on the *Mathematics Course Advice* for planning lessons. In the two observed lessons all the pupils did the same task and at the same pace. And with the follow up lesson on rounding off decimal numbers all the pupils completed the same set of tasks. This could indicate that Malcolm does not cater for individual differences.

Attempting to cover all of the learning outcomes listed in the *CSF* and the *Course Advice* became a perceived constraint to Malcolm's planning and approach to teaching.

Although Malcolm varied the organisation of lessons it is quite clear that he dominates in teacher explanation. Malcolm stated that he liked the class to be involved in activities where the pupils were physically involved with materials and group discussion. Manipulatives were not used in the two observed lessons although the content and the approach taken did not particularly require their use. Malcolm referred to his use of manipulatives and a hands-on approach in interviews. Even though collaborative group work was not used in the observed lessons Malcolm did refer in interviews to using it and stated that he thought that it was of value in mathematics. In the first observed lesson Malcolm had noted that some of the pupils were unable to round off numbers to the first decimal place. He did not directly deal with their lack of understanding at that point in time but planned a more formal lesson involving practice to take place a few days later. By dealing with this perceived pupil difficulty in this way meant that it was done without a context and from Malcolm's comments relied on his explanations rather than input from the ideas the pupils had. The implication may also be that Malcolm was not prepared to take a risk and alter the lesson plan especially with the observer present. Even though the observed lessons were integrated to the class theme this was not Malcolm's usual practice.

The classroom layout was appropriate for pupil-pupil discussion. From the SCAN analysis Malcolm's percentage of relational explanations (8%) was higher than that for most of the teachers although they were outnumbered by the number of instrumental explanations that he gave. Although Malcolm included questions requiring more than simple recall the percentage of these out of total events (15%) was lower than the median score for the group of teachers. However these questions outnumbered those that only needed simple recall. The Transcripts analysis indicated that Malcolm was the main provider of explanations and that questioning and follow-up to questioning was used in a limited way. Malcolm tended to impose his own solution methods with most dialogue in the observed lessons being teacher-pupil.

Table 6.3 gives a summary of indicators for Malcolm's classroom practice.

		Instrumental	Relational	Contradictory Evidence	Lack of Evidence
	Lesson source	*			
	Individual differences	•			*
Lesson	Innovation				*
Planning	External factors	*			
	Assessment				*
	Lesson pace	•			*
	Lesson initiation				*
	Teaching style	*			
	Pupil mode	*	•		
	Deviation	•			*
Classroom	Manipulatives		•		*
Implementation	Lack of understanding	*			•
	Pupil working time				*
	Struggling pupils				*
	Making connections	*	•		
	Classroom layout		*		
Discussion	Handling discussion	*			
and	Dialogue directions	*			
Questioning	Questioning approaches	*			
	Type of questioning	*			
	Explanations	*			

Table 6.3: Summary of classroom practice indicators for Malcolm.
(* indicators readily noticeable; • possible indicator)

This analysis confirms that Malcolm was generally instrumental in his classroom approach.

Explaining classroom practice

Malcolm: Perceptions of the role that pupils play in the learning process

Malcolm believed that there was value in group work for his pupils.

> What do I value in group work? Discussion. I mean, where a group is providing this participation and discussion. That is the value of the group. It's probably not what is produced at the end, but more the process that they go through. (Interview 1)

Malcolm's comment 'more the process they go through' refers to the social processes encountered by pupils rather than the development of mathematical understanding. The inclusion of group work was a recent development in what Malcolm valued in learning and teaching. As previously noted the professional development program *Maths Making Links* encouraged Malcolm to start 'doing a lot more of the group work maths' (Interview 2). He had noted that he 'was moving away from seeing maths as being on the board' (Interview 2) and that *Maths Making Links* had confirmed and supported a changing approach. However Malcolm's organisation of groups focused on how to group the class, for example, 'people with birthdays in even months' (Interview 1) or on matters such as choosing to use co-operative roles if the group 'needed to come back and report' (Interview 1) rather than on mechanisms to encourage discussion.

When Malcolm was asked how he thought children best learn mathematics he noted that children have different learning styles.

> It depends on the child. Some children learn better by manipulation, some need to be fairly formal and set out for them, some learn best by repetitive work. I think there are different ways of learning. (Interview 2)

However Malcolm noted that he believed that there was still a very important need for instrumental instruction.

> I think there are a number of kids who still need things to be spelt out to them . They need to know exactly what you want rather than an informal lesson. I suppose not informal but hoping that they will grasp that concept by purely hands on. (Interview 2)

This suggests that Malcolm has an underlying belief that he is the main provider of mathematical knowledge. This was certainly demonstrated in the first observed lesson . The two observed lessons demonstrated teaching that was not centred around the traditional approach of having 'maths on the board' but the explanation and discussion that occurred centred around Malcolm, particularly in the first observed lesson where he spelt out a rule-bound method in which the mathematics needed to be completed. The planning and organisation for both lessons could be said to contain innovative and possible relational-type approaches but the teacher role was along instrumental lines.

Partly through the influence of *Maths Making Links* Malcolm now believed that his mathematics teaching needed to include 'a lot more of the hands on or the activity-based maths' (Interview 2). However when Malcolm was comparing the learning of mathematics to the learning of science his comments suggest that he believed that the teaching and learning of science needed to be more hands-on than with mathematics. In science this hands-on experiential approach creates an interest for further learning with the inference that a hands-on approach in teaching mathematics does not achieve this in mathematics.

> Science I think is more experience. Experience and probably interest I guess. If kids have an interest in sciency type things like astronomy or whether it's chemistry or whatever and I guess if there's an interest they learn more than kids who don't have that interest. I think science is more interest-based learning. (Interview 2)

Malcolm believes that pupils have preferred learning styles that could include learning through the use of manilupatives, involvement in activities, and instrumental instruction. He believes that group work has advantages but sees these advantages in terms of organizational and social outcomes rather than increased mathematical understanding through pupil sharing and explanation. Malcolm believes that some subjects such as science can capture children's imagination with the inference being that mathematics would not do this.

Malcolm: Perceptions on the purpose for teaching mathematics

Malcolm recognised that mathematics is broader than just dealing with number and reinforced this notion with his pupils.

> We actually did that at the beginning of the year. What is maths? We put it on the board. And we got them to write up some of the things. Once they stop to think about it they sort of realise that maths is much more than number. (Interview 5)

When asked if his views about mathematics had changed since he had started teaching Malcolm replied:

> [Yes teaching maths to kids has changed my views about the nature of mathematics]. In what way? Well I guess the way I was taught maths compared to how I'm teaching maths now. Certainly I feel that there is more to maths than number. And I feel that very strongly at the moment that the usefulness of having an algorithm that I can work out is not that important in life. I explain this to my kids. I mean when they go out to work they're not going to sit down and have to write out a sum because they have to work it out. They've got a calculator that will work it out for them. They do need to know the process. They need to understand numbers and what they are about. (Interview 2)

When Malcolm was asked what he saw as the purpose of teaching mathematics the views that he expressed in the comments above were reinforced. He said:

> What do I see as the purpose of teaching mathematics? An understanding of number I guess. An understanding of numbers and concepts and I think maths is more than just numbers, like tessellations, perspective drawings. I think the purpose of teaching mathematics is to teach some sort of thinking skills. Skills that will help them understand more than ..... that will effect them in life. Whether they have to measure up the curtains or they have to measure a recipe or whether they have to go shopping, whether they have to pay their accounts. Whatever. It's life skills. (Interview 2)

The 'thinking skills' that Malcolm refers to are those needed for making selection of the processes required to answer everyday problems. His reasons given for the purpose of teaching Chance follow a similar argument.

> Purpose of teaching Chance? I think Chance really ties in with logical thinking. Thought process. In life we are always making choices, options. It's decision making. Sometimes you have to base your choices, your decisions on data. And Chance and Data helps kids to realise or to use that skill. (Interview 2)

Real life choices that he referred to included choosing to smoke or choosing to drink and drive.

Malcolm acknowledges that he still needs assistance to achieve what he believes would make him a better teacher.

> I think maths has covered a lot of territory in the last few years. I just feel that maths ..... I really enjoy maths. But I don't think that necessarily makes you a good teacher of maths and that's why I like to do these sort of things [professional development]. (Interview 2)

Malcolm attended the *Maths Making Links* professional development in a previous year and noted that it challenged and changed his beliefs about mathematics and the way he taught it.

> *Maths Making Links* was all activities and you started talking about different ways to do multiplication. Here I am standing at the board and saying this is how you multiply. And then give the kids an activity where the kids multiply, naturally the result is the same. I guess it did challenge the way I see maths. (Interview 2)

Malcolm noted that his greatest need in professional development was advice on how to pull together the mathematics understanding at the end of a lesson.

> I guess my weakness is summing up or closing off an activity. I'm fine in planning. I'm fine at doing the activities and that. But I sometimes don't always tie it up the way I'd like to. It's very hard to leave enough time in the day to actually do that. My weakness is probably pulling it together, pulling things back together. I still think a very important part of the lesson is to actually pull it together. (Interview 2)

Malcolm sees the purpose of teaching mathematics as the acquisition of thinking skills and for decision-making in life. He believes that it is the process of mathematics that is important and that he should not impose his way of solving problems. He also sees mathematics as including many topics which is a contrast from his own schooling and his views when he first started teaching. Malcolm values the end part of a lesson where the mathematics should be drawn together. He acknowledges that he does not often achieve this and needs professional development assistance to improve this aspect of his teaching. His attendance at *Maths Making Links* generated some of these changes in beliefs, changing what were instrumental beliefs about the nature of mathematics and their implications for teaching and learning into beliefs that would be more aligned with relational ideas. He acknowledges that he is in the middle of this change process and needs further professional development to consolidate the change and take it further.

Malcolm: Dealing with mathematics and pedagogy

It has already been noted that Malcolm enjoyed mathematics. He also enjoyed problem solving.

> Yeah I'm the sort of person that gets hold of [a problem] and look I'm not a fast problem solver, I'm a very slow problem solver but if a problem can be solved I will just keep going until I solve it. I'll wake up in the middle of the night with some option and I tend to come up with options for things. (Interview 2)

Malcolm could speak confidently about the curriculum content for his year level of Chance. This is interesting because Chance is a new inclusion in the primary mathematics curriculum.

> We've done probability lines, what was the most probable answer to this. It was during the very hot weather and we talked about the probability of it raining tomorrow. No chance at all because it hasn't rained for weeks. We did a lot of probability of giving examples that can never happen and one boy said, "Oh I'll never change to a girl". We just talked about things that had no chance of happening, things that had 100% chance of happening, and things that had a 50-50 chance. We played games. The *Course Advice* had Acey Duecy and we played that and talked about that sort of game. (Interview 1)

Malcolm was shown the T-shirts problem (page A-30) during Interview 2 and asked how he would implement it in his class. As well as being able to solve the problem quickly he readily made connections from this problem to similar problems that he had used in the classroom and suggested an appropriate approach for the class to use to tackle the problem.

We did an activity very similar just recently when we did our chance and data. It's just called cabbage patch ..... which was a very similar one where we had hair colour, top colour, and then one other colour. So actually three movable parts. If I was doing [the T-shirts problem] I would probably have these pieces on a sheet and let the kids cut them out and work in a group and say OK put all your pieces in the middle and then as a group start making all the combinations. See how many combinations you could come up with. (Interview 2)

Malcolm was then asked how a problem like this was then connected to the topic of Chance. The following discussion took place:

Malcolm: Connection to Chance is the availability of what you have to start with and I guess the other thing is probably looking at what the combinations are. So you're looking at combinations of ..... can you actually have the same top with different trousers? Yes you can. Can you actually look at all the combinations? You could actually end up with some sort of diagram. Tops to bottoms and bottoms to tops and join them all up. 1 2 3 lines that way or 2 lines matching up with those trousers or 3 lines from each pair of trousers.

Ron: When you've got all the combinations how does chance actually fit in?

Malcolm: Well yeah good question. Where does chance fit in? [laughs] Don't know. Where does chance fit in? I guess it's probably more on the probability side of things and what are the choices available rather than the chances available. Unless you wanted to extend it more I suppose. You could extend it then to say, "What are the chances of somebody turning up in this uniform?". (Interview 2)

Although Malcolm did not immediately know how there could be a connection to chance he eventually came to an appropriate response.

Malcolm claimed that learning mathematics was on-going and that it was possible to forget previously-learnt mathematics especially when it is not in regular use. This occurred in the discussion about whether learning mathematics was like learning to ride a bike.

I think you learn maths all the time and for instance I certainly don't agree with the idea that you don't forget it because I went through High School as a maths major and yet one area of maths I could never understand was using sine and cosine and tangents and all those sorts of things. And I remember with my son going through High School I was able to help him right up to that. I can't help you with that because it's something I've never used since I've left school. (Interview 2)

Malcolm's comments continued with some interesting insights into his views on children's learning and the nature of mathematics.

Once you've learnt something you can forget it. It depends on how much you use it. And secondly I think with maths you can always learn more. I mean I still learn things about maths in information and numbers and things like that. Mathematicians I'm sure would still have

> things to learn about maths so I probably wouldn't make that analogy of riding a bicycle and learning maths. (Interview 2)

Although Malcolm based the mathematics lessons of the first two classroom observations around the theme of transport this teaching approach was not typical. Malcolm said:

> But you can't ram maths into themes. I think you need to look at a theme and either it blends itself to maths or it doesn't. And to get a fairly rounded maths course I think you have to have stand alone maths because you could make connections just for the sake of saying, "Oh yes this is being applied". (Interview 1)

And contradictory to this, Malcolm believes that you learn much of your mathematics knowledge from everyday contexts.

> I think [children learn mathematics in the same way as they learn language]. Well with language ..... I mean a lot of their language is learnt incidentally I suppose in the home and at the shopping centres and I think maths is learnt in a similar way. I mean when they go shopping, when they weigh things, when they are cooking. When they have a problem to solve it needs to be solved. They learn maths that way as well. So a lot of language is learnt incidentally and I think a lot of maths is learnt incidentally too. (Interview 2)

Malcolm acknowledged that his own learning of chance would have been incidental through everyday events.

> When I was younger I certainly liked to have a bet on the horses and you certainly learnt about chance when you bet on the horses. I certainly play a lot of games and some games lend themselves to chance. So I probably learnt a bit about chance just purely in those sort of situations. (Interview 2)

In general Malcolm shows that he has confidence and a reasonably sound mathematics knowledge although he is quite prepared to acknowledge that there have been gaps in his understanding. He believes that you can forget mathematical processes if you do not keep using them. He also believes that there is always new mathematics to continue to learn. It would appear that Malcolm did not value putting classroom mathematics into a context even though he acknowledged that mathematics was learnt incidentally through everyday contexts and that his own learning of chance occurred in this way.

Malcolm: Summary and conclusion - beliefs

Malcolm believes that teaching mathematics is to prepare students to have the skills to process what is needed for everyday problem solving. He believes that there is new mathematics to learn. Malcolm believes that there are many ways to complete particular mathematical processes but that this is something that is new in his thinking. Malcolm values that process of inquiry inherent in problem solving situations.

Malcolm presents a mixed message about his beliefs in the role of the teacher. On one hand he knows that it is important for him to facilitate small group work and discussion, but on the other hand he believes that it is important for him to be supplying the correct methods, particularly for some pupils. It appears that the latter belief may be the stronger of the two. He knows that the important outcome of learning mathematics is to understand the broad processes involved in solving problems. Malcolm believes that a context need not necessarily be provided for the learning of mathematics, although he acknowledged that much mathematics is learnt through incidental everyday experiences.

Malcolm believed that learning mathematics is best achieved through small group discussion and use of hands-on activities, although he noted that these were new beliefs for him as a result of completing *Maths Making Links.*

Table 6.4 summarises Malcolm's beliefs.

		Instrumental	**Relational**	**Contradictory Evidence**	**Lack of Evidence**
Beliefs	Rules or process		*		
about	Fixed or developing		*		
the nature of	One or multiple solutions		*		
mathematics	Mastery or developing inquiry		*		
Beliefs	Knowledge source	•		*	
about	Lesson format	•		*	
the role of	Lesson outcome		*		
the teacher	Context provision	•		*	
Beliefs	Pupil working mode		*		
about	Pointers to success				*
how	Use of manipulatives		*		
children	Measure of learning				*
learn maths	Rewards				*

Table 6.4: Summary of beliefs indicators for Malcolm (* indicators readily available; • possible indicator)

Malcolm's beliefs present a number of contradictions and it is difficult to classify them as either instrumental or relational. His relational beliefs on teaching and learning such as the value of group work and the use of a hands-on or activity approach have resulted from the recently completed professional development program *Maths Making Links.* These newly-founded relational beliefs will be surface-level but are obviously challenging the instrumental beliefs that he holds. Closely working with other colleagues may possibly be adding to the formation and strengthening of these relational beliefs, but Malcolm does not refer to this as an influence.

Some of Malcolm's relational beliefs on the nature of mathematics may have also been shaped by *Maths Making Links.* One example that he alludes to is the notion that there are often many ways to tackle a process or a problem. However it is possible that he already held relational beliefs on the nature of mathematics. These could have been shaped by his past school experiences which has made him confident in his mathematics ability and given him personal pleasure at doing mathematics and problem solving.

His reaction to his past school experiences suggests that he now rejects the instrumental way in which mathematics was presented during his own schooling. However, he achieved success (that is, passed examinations) as a result of this instrumental teaching so he may still have deep-seated instrumental beliefs about the role of the teacher. It would appear that it is these deep-seated instrumental beliefs that impact on his teaching, particularly the way in which he takes control of discussion and questioning. The observed lessons had the potential for being implemented along relational lines but Malcolm's dominance in the classroom prevented this from happening. This suggests that his working with colleagues influences lesson planning and the way in which the lessons could be implemented. However, the 'CSF-focus' that Malcolm, and possibly his colleagues have, has led to instrumental planning approaches. Malcolm's newly-found relational beliefs will also be challenging his practice but at this stage this is only noticeable in the 'classroom implementation' category.

The connections and contradictions between Malcolm's beliefs, practice and influences are summarised in Figure 6.2.

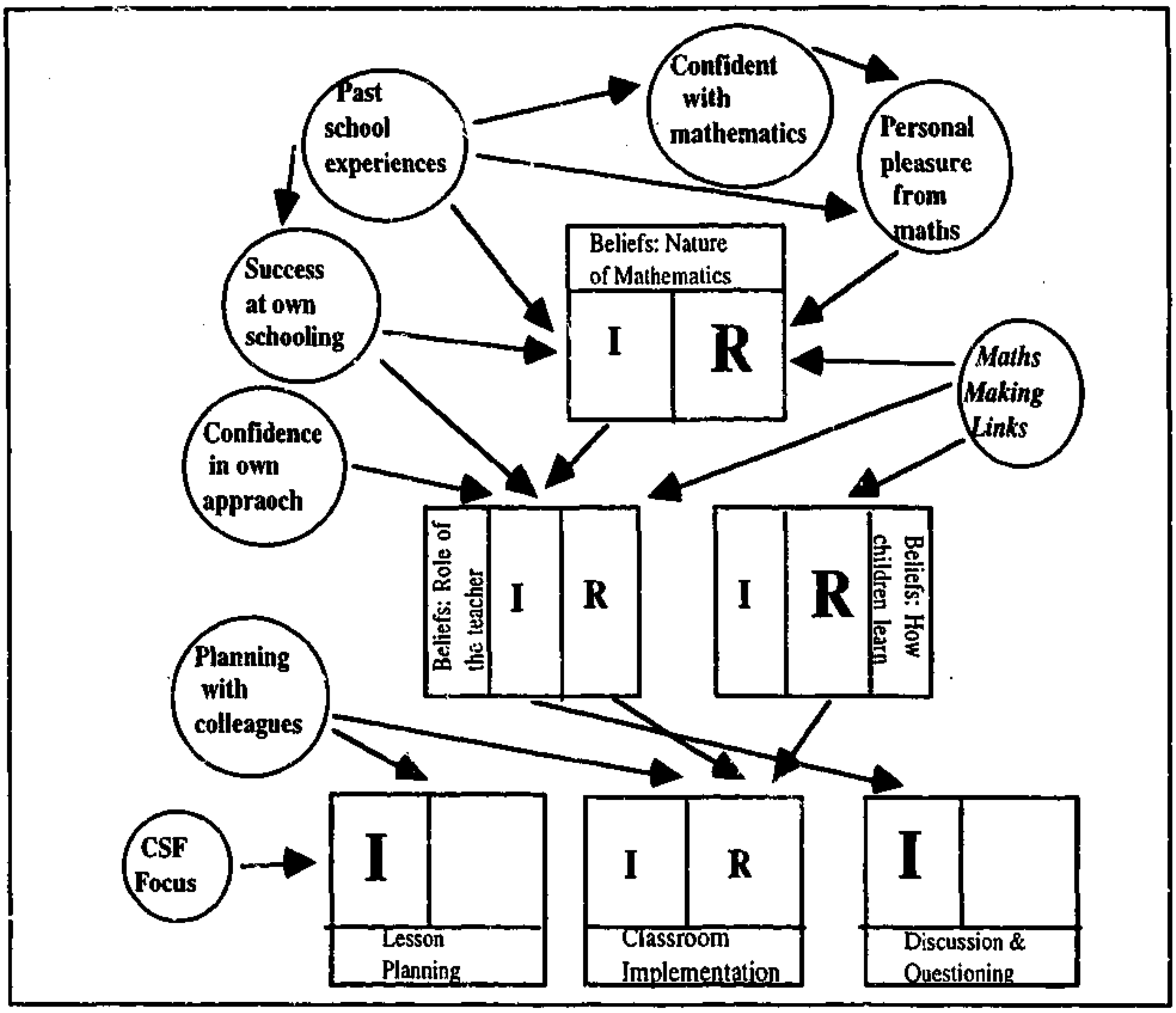


Figure 6.2: Summary of Malcolm's beliefs and practice and the influences that act upon them.

TASHA

Classroom practice

Tasha: Background and current situation

Tasha was teaching a composite 5/6 grade with about 25 children although there were twice as many boys than girls. Tasha's classroom had various arrangements of tables - some had children arranged in groups, others had children facing the front of the room. This classroom arrangement was little changed during the observations made later in the year. There was a library corner set up and a trolley with a good number of mathematics games. Along with some pupil's projects displayed on the classroom walls were a large number of teacher-prepared charts on language, grammar and punctuation. The classroom behaviour rules were written across the top of the blackboard.

Tasha: Lesson planning

When asked from where she took her teaching ideas Tasha said: "From my mind" (Interview 1). On one of the days when an interview was completed the class had been working on the topic of 3-dimensional shapes, but in a descriptive writing session. They were in groups of four and individually they were writing definitions for several shapes. Then they were to share their ideas and come up with a group definition. When Tasha was asked where she took that lesson approach from she answered:

> I think I just thought of that off the top of my head when I was in bed. And came in this morning and thought: "Well that's a good idea. I might do that". (Interview 3)

Tasha was asked if she made use of any particular teacher or pupil text.

> I actually use a text which has fantastic take-home sheets. I also use Eureka Maths, some of the activity sheets in there. Sometimes Young Australia but not as much. Mainly if I want an activity sheet and I have a specific thing that I want to do like if I want to do measurement with conversion of metres to centimetres or something like that and I want to re-inforce it somehow we do a follow up introduction. Then I would grab one of those out but as far as using it every day in my teaching, no. (Interview 1)

Tasha referred to how she organised the composition of groupings of children.

> And to also know ..... not to know so much that the helper has to spend all their time helping but that there's two of them in that group. One group would have two people that pretty much

> know what they are doing and then have two others. I make groups of four. It's a lot easier to work with and they're all mixed ability groups. (Interview 1)

With the groups in the descriptive writing session already mentioned Tasha had an expert on paragraph writing in each group so that 'they could effectively model the strategies to everyone else.' (Interview 3)

Tasha: Observation one

This session fitted in with an integrated unit on media. Each pupil was given a full copy of *The Australian* newspaper. They were asked to cut out as many advertisements as they could see. Pupils were allowed to work in whatever spaces they wanted as the papers were difficult to spread out on a table. Tasha stopped the pupils after a few minutes to state that they should help each other before coming to her for assistance. Although the class worked in a more collaborative way Tasha continued to help individual pupils who needed it.

Some of the pupils had difficulty distinguishing advertisements from articles and when Tasha realised this issue she then stopped the class and gave the following explanation:

> If you're unsure about what you are looking at in an ad, the first thing you may need to do is to have a bit of a read through it and ask yourself, "Is this telling me any information about some product, some company". Or maybe they're telling you how much it is or they're there in case you need them. If you are unsure whether it is an ad maybe you could cut it out anyway because later on when we go to group them you can have a really good look and a read of it then. For the moment all I want you to do is to cut out anything that you think is an ad. And speak to the people next to you and on your table and ask them. (Classroom Observation 1 Transcript)

The pupils continued with the task of searching for advertisements and this activity took the whole session. The task of grouping their advertisements was completed in a later session where the focus was on classification and sorting into appropriate categories devised by the pupils.

Tasha: Observation two

The aim of this lesson was to investigate relationships between simple fractions. The pupils were given sheets of coloured paper. One sheet was to be cut up into quarters, another into thirds, another into fifths, and so on. When the class were asked to cut one sheet into thirds Tasha reminded them that they had to be equal. Some pupils had difficulty achieving this and Tasha assisted them in two ways. Firstly, she noted how one child solved the problem.

> Craig has found an interesting way to do it. He's actually got his ruler out and he's measuring to make sure that each shape is even, that his folding is even. So if you're having trouble getting your shapes the same size you might like to get your ruler out. (Classroom Observation 2 Transcript)

Secondly, she asked those that had achieved it successfully to assist those who had not yet completed the folding into thirds.

The children cut out fifths and Tasha posed the problem of using their fifths to show tenths.

> What I'd like you to do now is to show me tenths with your fifths. Make your fifths into tenths. What I want you to do is talk to the person next to you and I want you to explain to each other how you did it. Have a bit of a chat now about what's special about fifths and tenths. (Classroom Observation 2 Transcript)

A similar task followed with using the quarters to show eighths and with the thirds to show sixths. Tasha asked a number of questions along the format of the following example:

> If I say to you that one half equals two quarters is it true or false? (Classroom Observation 2 Transcript)

The final task for the class was to make a picture on an A3-sized sheet using their fraction cutouts. On the back of this sheet they had to write about what they had learnt.

> I'd like you to write about the things that we have learnt about this morning. I want you to talk about different fractions. What you think it means and what you learnt from it all. Now I don't want it to be only about fractions. I want you to tell me about what you found interesting and what you found really surprising. You do not do your good copy straight onto this sheet. You do your rough copy on your jotter pad. Conference with a few people and then it comes to me and after that you write it on the back of the sheet. (Classroom Observation 2 Transcript)

Tasha: Summary and conclusion - Classroom practice

Tasha appeared to plan with her pupil's needs in mind and used resources from various texts not as direction to planning but when they fitted with her intentions. She was able to adapt ideas into new situations and by doing this was able to organise much of her planning about themes or integrated units. She appears to have catered for the individual differences of children in her planning and organisation some of which was based on the goodwill and sense of collaboration that she had engendered in the class. Tasha's planning allowed for reflection time for individuals.

From the two observed lessons Tasha appeared to vary her teaching style in accordance with the intended outcomes for that lesson. She encouraged pupils to assist each other and work in collaborative groups. Teaching materials and placing the mathematics in a context were an important part of her teaching. Tasha appeared to allow pupils to handle problems which arose in their own way.

The classroom layout and the way in which spaces around the room were used suggested a very flexible approach. The classroom dialogue included both teacher-pupil and pupil-pupil discussion and the P-P indicator from Chapter 5 confirms this. Although the two reported observations are limited Tasha did gain ideas from the class and use these in further explanation and discussion. Tasha gave a number of relational explanations and in greater proportion to instrumental explanations (refer to tables 5.6 and 5.7). Her questioning approach used 'q+ type' questions and in a greater proportion to 'qs-type' questions (refer to tables 5.8 and 5.9). Management and discipline statements were of a low priority in Tasha's teaching style and in fact she recorded the lowest incidence in such statements of all the teachers involved in the study (refer to table 5.10). Both the SCAN and Transcript (refer to Table 5.13 & 5.22) analyses found that Tasha's approach to discussion and questioning approach was generally relational.

Table 6.5 summarises Tasha's classroom practice.

		Instrumental	Relational	Contradictory Evidence	Lack of Evidence
	Lesson source		*		
	Individual differences		•		*
Lesson	Innovation		*		
Planning	External factors				*
	Assessment				*
	Lesson pace		*		
	Lesson initiation		*		
	Teaching style		*		
	Pupil mode		*		
	Deviation				*
Classroom	Manipulatives		*		
Implementation	Lack of understanding		*		
	Pupil working time				*
	Struggling pupils		*		
	Making connections		*		
	Classroom layout		*		
Discussion	Handling discussion		*		
and	Dialogue directions		*		
Questioning	Questioning approaches		*		
	Type of questioning		*		
	Explanations		*		

Table 6.5: Summary of classroom practice indicators for Tasha.

(* indicators readily noticeable; • possible indicator)

It is clear from Table 6.5 that Tasha's approach to teaching is predominantly relational.

Explaining classroom practice

Tasha: Perceptions of the role that pupils play in the learning process

The role that Tasha played in Observation 1 was very different to the role that she took in Observation 2. In Observation 1, once she had set the task her role became one of observer and she only intervened when there appeared to be a major problem. Whereas in Observation 2 Tasha acted as facilitator and maintained an appropriate working pace throughout the whole session. These differing teacher roles meant that the pupil's roles were also different. In Observation 1 the pupils were encouraged to assist each other and explored for themselves the differences between newspaper articles and advertisements. In Observation 2, through Tasha's instructions and questioning, the pupils offered and shared their own ideas, gradually building upon prior knowledge and at the end of the lesson were required to reflect on what they had learnt. Although both lessons were very different and the observed role of the pupils appeared to be very different, an emphasis was placed on the pupils own role in personal learning.

Tasha's two different observed teaching approaches were typical of her classroom approach. Her weekly program included mathematics sessions connected to the class theme (for example Observation 1), group work activities aimed at skill acquisition, and teacher facilitated activities (for example Observation 2).

> [My typical maths lesson] depends on what I'm doing at the moment. I have maths activities which focus in on things like number. A lot of the day to day stuff. My typical maths session would be that they would be in activity groups and then they'd work and they come to me if they need help. But I try to encourage peer tutoring and that especially because when the kids get to secondary school they can't rely on the teacher as much as what they have now. So we do a lot of work where they first of all have to do steps they have to go through. So they work in their groups. They ask the person in their group to help them and if they still don't understand it then they come to me. There's also the maths that comes out of my topic which is media at the moment. So we're doing a lot of graphing about that. So there's a bit of a difference. (Interview 1)

Tasha was asked how she had been able to develop the level of collaboration which was so noticeable in the class.

> With the ones that weren't struggling I had to sort of pull them up and say, "Well that's ok, you don't need to rush to get it done". You have to back off and tutor here and help the others out so you take on my role as a teacher in helping them. And they quite liked that. But the ones that were struggling, they ..... I needed to build up their confidence and say, "Hey look it's ok to make mistakes, it's ok to work with someone else, if you're working with someone else then you've got to be focussed on what you're doing because if you're not focussed on what you're doing and we did a lot of work on ..... if they were given an activity sheet, an activity to do, they had to focus on what was going on there and not talk about what was happening on the weekend. (Interview 1)

Tasha had noted a preference for teaching the upper primary levels because it was a 'touch easier' (Interview 3). She added:

> They can be left alone to discuss things and then report back with the facts and not sort of have it as if they are trying to please me. They're talking back and saying well I thought this and

that comes out so it's not just observation. It's them evaluating themselves as well. (Interview 3)

When Tasha was asked how she evaluated the success of a lesson she referred to her use of the Think-pair-share strategy (refer to page A-11 & A-19) and emphasised the value of pupil-pupil discussion and the understanding that would come from this strategy.

> They understand that they have their own thinking and you can see that in the way that they discuss what they think and feel without interrupting the other person because I set boundaries up. They weren't allowed to interrupt when someone else was talking. They had to be positive in everything that they said. So they're the indicators that I am looking for. That they're taking their knowledge one step further by helping someone else. (Interview 3)

Tasha offered the following reasons as to why she valued pupil-pupil discussion:

> They are getting their ideas ..... sometimes when I say something to them they might not understand it but if a child their own age does it in their own language then they're getting that. But I just think that it's very important just basically talking about it, talking about strategies, talking about how to solve it, different ways to solve it. Like when we did this morning [Observation 2] talking about their ideas with a third. "Why isn't a third the same as a quarter. What's the difference?" And getting their ideas instead and clarifying their thinking and saying that if I cut the cake and gave you a third ..... I think they're relation based and they're talking about what is going on in their lives. (Interview 1)

Tasha's beliefs on the value of pupils working together and on her own teaching role are clearly relational. These beliefs are consistent with classroom practice.

Tasha: Perceptions on the purpose for teaching mathematics

Tasha's approach to teaching is mainly relational. What then are her beliefs on the purpose of teaching mathematics? When asked this she replied:

> Life, you need it to survive. You need the basic things and even problem-solving, looking at fractions and decimals. They need it. They need it to survive. They need to know about it all. (Interview 2)

This is an instrumental view of the purpose of teaching mathematics and does not acknowledge the value of mathematics as a discipline. However, her views on the purpose of teaching Chance tend towards being relational.

> I don't know if [Chance is] as important as what the others are because Chance by name involves a lot of chance. It also looks at logical thinking. I'd prefer that it developed logical thinking with kids and looking at different ways to solve problems. So in that case yes it gives them something important. (Interview 2)

But following the third *3Cs* workshop Tasha was asked the same question, that is, about the purpose of teaching Chance. She appears to have moved away from a belief that could have been considered to be relational to one that corresponds to her instrumental beliefs on the purpose of teaching mathematics, that is, teaching mathematics so that the children will be able to cope with the day-to-day mathematics outside the classroom.

> No [my views on the purpose of teaching chance, have not been challenged or altered by the *3Cs* sessions]. They have probably made me more aware of how important, much more important it was because of the things that take place in the society outside. A lot of kids know about the odds, horses and gambling. And they're into footy and you want to make a bet. But they don't really understand what they are saying or what's involved in it. So it's probably just extended my understanding of how important it is outside to the children to understand it. (Interview 3)

Perhaps this shifting from relational to instrumental ideas is part of the process of consolidation and re-shaping of ideas and not necessarily a contradiction.

Tasha's instrumental beliefs about the nature of mathematics are further documented with her reply to a question which asked her to compare the learning of mathematics to the learning of a musical instrument.

> It's hard. I mean sometimes you hit the wrong notes and have to go back and redo it. Or sometimes you forget the tune which is like the method and you have to go back and practice it. It's like times tables. I mean it's never at 100% unless you keep practising it. (Interview 4)

However, there was some similarity and also contrast to the reply Tasha gave when she was asked if learning mathematics was like learning to ride a bike.

> I suppose yes [learning mathematics is like learning to ride a bike]. Once you get on you never stop riding. You never stop learning. And you fall down a lot. Yeah. That's good. I agree with that one. (Interview 2)

Tasha appears to be saying that learning mathematics and adding to one's knowledge is something that is ongoing which is a relational notion, but she also appears to make the point that learning mathematics has many difficult steps to be overcome.

Tasha's lessons aimed at skill acquisition were a recent addition to her planning.

> I was getting sick and tired of going back to say long multiplication and the kids saying, "I can't remember how to carry" or " I can't remember what to do" and it was because I worked out that they needed to have it constantly at them all the time even if it was just doing it incidentally or during a maths activity sheet where they are completely focused on just that process. So that's why I started mine off [on skill focussed activities]. (Interview 1)

Tasha believed that the need to have regular lessons on skills and processes was based on the notion that 'it's just the practising that needs to come through' (Interview 1).

However a 'mixed message' resulted when Tasha was asked if children learnt language and mathematics in the same way.

Tasha: With language it's more practice and making mistakes. Actually no I'd take that back. I think they do learn them the same way but probably under different conditions. The avenues for language are probably a lot more stricter than what the avenues for maths are. Maths you can afford to be a bit more open with what you are doing. Like today [Observation 2] I could afford to let them go a bit. But with language there is a lot more that you can't ..... they can't have so much freedom.

Ron: Right. And what are avenues? What do you mean?

Tasha: Like ..... paths really. Like you've got your maths and you've got the language that goes down here. But maths is probably a bit broader than what language is. There's a lot more with language and it's so individualised too. Whereas with maths you can do a whole group thing of it. It doesn't matter if some people have to revise it whereas with language you can have spellers down here and spellers up here and that bottom group are never ever going to get up to the top group unless you work with them quite strenuously. (Interview 2)

This discussion suggests that Tasha believes that the nature of teaching and learning mathematics gives rise to some greater flexibility in approach than when compared to language.

It would appear that Tasha's beliefs on the nature of mathematics are instrumental. She sees that mathematics is about mastery of facts and skills and that this can be achieved through practice.

Tasha: Dealing with mathematics and pedagogy

As has already been noted Tasha approached teaching mathematics in several different ways.

> Oh yes [you need to have different approaches]. I don't think you can teach maths without doing that. You need to have a variety and the kids need to establish skills. Even though a lot of the number facts come into my other sessions ..... theme work and all of that, even though it comes into that it still needs to be re-inforced through the day. (Interview 1)

Tasha claimed that much of her mathematics teaching approach was based on themes.

> A lot [of my mathematics teaching is based on a theme]. I try and make sure that two sessions [each week] are the group work rotation. Everything else comes out of my theme. So I focus a

> lot on chance and data with surveying and that. But also things like percentages come into it. A lot of it is incidental too. (Interview 1)

The notion of incidental teaching was also mentioned when Tasha explained that the theme on media included radio as well as newspapers.

> We were looking through a radio list and did some incidental maths activities. We just turned on the radio and I said, "Every time you hear an ad for the DJ launch tell me and we're going to mark it up on the board and we'll do a tally and a comparison. And we'll actually go into the costs of advertising on the radio. (Interview 1)

However Tasha had difficulty seeing how Chance could fit into a teaching approach based around themes.

> With Chance I go to the text [for classroom activities]. There's not a lot I can do with Chance. Like I can't bring Chance into a lot of my themes because it is a very abstract kind of thing because it's got something to do with chance. And a lot of the stuff we do isn't chance. So a lot of the work on chance comes out of activities. I do think that unless your theme fits into it nicely it's very hard to try to fit it in. And sometimes like with number you have to go out on that other end and work on it as a different topic that's separate to what is going on with your theme. (Interview 1)

However, providing a context for teaching in the topic of Chance is still important for Tasha.

> So for me it's more ..... with the dice games ..... well, yeah with that one it was just because that came up through the Melbourne Cup happening the week before and they were talking about how they did this and they had won that amount of money. So it came about through that. So it got its context through that. (Interview 4)

Tasha believes that children best learn mathematics by being actively engaged and to be given time to absorb their new understanding.

> [Children best learn mathematics] by doing. By ..... like today's session [Observation 2] by being there ..... by seeing it ..... by being able to play with and explore it all and to think about it. I think that's the important thing. They need time to think about it and they need time to adjust what they're seeing. (Interview 2)

Tasha was asked how she learnt new mathematics as an adult and she said:

> By doing it. I remember a couple of years ago I went to sit for the entrance exam for the Police Force and I had no idea with algebra. I mean I just could not understand to save myself with different fractional parts. But actually just practising. And I had to get people to explain it to me over and over and over until I got it and then it just clicked. (Interview 2)

And when Tasha was discussing the teaching of mode, median and mean (refer to Activity 4-4, page A-48) she said that she found that 'very difficult' and continued to claim:

> No [I haven't tried that in my class]. No not that one, oh no. I would probably have to do a lot more on that for me to understand it. But I mean it probably wouldn't stop me from trying it. (Interview 4)

Even though there are several comments which suggest that Tasha either perceives that she has gaps in her mathematical knowledge or that she feels that she lacks confidence in her own mathematical understanding she does note that she enjoys mathematical challenges.

> Yeah I'm a thinker. I used to adore doing puzzles. I like tangrams and connecting them up. And I do cross stitch. (Interview 2)

Tasha believes that lesson planning for mathematics sessions needs to include variety in instructional approaches. She believes that it is important that pupils are involved in hands-on activities and that the mathematics needs to have a context. It appears that a perceived lack of understanding or unfamiliarity with a mathematics topic places limits on what Tasha is prepared to implement in the classroom.

Tasha: Summary and conclusion - beliefs

Tasha believes that it is important for children to be able to master certain processes and to regularly practice these so that they are not forgotten. Tasha would also appear to believe that the discipline of mathematics was a fairly fixed body of knowledge.

She does not see herself as the only source of knowledge in the classroom but values and respects what her pupils can bring to classroom discussion and the role that they can play in informing their peers. She believes that she should act as a facilitator providing experiences where children can provide much of the input. She places an emphasis on children taking on her role as teacher and giving their own explanations to those who do not fully understand. She sees that it is important to provide a context for her mathematics instruction.

Tasha believes that pupils learn best by working in collaboration. She also believes in the importance of active participation in lessons, where pupils are involved in doing, and using manipulatives. Tasha places an emphasis on pupils struggling with constructing knowledge and encourages pupils to ask their peers for assistance before they come to her for help.

Table 6.6 summarises Tasha's beliefs.

		Instrumental	Relational	Contradictory Evidence	Lack of Evidence
Beliefs	Rules or process	*			
about	Fixed or developing	*			
the nature of	One or multiple solutions				*
mathematics	Mastery or developing inquiry			*	
Beliefs	Knowledge source		*		
about	Lesson format		*		
the role of	Lesson outcome		*		
the teacher	Context provision		*		
Beliefs	Pupil working mode		*		
about	Pointers to success				*
how	Use of manipulatives		*		
children	Measure of learning		*		
learn maths	Rewards				*

Table 6.6: Summary of beliefs indicators for Tasha (* indicators readily available; • possible indicator)

Tasha exhibits relational beliefs about the role of the teacher and about how children best learn mathematics. These beliefs appear to be quite definite beliefs, put into practice and are possibly deep-seated. However her beliefs on the nature of mathematics are not as consistent but tend towards being instrumental. It is possible that her past experiences which have resulted in a lack of confidence in her own understanding were instrumental in nature. Her preferred way of learning any new mathematics is along instrumental lines. Her teaching experiences and her beliefs on teaching and learning may have challenged these instrumental beliefs. These experiences could be the reason for the 'mixed messages' that are evident about her beliefs on the nature of mathematics. This could in turn place some restrictions on the way she views and teaches mathematics and is noticeably the case in the topic of Chance and Data where she has difficulty in seeing the purpose for teaching the topic and connecting it into her thematic approach. This is understandable because she will have had few training experiences or past learning experiences in what is a newly introduced topic into the primary school.

Tasha appears to have deeply held relational beliefs on the role of the teacher and on how children best learn mathematics. The level of these beliefs contrast with the surface level beliefs that she holds on the nature of mathematics. Her beliefs on the nature of mathematics are probably in a state of change and are being challenged by her deeply held beliefs and from observations of what occurs in the classroom. In balancing out the surface level and deeply held beliefs it is the deeply held beliefs which appear to dominate and influence what is put into practice in the classroom, although the recent inclusion of skills acquisition lessons challenges this balance.

The connections and contradictions between Tasha's beliefs, practice and influences are summarised in Figure 6.3.

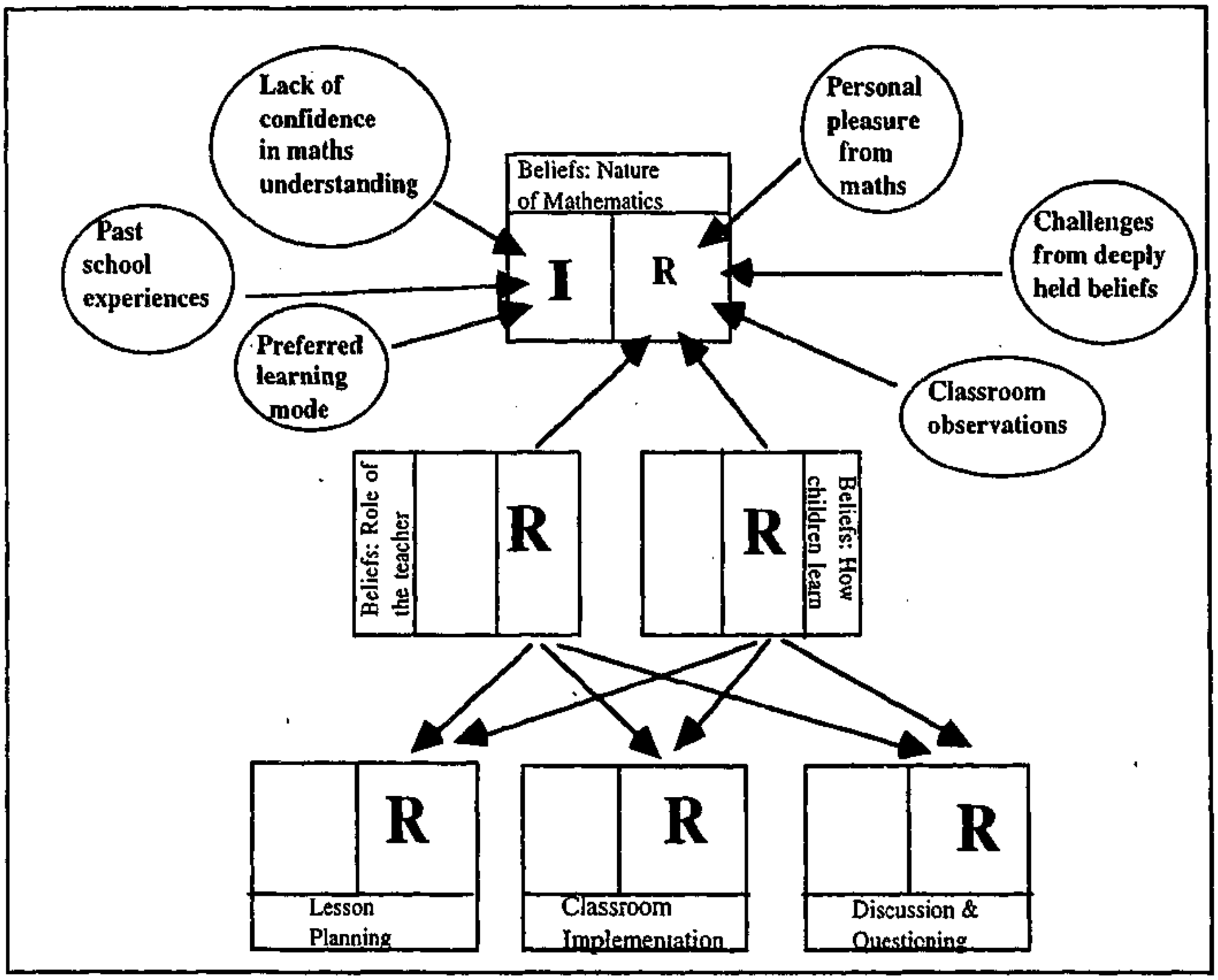


Figure 6.3: Summary of Tasha's beliefs and practice and the influences that act upon them.

GERRY

Classroom practice

Gerry: Background and current situation

Gerry, an experienced teacher, was currently teaching a year 4/5 composite and it was this middle/upper primary level that he had mainly taught in the past. Gerry's classroom was in a double portable at the far end of a row of about ten classrooms that extended out from the main school building. The teacher working at the other end of the portable had year 4. The other two year 5s at the school were in the main building which meant that the year 5s in Gerry's class were quite isolated from their year 5 peer group. This isolation for the year 5 and Gerry's claim that the year 5s did not want to be seen as year 4 was problematic for Gerry. He was concerned about which year level should be the focus in planning and which group of teachers he needed to relate to most.

> I guess my physical location is awkward. I mean as you know I'm a fair way away from the other grade 5s, closer to the other grades 4s, but with a grade 4/5 composite the grade 5 children are probably the ones that dictate more. They don't want to be regarded as grade 4 and they see themselves, probably to some extent disadvantaged because they are not with the other grade 5s. So therefore I've got to be careful that I don't do too many things aligned with the grade 4s as such. (Interview 1)

At the first two classroom observations the tables were organised in rows facing the front of the classroom. Since there were thirty-two pupils this led to a very crowded classroom and one where movement around the room was difficult. There were no sections of the room set up for special activity such as reading library books or playing games and no noticeable mathematics materials on display. Several commercial posters on explorers were displayed along with the 'Room Rules', but not any pupil work.

Gerry justified the arrangement in the classroom by claiming that the year 5s and year 4s did not mix together well.

> With a composite you've got to assess after a period of time on how the grade are going to integrate. As I said the grade 5s don't like working with grade 4s. It looks very structured the way it's set up with them all looking at the board. That's not the way it was at the start of the year. We did have them at tables of 6 and 8. I just felt that it wasn't working with this particular group of kids. For the whole ..... like ideally I'd like to be able to shift and move the tables for different activities. I like to have a floor space where we can all sit together. The only floor space I've got at the moment is the lino tiles which is not comfortable but it's the

> only floor space I can come up with. It's just not the right space. But it doesn't look like a group friendly-type of attitude. (Interview 1)

Gerry: Lesson planning

The first two observed lessons were taken from the *Young Australia Maths* series of teacher and student texts. Gerry said at the time of one of these lessons that he used this source once a week. He also said:

> I don't think any of the others use the Young Australia Maths mainly because, whilst I sing its praises, unless you actually used it and are comfortable with it I think you tend to stick to what you know. We have got it in Grade 5 and 6 and I don't know whether they use it too much up there but I certainly use it. But then other days during the week I might just focus on one particular ..... I might just be doing addition for example or division. (Interview 1)

Gerry was asked if he followed lessons from teacher texts exactly as they are planned in the book and he replied:

> I read the teacher's guide through. I know a lot of people that use different texts without reading the teacher's guide but I always find that the teacher's guides are important. You're going to get a lot more out of any text if you know the ideas behind it. Well I've always read the teacher's guide if I can. [And I follow the notes] fairly closely. I changed a little bit but I think if you know what the basic plan of a lesson is then you can sort of go off at a tangent if you feel comfortable. You are just feeling in the dark without any real guidelines. (Interview 1)

When he was asked where he got his teaching ideas from Gerry replied:

> From staff members around the place. Things that I've done before that I've found have worked. ..... Things that with the CSF the way it is now where we have to actually have to plan pretty rigidly along the lines of the CSF itself. So that limits it to some extent. But in terms of ideas what I've seen and heard and feel comfortable with. (Interview 1)

During the interviews Gerry raised a number of constraints for his mathematics planning. For example the comment above refers to planning restrictions due to meeting the requirements set out in the *Curriculum and Standards Frameworks: Mathematics* (Board of Studies, 1995). The problems Gerry found in teaching a year 4/5 composite have already been mentioned but planning for mathematics instruction added a further complication for Gerry. The *Mathematics Curriculum and Standards Frameworks* has learning outcomes for Year 4 pupils attached to level 3 and for year 5 pupils to level 4. Gerry expressed concern at coping with this in a comment that followed up attending a workshop taken by a well-known in-service presenter in Victoria.

> One of the questions asked [at the in-service] was how would you handle grade 4/5 composite. And [the presenter] said that's a very difficult one because that's over the two basic strands. So therefore he said he'd felt he'd pretty much look at the kids, which is what I generally do, and let them guide you in what they're capable of as a main thrust. But he said the grade 5 would be the main focus. You'd sort of have to construct your work so that the grade 4's would be able to cope with it. (Interview 2)

Another constraint to appropriate planning mentioned by Gerry was focussed on the pressure that teachers and schools are under to be more accountable and in conclusion he stated:

> So therefore I've got to be covering things that maybe I would like to do in different ways. I think education these days is too structured. That's my basic feeling and we've tended to let our kids learn to walk at their own pace but at school we all have to do the same things at the same time and achieve the same results. (Interview 1)

And Gerry, in a response to another question claimed that current demands were 'actually saying that we want to be inefficient' (Interview 2). He referred to the change from the 3-term year to the 4-year term, increasing number of school events, and further government initiatives and concluded by saying:

> We're actually doing things fairly inefficiently in my way. We've pushed too much into it rather than do something and do it properly. (Interview 2)

Gerry was asked if he linked his mathematics into themes or integrated units and he stated:

> Yes we tried that. Where possible. We're doing space for example in the afternoon and we're looking at speeds and distances. (Interview 1)

Gerry: Observation one

This session, which made use of two black-line masters from *Young Australia Maths Level 4,* involved map reading, totalling distances and problem solving.

Gerry began the lesson with some discussion on the meaning of scale and part of the introductory classroom discourse is in discussion extract 5 in Chapter 5. As noted in this discussion extract the pupils gave suggestions - "it's a balance", "measuring", "it's smaller" - which Gerry built upon in further explanation. Using a rough sketch map drawn on the board Gerry posed several problems involving the shortest routes to take between various towns. He consistently used pupil's comments as a springboard into his own explanations and in the direction the lesson took. Gerry's explanations do dominate the discussion where in fact further questioning of the pupils may lead to more meaningful discourse from the pupils' point of view.

Gerry appeared to make a deliberate decision that it was an appropriate time to hand out calculators even though many of the pupils would have found them advantageous before this. When Gerry was asked about this incident he said:

> With the nature of the kids I've got if I'd given out the calculators first I would have had to allocate fifteen minutes for fiddling with the calculators. So I wanted them to have the calculators but I didn't want them to be fiddling with them. So therefore I had it always in my mind that the calculators were going to go out but as to the precise moment no. I just felt that it was time then that we needed to use them. (Interview 1)

Gerry then explained what to do on the first worksheet. This contained a map with distances between towns and some pictures of people who made a journey using the map. There was a set of clues to help work out where each person travelled. The task for the pupils was to work out the total distance travelled by each person. Gerry stopped the class on several occasions to check their calculations and their progress. The following class discussion is an example of this and it shows that Gerry can use further questioning to probe children's thinking.

Gerry:	Oh just stop for a moment. We all know that she went from Bendino to Murray. Which way do you think she went Carrie? Did she go straight along the 281 km way or would she have gone through Milton, what do you think?
Carrie:	The 281 km way.
Gerry:	Why?
Carrie:	Because she bought petrol from Murray.
Gerry:	Yes but she could've gone through Milton and not bought petrol there. Why would she have gone the 281 km way?
Pupil:	Because it's a freeway.
Gerry:	It looks like a freeway. And what else?
Davy:	It would save time.
Gerry:	Why would it save time Davy?
Davy:	Because it's shorter.

Once most pupils had had sufficient time to complete at least some of the calculations Gerry discussed solutions with the class. He commented that the calculators had made it easier. He then began to explain the second worksheet but the lesson had to be stopped because the class reminded him that they were to be at a specialist's lesson.

Gerry: Observation two

This lesson also used a black line master from *Young Australia Maths Level 4.* The sheet had a full page copy of a Snakes and Ladders board. Gerry started off the lesson by saying:

> One of the first games that I ever learnt to play was Snakes and Ladders and it intrigued me that I hardly ever seemed to win. And in fact I thought to myself that this game's not fair. I want you to look at your Snakes and Ladders game in front of you, you've all got one, and I want you to tell me if you think the game is fair.

A number of responses were given by the class:

> It's fair because there's an even lot of numbers.
>
> I think it's only unfair if someone cheats ..... by moving their dice to another number.
>
> It's not fair. There are more snakes.

This last suggestion was taken up by Gerry and the class noted that there were eight snakes and seven ladders. Gerry concluded:

> Eight snakes. So there's eight chances to go down and only seven chances to go up.

The class thought that the chances for going both up or down should be even. But then one boy noted that there were "really long snakes and really short ladders". And with Gerry's guidance the class set about calculating the total number of spaces that snakes took you down and the total number of spaces that ladders could take you up. The need to do a 'take-away' process for 'going up a ladder' proved confusing to the pupils and Gerry spent some time assisting pupils with this. Gerry talked about this incident at the following interview.

> A lot of the kids couldn't understand that going down, getting the difference between the numbers required you to do a subtraction sum and then to add it to the total that you already had for either going down the snakes or going up the ladders. So we would need to do some more structured sorts of lessons on that. (Interview 1)

At several points in the lesson various pupils made a comment such as:

> Everyone's got the same chances of getting on the snakes and on the ladders.

At first Gerry appeared to ignore this notion but he did eventually acknowledge the comment and agreed with it but did not pursue any further class discussion on the idea. At this point in time he seemed more intent on following through the calculations for totalling all the 'snake moves' and all the 'ladder moves'. This worked out to be a total of 160 for going down snakes and 108 for going up ladders. Gerry concluded:

> Now that's a lot more squares going down than there are going up. Jane said that the game is fair because it's just a matter of luck where you land, isn't it? Some people might say it's not

> quite fair because you've got more squares going down when you're actually going down the snakes compared to how many squares going up the ladders.

Discussion finished here and the pupils used the worksheet to play a game of Snakes and Ladders.

Gerry had photocopied another set of worksheets that were of a blank Snakes and Ladders board to be used for designing a game board but this was not used in this session. They had not been used by the time of the first interview (a week later) and Gerry again referred to the constraints of a crowded school day – 'cross country this morning' and 'Mother's Day coming up' (Interview 1).

When Gerry was asked what the outcomes for this lesson were he answered:

> Well certainly looking at problem solving and I'd have to actually look at the checklists to determine that. Problem solving and the ability to add and subtract. The ability to use the calculator. Probably that would be about it. Simply I mean I think that any lesson you wouldn't be looking at too many outcomes. Two or three would be about it. And [for assessment purposes] from what I did I'd probably have to talk individually to the kids to be able to determine what they understood. (Interview 1)

The tenor of this comment may suggest that Gerry chose the activity because it looked interesting rather than on the learning outcomes inherent in the task.

Gerry: Summary and conclusion – classroom practice

Gerry did not make use of just one resource in his planning but took ideas for planning from a variety of sources, including his past experiences. There were many instances where Gerry noted external factors that impeded what he planned and implemented in the classroom. A lesson pace appeared to be established where Gerry read the response he was getting from his class and made decisions as to whether to alter the pace or even abandon the lesson and change to something different. It is possible that Gerry tended to run with one-off lessons and based planning on 'good activities' that he knew of rather than work from the needs of the class.

Although Gerry seems to take control of most explanations, the stimulus for his explanations has arisen from pupil responses and comment. These explanations are not teacher-directed in the sense that they necessarily follow a step-by-step set of procedures. For the two observed lessons Gerry did not make use of collaborative teaching strategies although an atmosphere was established where pupil input into whole class discussion was valued. In interview comments Gerry made reference to valuing pupil input and explanation and that he preferred pupils to work in small groups, but this was not observed. As already noted Gerry was prepared to deviate from what was planned and in fact much of the direction of the lesson was directed by the input from pupil comments. The only teaching aids used in the observed lesson were calculators although Gerry did state that he thought that pupils should be immersed in experiences and activities using manipulatives. Gerry acknowledged that he was aware of groups within a class that might be educationally disadvantaged but it is not clear as to whether such groups were catered for during the lesson. Gerry stated that he made mathematics connections to other curriculum areas but the overall impression is that this occurred incidentally and that the planned mathematics lessons were most likely not related to what else was going on in the classroom.

At the start of the year Gerry's classroom layout had been conducive to pupil-pupil discussion but at the time of the first two observations he had altered the layout to rows of tables because of perceived constraints. Gerry was quite accepting of pupil's comments and used these to generally direct the flow of the lesson. However, rather than probe pupils' ideas further with on-going questioning Gerry used the pupil input for his own explanations. Because of this it is probably understandable that the SCAN analysis noted that Gerry's use of explanations ranked as the highest - especially for relational explanations. Nearly all of the dialogue was teacher-pupil. The SCAN analysis completed in Chapter 5 rated Gerry with five indicators as relational and two indicators as instrumental. Gerry rated as relational on the proportion of questions requiring more than just simple recall (q+) and the indicator QQ which involved the ratio of 'q+ questions' to 'qs questions' favoured the asking of 'q+ questions'. The indicator 'con' which measured the proportion of times that confirming events were used rated Gerry as the one who did this the most. The analysis based on Transcripts showed that Gerry made use of questions to ascertain the pupil's knowledge and that a range of responses, although not necessarily encouraged, still resulted. Gerry was accepting of the pupil responses and used these to give direction to the lesson and on which to build his own explanations.

Table 6.7 summarises Gerry's classroom practice.

		Instrumental	Relational	Contradictory Evidence	Lack of Evidence
	Lesson source		*		
	Individual differences		•		*
Lesson	Innovation				*
Planning	External factors	*			
	Assessment				*
	Lesson pace		*		
	Lesson initiation	•			*
	Teaching style		*		
	Pupil mode			*	
	Deviation		*		
Classroom	Manipulatives		•	*	
Implementation	Lack of understanding		•		*
	Pupil working time				*
	Struggling pupils				*
	Making connections		*		*
	Classroom layout	*			
Discussion	Handling discussion		*		
and	Dialogue directions	*			
Questioning	Questioning approaches		*		
	Type of questioning		*		
	Explanations		*		

Table 6.7: Summary of classroom practice indicators for Gerry.
(* indicators readily noticeable; • possible indicator)

This summary generally confirms Gerry as a relational teacher. Interview comments suggest that Gerry felt very restricted in his teaching approach by a number of external constraints.

Explaining classroom practice

Gerry: Perceptions of the role that pupils play in the learning process

Gerry valued the pupil's comments and responses and tended to base the direction of the lesson around what happened in the classroom. However, unlike some other 'relational teachers', he didn't follow through with further questioning to probe children's thinking but became the main provider of explanations. In the two observed lessons there was no planned opportunity for pupil-pupil discussion or reflection.

Although neither of the observed lessons involved pupil collaboration or a large amount of pupil explanation Gerry claimed in interviews that he valued the input that pupils could make and that he made use of small group work.

> Yeah I like kids working together. I mean I think it breaks down a lot of frustrations with kids if they've got somebody else who can help them. I mean some kids who are quite reasonable mathematically but haven't got some of the basic skills in mathematics ..... if they've got somebody there who can use a calculator or can do this, that and the other thing or do the subtraction sum they can still have the ideas and work together. (Interview 1)

Gerry picked out pupil collaboration as a key to his judgement of a successful lesson.

> [I would judge as successful] any lesson where the kids are talking a lot, where the kids are interacting a lot and realistic interaction where they are prepared to listen to one another indicates to me that the kids are pretty much on track at least. Then at the end of the lesson hopefully you can share together in groups or together as a total class and you can share what you have got from it. (Interview 3)

The pupil interaction that Gerry refers to in Interview 3 may not necessarily relate to the pupils working collaboratively but could be the reactions he likes to observe in whole class discussion. That is, are the children responding to his comments in an on-going way providing him with the impetus to continue with what he wanted to achieve.

Gerry's belief in the value of pupil collaboration was probably summarised when asked if he valued pupils working together:

> I think that maths is a lot less threatening for kids if they can share things and talk about it with others. I think they are just sitting in a vacuum with a sheet of paper and a pencil and told. It can be very threatening. (Interview 4)

However Gerry added:

> But then a lot of classes seem to work quite well that way. (Interview 4)

This last comment is interesting. The most likely implication is that Gerry is saying that the 'teacher exposition and transmission of knowledge' approach is still an appropriate means of instruction for some teachers but that it is not his preferred way of teaching. Gerry has alluded to achieving results through 'exposition and transmission' in several other comments. For example, Gerry made the following comment when he was outlining his typical mathematics lesson.

> I guess it depends on the group of kids I've got. I'd say that it'd be fair to say I find that some kids respond very well to rote inane stuff, others don't. (Interview 1)

And when asked if learning mathematics was like learning to ride a bike his initial response was:

> Well I think, you know, you learn your tables and I don't think you ever tend to forget them. (Interview 2)

During the interviews Gerry offered a number of insights into his views pertaining to giving explanations. When asked if he thought children learnt Chance in a different way to other mathematics topics he said:

> You can actually explain things but then if you explain too much there's a fine line between explaining too much and them not actually discovering for themselves. I think immersion is the key, giving them as many different experiences as possible. (Interview 2)

Midway through the *3Cs* sessions Gerry was asked which of the three content areas in the workshops was the most useful to him. He chose the 'strategies which encourage children to talk' topic and said:

> I like the kids to talk about what's happening too. I don't think kids learn a lot specifically by being told. I think they learn actually experiencing first hand and I think that they're all at different levels and stages of development. (Interview 3)

When he was asked if he thought the teaching of chance was different to the teaching of other mathematics areas he replied:

> Like often I'll get a kid to come out the front if I've been trying to explain something for ten minutes and getting no where. Often a kid will come up with the right word and sort of get through. (Interview 1)

These comments suggest that Gerry believes that there has to be a balance between his involvement in explaining and that he values the input the children may be able to give.

The classroom observations do indicate that pupils were encouraged to share in the discussion, but on a whole class level not in small groups or with each other. The classroom observations also showed that Gerry dominated the giving of explanations. Perhaps this can be explained by the constraints that have already been mentioned. Gerry does allude to difficulties that he had in implementing what he really preferred.

> Ideally I like the kids to be actively involved and discussing and integrated with one another, sharing ideas that they might have but some groups just don't work all that well that way. (Interview 1)

Gerry believes that pupils have an important role to play in the learning of mathematics but a number of perceived and real constraints means that he is not fully implementing his preferred teaching style. Perhaps he sees the solution as returning to a more traditional model of teaching. Thus the classroom layout has been rearranged to have children in rows facing the front of the classroom. And perhaps his dominating role in explanations is also a way of coping with this perceived difficult situation. In conclusion Gerry believes that the contributions that pupils can make plays an integral part in the learning process but because of a number of constraints he is not fully implementing these beliefs.

Gerry: Perceptions in the purpose for teaching mathematics

It would appear from the two observed lessons that Gerry sees the purpose of teaching mathematics as meaningful exploration of concepts. Class discussion is managed in a way where pupil input plays an integral part in the direction which the course of the lesson and the explanations take.

When Gerry was asked what he saw as the purpose for teaching mathematics he replied:

> I think mathematics is part of life. It's around us every day. I mean it's something that should be enjoyed really. I think mathematics hopefully is part of our everyday life that's fun. (Interview 2)

This comment fits the observation that Gerry's lessons were all about exploring mathematical concepts of real value to his class. Gerry's belief is that you learn mathematics to be able to participate in life in general. And note that he saw that this should be an enjoyable experience. When asked what he saw as the purpose for teaching chance he added that learning mathematics was preparation for being able to cope with the challenges presented in life, which he exemplified by referring to workplace changes.

> Who knows where, not so much in my workplace, but these kids where their workplace is going to go. I mean the way that they can slot into computers now and they're prepared to experiment and if they don't get it right they try again sort of thing. Kids are much more into experimentation and being prepared to not get it right and still go on these days. And that will stand them in good stead for what ever forms of employment pop up in the next few years and hopefully that ability to adapt will certainly help them. (Interview 2)

These views on the purpose for teaching mathematics are consistent with Gerry's views on the nature of mathematics. When asked if he thought learning mathematics was like learning to ride a bike he initially gave an instrumental view, but qualified this by stating:

> But I think you've just got to continue to exercise your mind. I think it's ..... you've got to continue to put yourself in the position where you're working from the known ..... from the known to the unknown and I think you've got to keep exercising. I think mathematics is something that's always something new, really. (Interview 2)

After the *3Cs* program was completed Gerry was asked if he still had the same view about how children learn chance. He replied:

> Well I think that you can help kids along the way by giving them lots of opportunities. I think I probably would have said that at the outset. But with varied and more structured settings I think the kids maybe get more from it, maybe progress more quickly if you give them more structured and varied activities again to hopefully clarify a little more in the kid's minds. (Interview 4)

These notions of learning being seen as building upon existing knowledge and for learning to be a gradual process resulting from a series of structured events is closely in line with constructivist thinking.

Gerry noted that his past schooling experience, because of the teaching approaches at that time, had left him with a negative attitude towards mathematics whereas he now enjoys and is stimulated by the mathematics tasks that his Year 8 son completes at home. He indicated that a change occurred in his attitude towards mathematics in his first years of teaching.

> See I did probably then have a reasonably negative view towards mathematics. Not something that I hated or anything like that but I felt that I wasn't strong in that area. And probably actually when I was teaching in a rural school when I had some very clever grade 6's we did a lot of work there that I never understood at school. I learnt a lot there and I thought, "Well I'm not all that bad you know". (Interview 2)

In the third classroom observation Gerry attempted to have the class investigate the chances of winning the AFL premiership from their position in the final eight, a task beyond the capabilities of most Year 4/5 pupils. Gerry admitted that he partly did this lesson because of personal interest and that he 'wanted to see how the pattern went' (Interview 4).

The notion of enjoying mathematics and having a positive attitude is part of Gerry's underlying beliefs in children's learning.

> Well I think probably a lot of the things that we try to teach in mathematics to young children we probably teach too early. And I think as you get older I mean, some things that I could never really grasp at school I could obviously grasp really easily now. And I think maybe we push kids too early and as result they get a little bit of a negative view of mathematics. Thinking it's too hard and they get an impression of themselves as failures which is obviously something we try to avoid. Because I think most people can achieve a reasonable level of mathematics but I think in our school situation we're a bit into overkill and we push them too early. (Interview 2)

In a later interview Gerry was asked if he thought learning mathematics was like learning to play a musical instrument and his response to this query drew out the related notion of confidence in mathematics ability.

> Well I think one thing about mathematics compared to playing a musical instrument or riding a bike or .... you really need confidence. ..... So I'd say playing a musical instrument you've got to be prepared to take a chance and you've got to have confidence in your own ability to take that chance and be reasonably successful. (Interview 4)

Gerry: Dealing with mathematics and pedagogy

From the observations and interview comments Gerry gives the impression that he was quite capable of dealing with the mathematics content in what he was teaching. Although for the two observed lessons he relied on a commercial text, Gerry did state that he drew his classroom activities from a variety of sources. Gerry also had the confidence to allow a lesson, within certain parameters, to take it's own direction. On the other hand Gerry's lessons appeared to be one-off sessions and it was difficult to gauge whether there was any developmental flow in the mathematics lessons planned and whether there was very much connection made to other areas of the curriculum.

There are many examples which illustrate Gerry's capabilities in mathematics, his insights into children's thinking, and his general pedagogical knowledge. Some of these have already been included in previous discussion but other examples are given here. One example occurred in the first *3Cs* session when Gerry's table group was discussing their responses to the question posed in the 'Rolling two yellows' problem (refer page A-11 & A-19). Gerry's table group were sharing their thinking:

> Helen: This [obtaining yellow on Die 1] has a 50% chance and this [obtaining yellow on Die 2] has more than a 50% chance so wouldn't it be somewhere in the middle?
>
> Gerry: It actually reduces. You actually multiply the two together. I think you end up getting a lesser chance. You've got to get it on both. (*3Cs* session 1 transcript)

When asked about some of the chance activities that he had tried from the *3Cs* workshops Gerry talked about the Dicetracks game [page A-7] where the main point of the lesson for Gerry was for the pupils to see an overall pattern emerging.

> It was interesting to see how kids saw it differently and came around to the thinking that one particular colour had more of a chance than others. Well a lot of the younger ones assumed the short track was going to be the best way to go initially. And then when the short track didn't win the first time they instantly changed over so it was like they were sort of following their tails if you know what I mean. They really weren't trying to work out a sort of a pattern or system. Which ever one won last time they assumed that it was the most likely one to come up. It was interesting. (Interview 3)

When Gerry was asked if he thought that language and mathematics were learnt in the same way he noted that he preferred children to be actively engaged in a lesson. He said that he thought that mathematics and language were both developmental. When asked to explain what he meant by developmental he replied:

> Stages. One step after another. And I think whilst you can move ahead in steps you've got to be careful you haven't gone too far ahead so that they just haven't got the foundation. If you're immersed in number and number activities you will be going to learn mathematics. (Interview 2)

Gerry thought that children best learn mathematics through activity and handling materials thus reinforcing this 'immersion notion'.

> Certainly they learn through a hands on approach. I think they actually need to have as many physical aids as they can. (Interview 2)

Gerry's 'immersion' approach was clarified further when he described how he would implement several tasks in his classroom. In interview when Gerry was asked how he would implement the 'Green & Blue Card' problem (refer to Shaughnessy, 1992, page 474) with his class he said:

> We'd just experiment for awhile until some sort of pattern arose I think. [We'd do lots of trails] and we'd note down and see if there was any pattern. (Interview 2)

Gerry saw that mathematics was a part of other curriculum areas.

> Well I suppose a lot of our classrooms these days have got integrated curriculums where I guess we're trying to put the whole lot into a package and covering as many things as we can all in the one. (Interview 2)

Gerry: Summary and conclusion - beliefs

Gerry sees that mathematics as a discipline is dynamic, changing and open to revision ..... 'working from the known to the unknown'. He also sees that it is important to develop processes of inquiry and adaptability. Although he acknowledges that rules and skills need to be learnt he also feels that it is important that children learn from first-hand experiences and build knowledge on previous learning.

Gerry believes that pupils have ideas that are valuable. He considers that pupils should play an important part in the lesson, sharing ideas with each other and being immersed in the experience. This immersion includes making use of manipulatives and where possible providing a context. Gerry argues that as a result of the pupil's immersion in activities they should be able to understand underlying concepts and patterns.

Table 6.8 summarises Gerry's beliefs.

		Instrumental	Relational	Contradictory Evidence	Lack of Evidence
Beliefs	Rules or process		*		
about	Fixed or developing		*		
the nature of	One or multiple solutions				*
mathematics	Mastery or developing inquiry		*		
Beliefs	Knowledge source		•		*
about	Lesson format		*		
the role of	Lesson outcome		*		
the teacher	Context provision		•		*
Beliefs	Pupil working mode		*		
about	Pointers to success				*
how	Use of manipulatives		*		
children	Measure of learning		*		
learn maths	Rewards				*

Table 6.8: Summary of beliefs indicators for Gerry (* indicators readily noticeable; • possible indicator)

Overall Gerry exhibits relational beliefs on the nature of mathematics, the role of the teacher, and how children best learn mathematics. It is likely that these beliefs have developed over a long period of time and each set of beliefs has influenced the other two sets of beliefs. These relational beliefs are certainly a product of past classroom observations and working with children, especially in Gerry's early years of teaching. These past experiences, according to Gerry, reversed a negative attitude towards mathematics that he had during his own schooling. The current positive attitude and relational beliefs that Gerry has towards mathematics has resulted in a pleasure that he gains from his own personal endeavours in problem solving. This enjoyment from problem solving may have in turn reinforced the relational beliefs that he has on the nature of mathematics.

Gerry implements his relational beliefs in mathematics by encouraging pupils to think about and explore the concepts under consideration and to give input into class discussion. Connected to these beliefs are the notions that learning mathematics should be enjoyable and that teaching should be approached in a way that allows pupils to feel confident about what they are attempting. A relational approach to teaching mathematics has been adopted and the classroom discussion that occurs is aimed at meaningful understanding, even though Gerry dominates explanations. His lesson planning generally follows a relational approach, although it is constrained by his perceived difficulties with coping with a composite grade, a 'crowded curriculum', and the need to be 'CSF-focussed'.

The connections and contradictions between Gerry's beliefs, practice and influences are summarised in Figure 6.2.

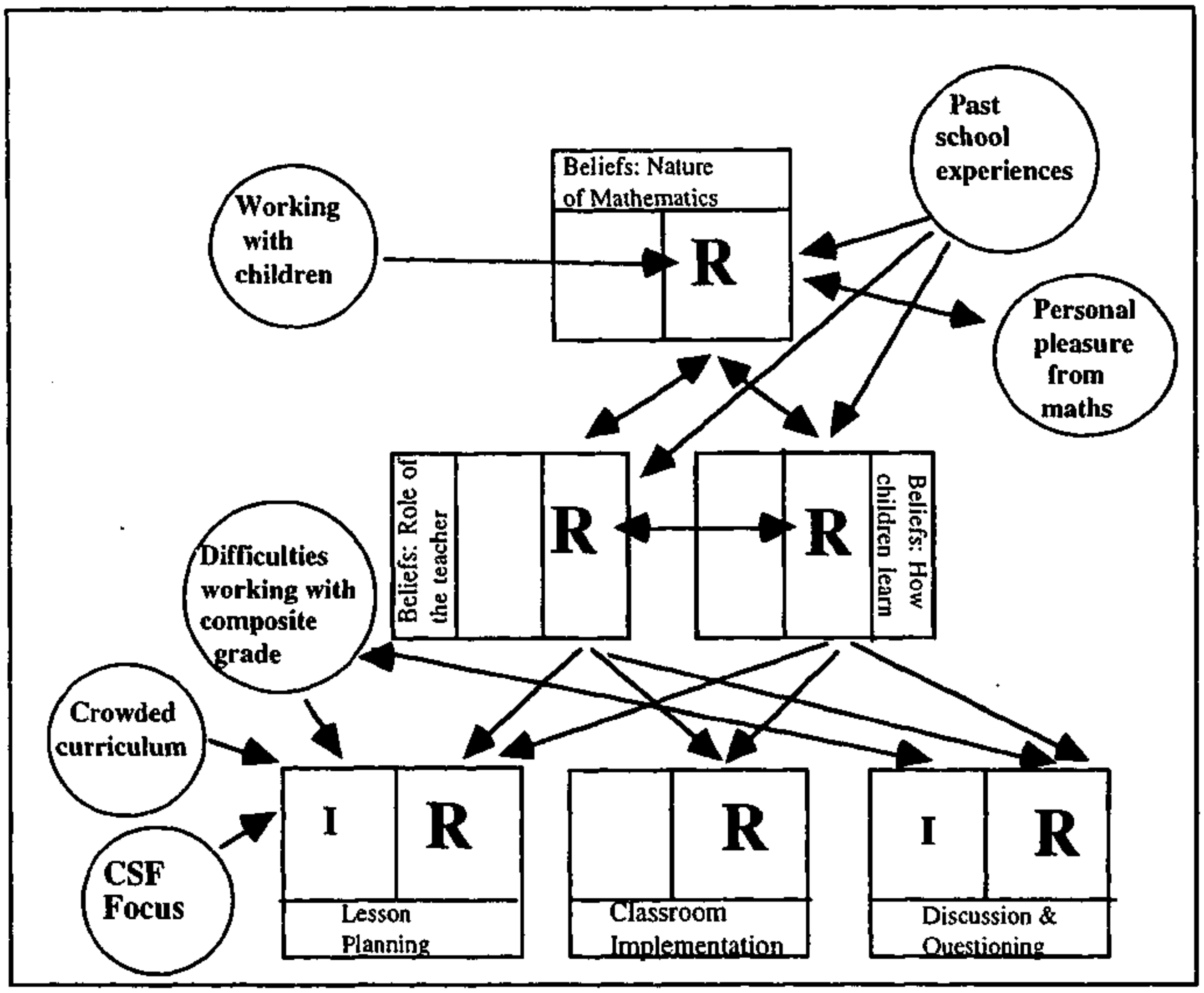


Figure 6.4: Summary of Gerry's beliefs and practice and the influences that act upon them.

INSIGHTS

The analysis and interpretation of the case study teachers' classroom practice and beliefs has led to additional insights into instrumental and relational differences. However these insights are based on the analysis of data pertaining to only four teachers, so they may not be as indicative as the insights made at the conclusion of Chapter 5.

Insight 6.1: Classroom practice results from a balancing of deep-seated and surface-level beliefs

Table 6.9 summarises the possible scenarios for each case study teacher (refer to the text following Tables 6.2, 6.4, 6.6 and 6.8). This table shows that the resulting classroom practice for each teacher is a result of deep-seated beliefs over-riding surface-level beliefs, even when the surface-level beliefs are counter to the deep-seated beliefs. This generalization does not take into account any other influences and constraints that may be contributors to the teachers' classroom practice. For Malcolm one set of deep-seated beliefs over-rides another set of deep-seated beliefs.

Case study teacher	Deep-seated beliefs	Surface-level beliefs	Classroom practice
Deidre	•Instrumental beliefs on the nature of mathematics •Instrumental beliefs on the role of the teacher	•Relational beliefs on How children learn	Instrumental
Malcolm	•Relational beliefs on the nature of mathematics •Instrumental beliefs on the role of the teacher	•Relational beliefs on How children learn (•Developing relational beliefs on the role of the teacher)	Instrumental
Tasha	•Relational beliefs on the role of the teacher •Relational beliefs on how children learn	•Instrumental beliefs on the nature of mathematics	Relational
Gerry	•Relational beliefs on the nature of mathematics •Relational beliefs on the role of the teacher •Relational beliefs on how children learn		Relational

Table 6.9: Summary of the possible explanations for classroom practice

An analysis of Table 6.9 also leads to the following further insights:

Insight 6.2: Each teacher has their own unique I/R profile and explanation for their resulting classroom practice (thus reinforcing Insight 5.1)

and

Insight 6.3: 'Instrumental' and 'relational' teachers do not necessarily have corresponding beliefs on the nature of mathematics

Insight 6.4: Deep-seated beliefs are likely to result from past school experiences

and

Insight 6.5: Teaching experience is a contributor to shifting instrumental beliefs and practice towards relational beliefs and practice

Deidre and Tasha's past school experience and the success that resulted has possibly meant that they have maintained instrumental beliefs on the nature of mathematics. For Malcolm, his past school experience has possibly influenced his beliefs on the role of the teacher. Whereas Gerry, who is the teacher with longest experience, readily acknowledges that various incidents throughout his teaching career have altered his beliefs. Through professional development this is also occurring for Malcolm, but not to the extent that it has produced dominant beliefs. This infers that over time a teacher's own school experiences become less a determinant of beliefs and practice.

Insight 6.6: Enjoyment or pleasure from solving mathematical problems may lead to relational beliefs on the nature of mathematics

and

Insight 6.7: Confidence in mathematical ability can reinforce instrumental beliefs on the nature of mathematics

Both Malcolm and Gerry gained enjoyment from solving mathematics problems and it is quite possible that this has encouraged them to see that mathematics is more an exploration of ideas rather than the regurgitation of a set of rote rules.

Both Deidre and Tasha rely on practice and completing set procedures for their own mathematics, notions that come from past school experience. Because this has brought success in the past it has reinforced their instrumental views on the nature of mathematics. In fact, Deidre is so confident about her mathematics ability that these instrumental approaches greatly influence her classroom practice.

Insight 6.8: External factors and constraints generally produce instrumental classroom practice

Other than Tasha the introduction of the CSF had been seen as a constraint to a more open-ended approach to lesson planning and other curriculum decisions and in turn had resulted in perceived restrictions to teaching approaches. For Gerry a number of other perceived constraints had meant that he had adopted some instrumental practices during the time of the pre-*3Cs* classroom observations.

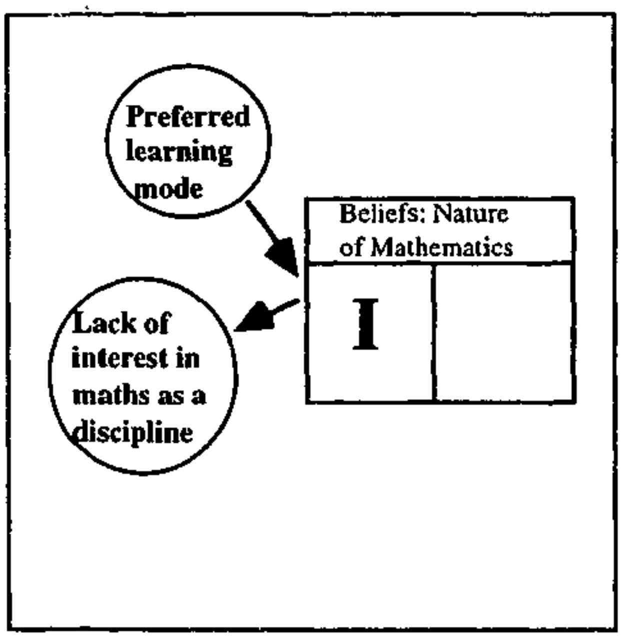
Predictions

The following section makes use of the summaries for each case study teacher in order to predict their reactions to both the *3Cs: Chance, Constructivism & Collaboration* course content and to features of effective professional development. The reaction to *3Cs* content will be gauged by the extent to which *3Cs* activities are trialled in classrooms. Each prediction is accompanied by the appropriate section of the relevant figure (Figures 6.1, 6.2, 6.3 and 6.4) used to summarise that case study teacher's beliefs, practice and the influences acting on their beliefs and practice.

Deidre - PD prediction

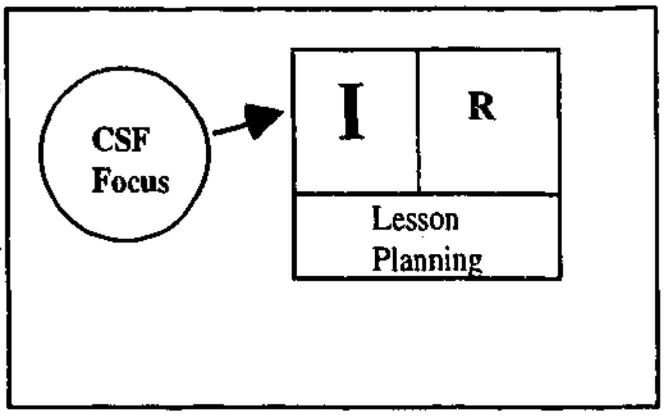
Prediction - trialling of *3Cs* content

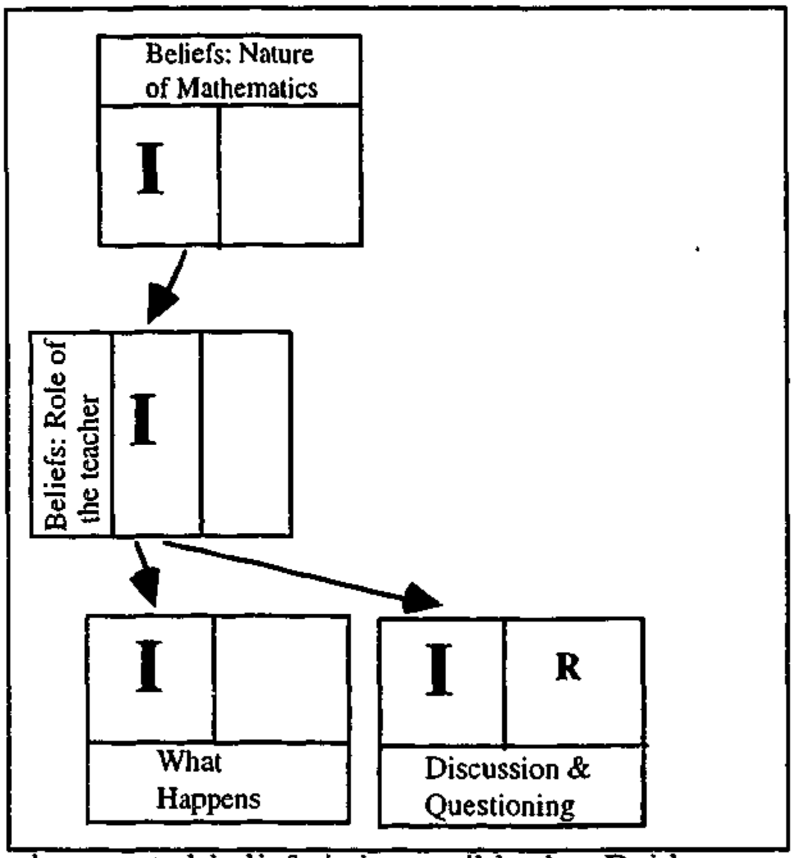
Deidre displays strong instrumental beliefs about the nature of mathematics. Most of the *3Cs* mathematics activities and the way in which they were presented mirrored relational beliefs on the nature of mathematics. Such activities rely on exploration of ideas and learning through discovery that is not Deidre's preferred way of dealing with mathematics.



Because of this Deidre may trial only a few of the activities and prefer activities that have as their outcome the establishing of a rule or set process. The way in which the activities are presented may also be modified so as to accommodate Deidre's instrumental beliefs. These instrumental beliefs have produced a lack of interest in mathematics and it could be expected that this factor will discourage her from being interested in the problem solving activities presented at *3Cs*.

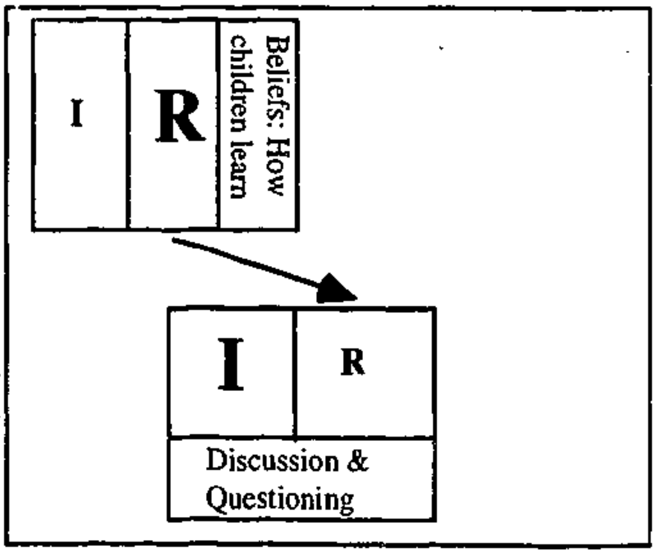
However the mathematics activities in the *3Cs* workshops were not presented in any context and tended to be one-off tasks. This is likely to fit in with the way Deidre plans her mathematics teaching where she uses a structure that does not tend to relate one mathematics topic to another and she does not usually relate mathematics to class themes. This planning structure is supported by her CSF focus and her beliefs about the role of the teacher.

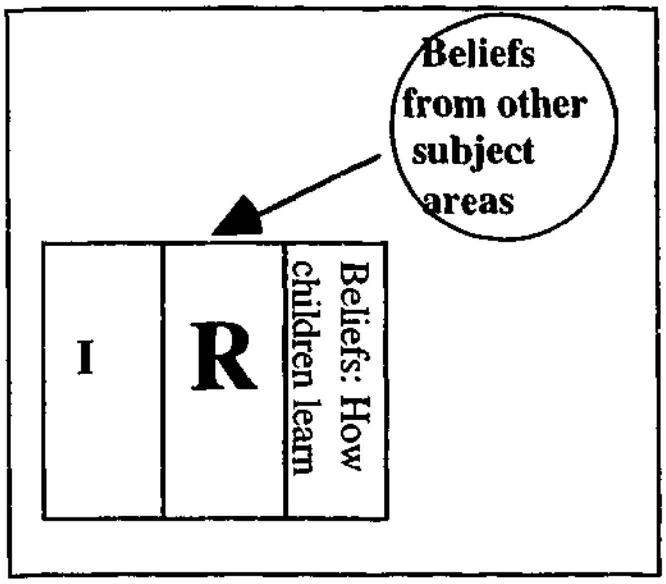




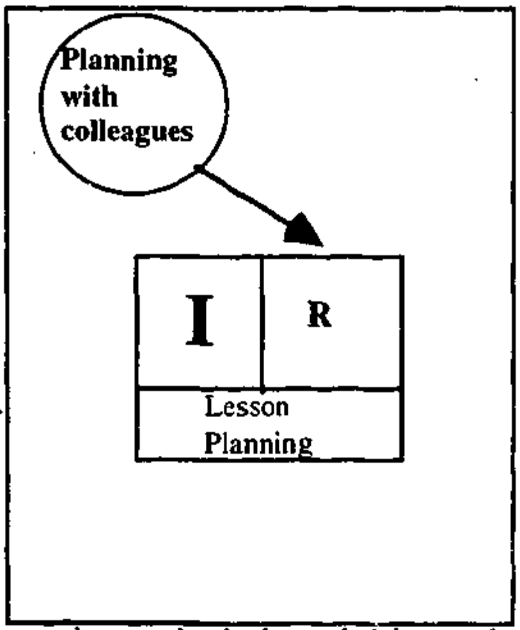
Deidre's instrumental views about the nature of mathematics appear to inform her beliefs about the role of the teacher and it is these beliefs that are implemented in the classroom. Deidre regards her role as being 'explainer' rather than as a 'facilitator' and it is this 'explainer' role that is implemented in the classroom. The *3Cs* program, with its emphasis on using collaborative teaching strategies and constructivist notions will not support these beliefs and practice but challenge them. Since the instrumental beliefs appear to be deep-seated beliefs it is possible that Deidre may be reluctant to trial the collaborative strategies and constructivist ideas presented at the *3Cs* workshops.

However, Deidre does have relational beliefs about how children learn mathematics. implemented in the way she organises the layout of her classroom and are thus possibly surface level beliefs. This conflict then presents a dilemma for Deidre. Deep-seated instrumental beliefs about the role of the teacher are challenged by surface level beliefs about how children learn mathematics. Deidre is thus likely to be tempted to trial the collaborative strategies and the construcivist notions, but in the balancing of her beliefs may opt not to try them in the classroom.

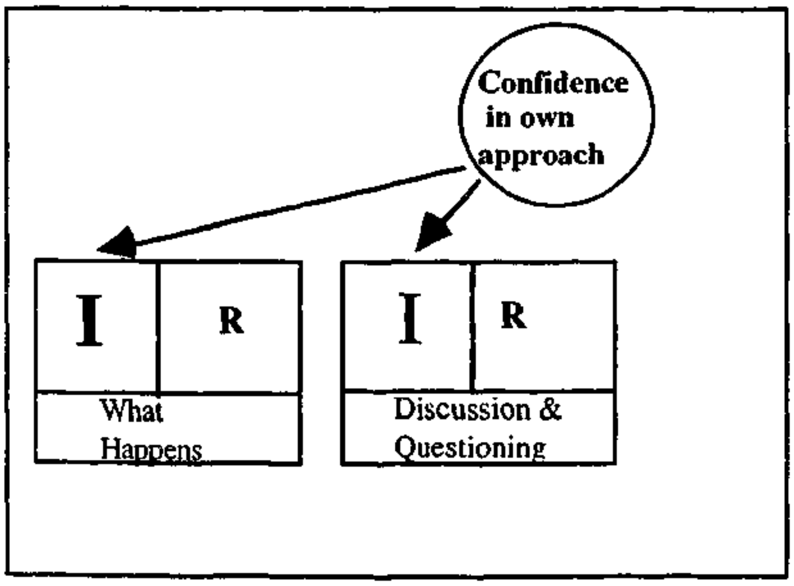




Deidre's relational beliefs are possibly supported by her beliefs as to how children best learn in other curriculum areas. If the activities from the *3Cs* workshops tap into other curriculum areas Deidre may be encouraged to attempt the activity with her class. The most obvious example of this is Activity 1-2 which makes use of the language of Chance (refer page A-4).



Since Deidre plans closely with her colleagues much of her classroom trialling of *3Cs* activities will depend on their reactions and enthusiasm. If the team decides to trial the *3Cs* activities Deidre is most likely to trial the ones involving collaborative teaching strategies because these are the ones where she has corresponding beliefs, even though they are surface level. The support of her colleagues may allow an element of risk taking and result in Deidre's trialling of these strategies. The team planning in which activities are drawn from a number of resources provides an opportunity in which it will be appropriate to include activities and ideas from yet another resource, especially one in which they have all participated.



Because Deidre is very confident that what she is doing is sound her colleagues will need to be quite persuasive if they want to plan as a team the trialling of *3Cs* activities. This will particularly apply to the mathematics content and the open-ended approach that was taken for many of the activities.

Summary

In regard to the *3Cs* mathematics content Deidre:

- may trial few mathematics content activities because the ones presented in the *3Cs* workshops do not generally match her deep-seated instrumental beliefs in the nature of mathematics nor the way in which she prefers to deal with mathematics;
- may trial a low amount of mathematics content activities because of lack of interest in mathematics problems;
- will favour, because of her instrumental beliefs, those mathematics activities that result in pupils being shown how to do set procedures or learn rules;
- is likely to adapt the modelling of the mathematics activities so that they reflect her preferred instrumental style of teaching;
- may find it difficult to balance whether she trials the 'one-off type' mathematics activities advocated. It will be easy to incorporate such activities because most of her mathematics instruction is context free and when team planning takes place activities and ideas are drawn from a number of resources. But it may be difficult to include one-off activities from the *3Cs* program because she plans having in mind the pupils' needs and not the effectiveness of the activities;

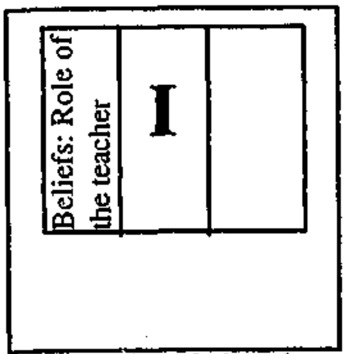
In regard to the *3Cs* teaching strategies content Deidre:

- may trial activities because of the support and enthusiasm her colleagues have although the confidence that she has in her instrumental classroom approach will be difficult to counter:
- could be reluctant to trial the collaborative strategies because they do not match her beliefs about the role of the teacher. On the other hand may be tempted to trial them because they match her relational beliefs about how children best learn mathematics;

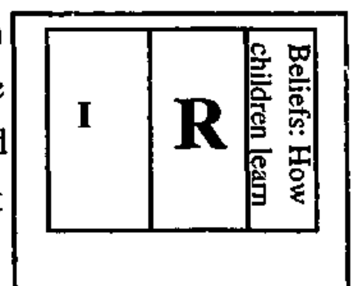
In regard to the *3Cs* constructivist notions content Deidre:

- could be reluctant to trial the *3Cs* activities involving constructivist notions because they do not match her beliefs about the role of the teacher although she may be tempted to trial them because they match her relational beliefs about how children best learn mathematics.

Prediction - reaction to features of effective professional development



Deidre's instrumental views on the role of the teacher suggest that she sees herself as the holder of knowledge, that lessons are teacher-directed, and that an important lesson outcome is for the pupils to gain correct answers. These beliefs result in Deidre taking on an 'explainer' role. This may mean that she prefers a professional development presenter to also have such a role. If so she will have found the *3Cs* presenter frustrating because of her 'facilitator' role. Because she does not believe that pupils have an important role in the learning process it is possible that this translates into a view that her input into professional development is also not important. This may imply that Deidre would not value the effective features of 'ownership' and building upon the 'issues of concern held by teachers'. One aspect of implementation of instrumental beliefs on the role of the teacher is that reflection for pupils is not provided. If this translates into professional development it may mean that Deidre would prefer professional development that is not 'over an extended period of time'. It may also mean that, if she trials *3Cs* activities in her classroom, her reflection on the value and outcomes in terms of benefits for her pupils could be limited. This limited view of the value of reflection time could also mean that she does not have a long term view for own professional development.



However Deidre has some relational beliefs as to how children best learn mathematics which sets up a possible dilemma. She believes that pupils learn better by working collaboratively and that the use of manipulatives is beneficial. This could mean that Deidre will value going to the *3Cs* workshops with a group of staff from her own school. This could be especially meaningful because Deidre already plans with a collaborative teaching team. It may also mean that she will appreciate the manner in which the *3Cs* presenter facilitates small group work where hands-on activities are undertaken. These relational beliefs may mean that Deidre values the idea of 'researching in classrooms' and judging this by the responses from the pupils. However it must be remembered that these relational beliefs held by Deidre are surface-level beliefs and not actually implemented in her classroom. It is thus possible that in the balance of what happens that Deidre favours the professional development features implied by her instrumental beliefs in the role of the teacher.

Summary

In regard to features of effective professional development that provide procedures for support and collaboration Deidre:

- is likely to value attending the *3Cs* program with her team-teaching colleagues based on her relational beliefs about how children learn mathematics and because of the importance that the group places on joint planning;
- could be frustrated by the relational/constructivist approach taken by the *3Cs* presenter because of her instrumental beliefs that a teacher has an explainer role. Her relational beliefs about how children learn best may lead her to appreciate the presenter's facilitation of small group discussion and hands-on activities;
- is likely to value listening to the discussion from other teachers because of her relational beliefs about how children learn;

In regard to features of effective professional development that provide a teacher-centered focus for content and organization Deidre:

- is likely to place a low priority on the professional development features of 'ownership' and 'issues of concern recognised by the teachers themselves' based on her instrumental belief on the role that children play in the learning process;

In regard to features of effective professional development that provide opportunities for observing outcomes and reflection Deidre:

- may have a limited view of the idea of 'researching in classrooms' but could judge the success of the outcome on either instrumental or relational terms;
- may prefer the *3Cs* program to have been conducted over a much shorter period of time because her beliefs do not translate into giving pupils reflection time;

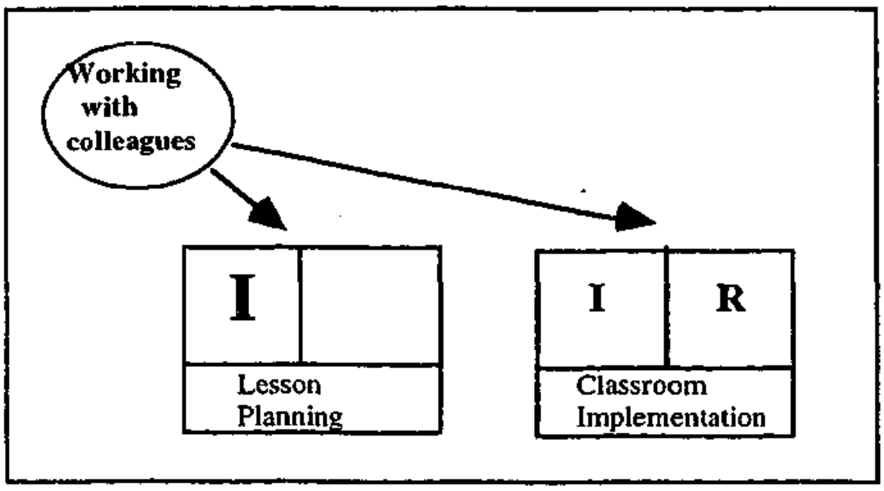
In regard to features of effective professional development that provide a philosophy on teacher change Deidre:

- will probably not have a long term view of her professional development needs because she has instrumental views on the value of reflection.

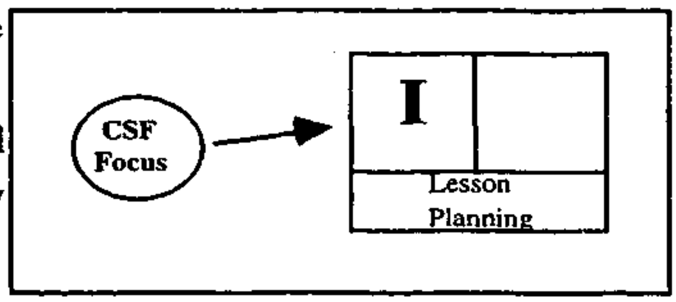
Malcolm - PD prediction

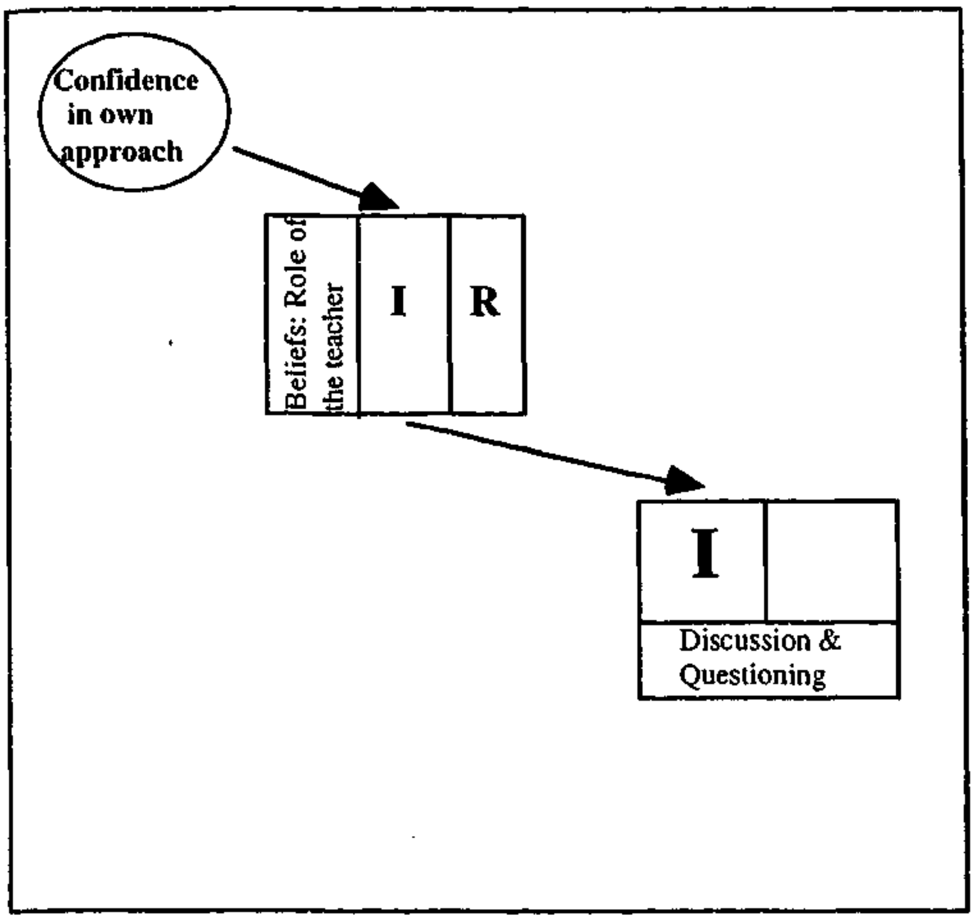
Prediction - trialling of *3Cs* content

Malcolm planned lessons with his Year 6 colleagues although he does not refer to this aspect of planning in any great depth. It is thus difficult to ascertain how this aspect will influence his trialling of *3Cs* activities. Because he has some beliefs that correspond to the approaches taken in *3Cs* he is likely to be willing to trial any activities suggested by his colleagues. Collegial support will then allow him to take greater risks. Malcolm refers to informal discussion with colleagues teaching at both Years 5 & 6. This is also likely to encourage Malcolm to trial *3Cs* activities provided that what is being shared is consistent with the way he balances his deep-seated beliefs on the role of the teacher and his surface-level beliefs on how children best learn mathematics.

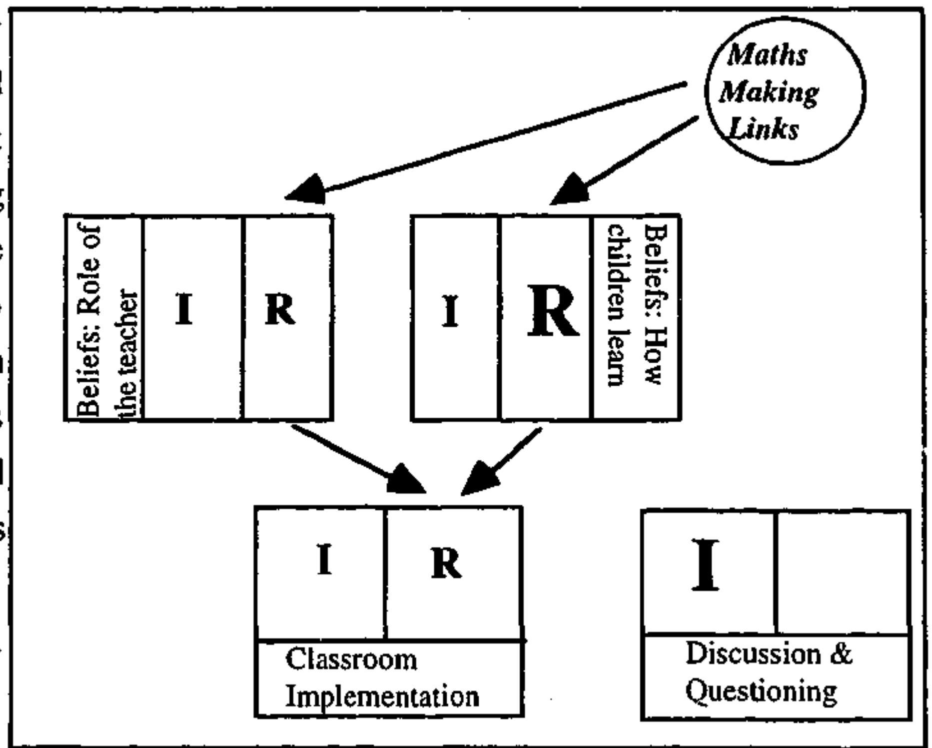


Because Malcolm prefers not to relate mathematics to class themes the one-off nature of the *3Cs* activities will allow him to readily include these activities in his teaching. During the *3Cs* workshops CSF-type learning outcomes were often discussed in relation to various activities so this will also encourage Malcolm to see that they were valuable activities.



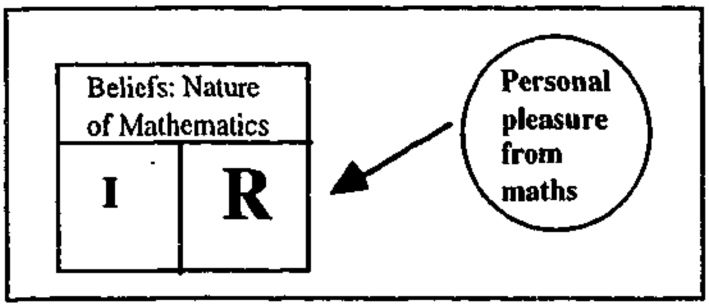


Malcolm, with his colleagues' assistance, may plan to include *3Cs* activities, but because of the dominant role he takes in classroom discussion it is possible that the trialled activities are not actually implemented in the same way as they were modelled at the *3Cs* workshops.



However *Maths Making Links* has challenged Malcolm's beliefs about teaching and learning and added a more relational dimension to them. At this point in time these new beliefs have had only minimal effect on Malcolm's classroom implementation and possibly no effect on his use of discussion and questioning. The approaches modelled in *3Cs* will have been confirming of these surface-level beliefs. This approach to professional development is likely to encourage Malcolm to trial the activities, especially the strategies aimed at encouraging pupil-pupil discussion.

Malcolm's confidence in mathematics and the personal pleasure that he gains from doing mathematics should attract him to many of the open-ended and problem-solving type activities in *3Cs*. This should lead to him trialling many of the mathematics activities. Malcolm had previously included Chance activities in his teaching so the nature of the topic would not have been new to him. Malcolm's relational beliefs about the nature of mathematics are likely to outweigh any other instrumental beliefs.



These considerations probably will also mean that he will try many of the activities that were associated with constructivist notions.

Summary

In regard to the *3Cs* mathematics content Malcolm:

- is likely to trial many of the mathematics activities because of his beliefs about the nature of mathematics;
- may trial many mathematics activities because he has instrumental beliefs on selecting good activities rather than planning with pupils' needs as important;
- will choose to trial mathematics activities because of personal interest and confidence in mathematics ability;
- may trial some mathematics activities because the approaches modelled in *3Cs* workshops confirm his newly-found relational beliefs, particularly those in relation to the use of group work;
- will most probably select activities for trialling that fit in with recognisable CSF outcomes because of planning based on a CSF focus;
- may implement some activities in a different way to the *3Cs* modelling so as to accommodate his instrumental beliefs and practice;

In regard to the *3Cs* teaching strategies content Malcolm:

- is likely to trial many of the teaching strategies because of his interest recently aroused in the use of group work;
- will most likely plan these as they were modelled in the *3Cs* workshops, but their actual implementation may be more along an instrumental approach;

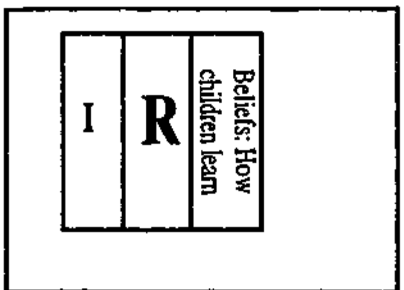
In regard to the *3Cs* constructivist notions content Malcolm:

- is likely to trial many of the activities which focussed on constructivist notions because of his interest in mathematics and the relational beliefs about how children best learn mathematics, although this may be limited by his instrumental beliefs about the role of the teacher;

In regard to other aspects of reaction to the *3Cs* content Malcolm:

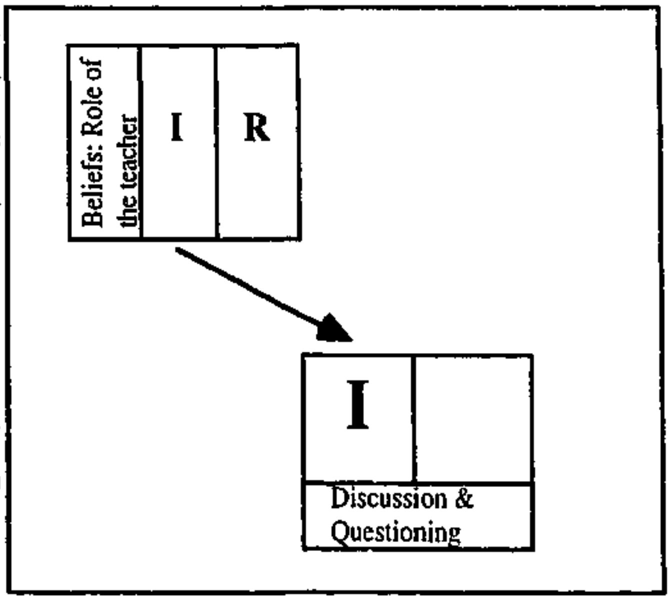
- may restrict his trialling because of his CSF focus;
- is likely to trial activities from throughout the *3Cs* program because it is appropriate for him to fit one-off activities into his planning. In general he prefers not to work in themes.

Prediction - reaction to features of effective professional development



Because Malcolm believes that children best learn mathematics by working collaboratively he may feel that it is best for a group of teachers from a school to attend professional development activities so that they can share ideas and support each other. He may also favour the use of small group work in professional development workshops where teachers share ideas and listen to each other. The hands-on nature of completing workshop activities also complements his relational beliefs. However for Malcolm these relational beliefs are surface-level and appear to not be entirely implemented in the classroom. This difference may mean that on balancing his beliefs on the features of effective professional development that 'attending as a group of teachers' and 'workshopping in small groups' may not be given as high a priority as other features.

Although Malcolm gave contradictory messages about his beliefs about the role of the teacher he implemented discussion and questioning in an instrumental way. This implies that his deep-seated beliefs about the role of the teacher are possibly the ones that dominate when it comes to implementing a mathematics lesson. Malcolm takes on the role of explainer and is the source of knowledge. This may mean that he would prefer a professional development presenter who also takes on the explainer role. If so he would have found the *3Cs* presenter frustrating. His instrumental classroom approach may also imply that Malcolm would not value the effective features related to 'ownership' and building upon 'issues of concern held by teachers'. With an instrumental approach to teaching, reflection time for pupils is not provided. There was no evidence collected as to whether Malcolm provided reflection time for his pupils. But if Malcolm does not provide reflection time he may not value it as an integral part of his own practice. This could imply that trialling in the classroom has limited benefits for Malcolm, that professional development conducted over an extended period of time would not be his preference, and that he may not have a long term view of his own professional development. However these predictions must be balanced against the ideas generated in relation to Malcolm's relational beliefs, particularly to those on how children best learn mathematics.



Summary

In regard to features of effective professional development that provide procedures for support and collaboration Malcolm:

- will value attending professional development with other teachers from his school because it mirrors the use of pupil-pupil collaboration in the classroom but because of contradictions in beliefs this aspect may not be of highest priority;
- may prefer a professional development presenter who uses an explainer role because this matches his instrumental beliefs about the role of the teacher;
- is likely to value listening to the discussion from other teachers because of his relational beliefs about how children learn;

In regard to features of effective professional development that provide a teacher-centered focus for content and organization Malcolm:

- is likely to place a low priority on the professional development features of 'ownership' and 'issues of concern recognised by the teachers themselves' based on his instrumental belief on the role that children play in the learning process;
- will appreciate being able to undertake hands-on activities and small group discussion in workshops because this matches his relational beliefs about how children best learn mathematics;

In regard to features of effective professional development that provide opportunities for observing outcomes and reflection Malcolm:

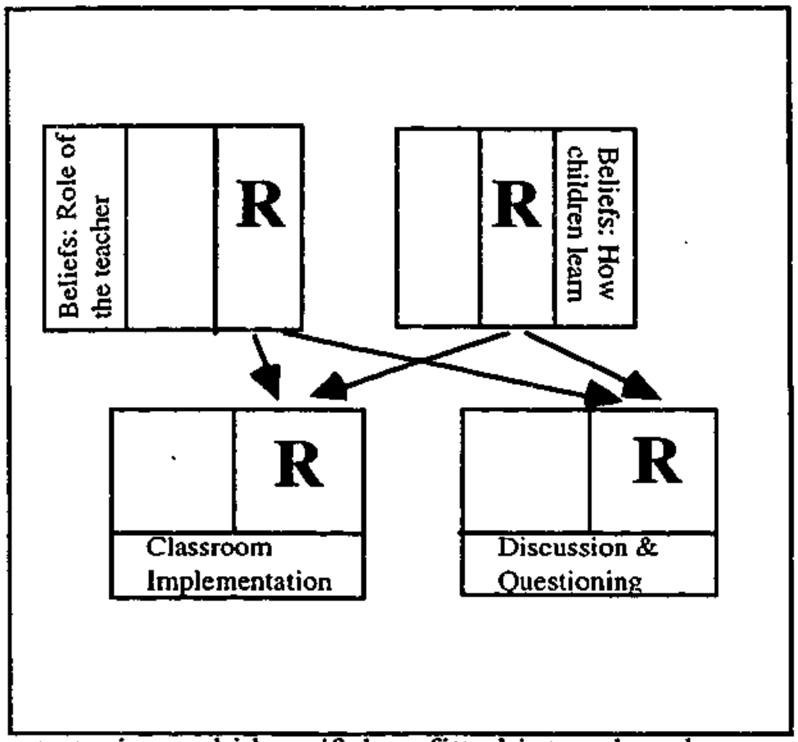
- will probably argue that there are limited benefits for trialling in the classroom because he may not value the use of reflection time in his own teaching;
- has a preference against professional development being conducted over an extended period of time because he does not value reflection time for his pupils;

In regard to features of effective professional development that provide a philosophy on teacher change Malcolm:

- may not value that there needs to be a personal long term plan for professional development because he may not value the use of reflection time in his own teaching.

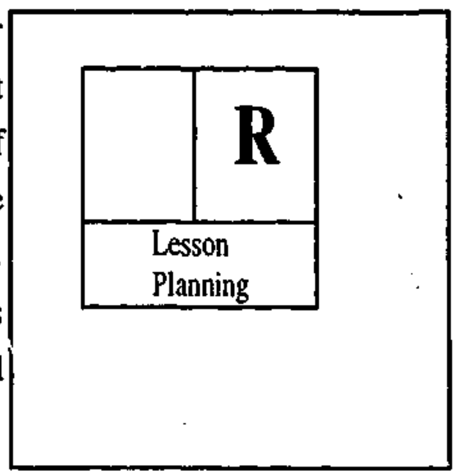
Tasha - PD prediction

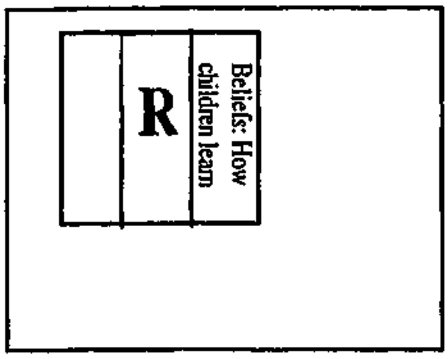
Prediction - trialling of *3Cs* content



It would be expected that Tasha would find the teaching strategies and the constructivist discussion from the *3Cs* program confirming of her classroom approach, matching her beliefs about teaching and learning. So it is likely that Tasha will have been interested and positive about both of these *3Cs* strands and feel encouraged to trial them. However Tasha would most likely have only used the strategies and ideas if they fitted into what she wanted to cover with her pupils. It is possible that if she trialled the strategies and ideas that she may have been adapted them to fit contexts different to those used in the *3Cs* workshops.

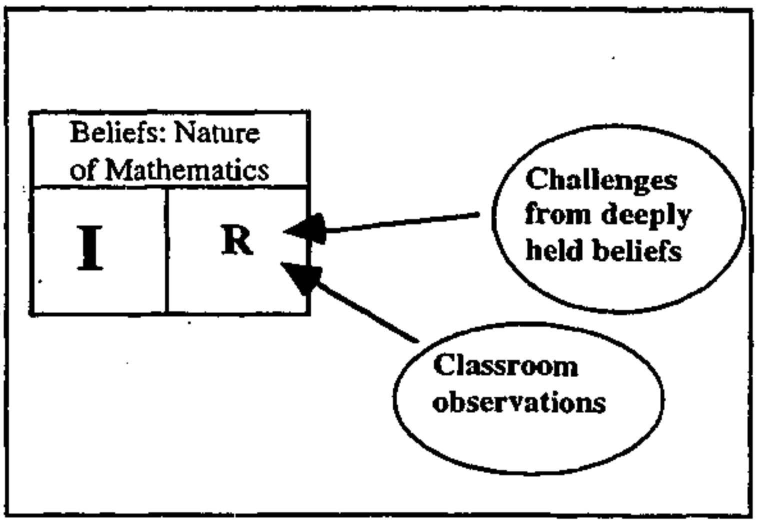
Because Tasha used a variety of resources for her planning rather than following a set program from a text it would have been an easy task for her to include any of the *3Cs* content in her teaching. But because she includes much of the mathematics instruction in the class theme the use of the mathematics content activities especially the one-off type games may have had restricted appeal.

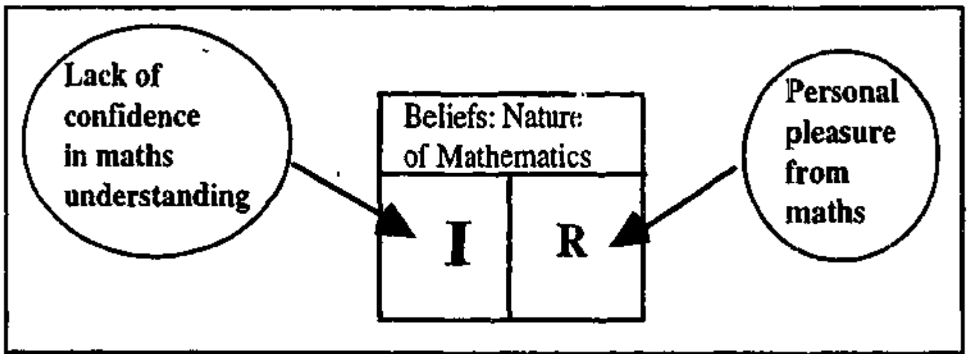




The hands-on nature of the *3Cs* workshop activities correspond to Tasha's belief that children learn mathematics best by doing, by being involved. It is thus likely that she will have a positive attitude to such activities and their inclusion in her teaching program, but only when appropriate.

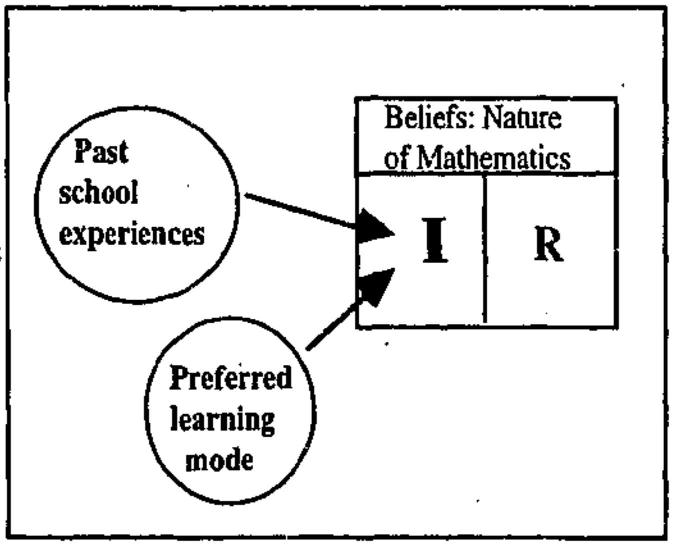
It appears that Tasha's instrumental beliefs about the nature of mathematics are currently under challenge. The evolving relational beliefs will be supported by the *3Cs* program. This may assist her to firm up these beliefs particularly if, through the trialling of activities, the responses from the pupils are positive and supportive of the current relational beliefs she holds on teaching and learning. This scenario may encourage her to trial activities from the *3Cs* program.





These two influences produce an interesting possible scenario. On one hand Tasha enjoys mathematical challenges but on the other she lacks a certain amount of confidence to handle mathematics. Many of the *3Cs* workshop activities involved problem solving and logical thought - the very notions that Tasha claims to enjoy doing. She also acknowledged that some of the Chance and Data ideas were too difficult for her. This latter acknowledgment may be a discouragement in trialling the *3Cs* activities where the mathematics content was judged by Tasha to be too difficult.

Chance was an unfamiliar topic for Tasha and her teaching of Chance is unlikely to be specifically influenced by past school experiences. This could lead to two possible outcomes. Firstly, the trialling of mathematics content activities will not be hamstrung by the instrumental beliefs brought by past experience. This will act as a positive towards classroom trialling. Secondly, her lack of familiarity with the topic of Chance may mean that she resorts to her own preferred learning mode and instrumental views and teaches the topic of Chance in an instrumental way or has limited trialling. The instrumental beliefs she has about the nature of mathematics could reinforce this likely outcome.



Summary

In regard to the *3Cs* mathematics content Tasha:

- will favour those activities that fit in with her current themes because she believes that teachers need to provide a context for mathematics activities;
- may trail few mathematics activities because of her instrumental beliefs about the nature of mathematics;
- could be reluctant to trial the one-off type mathematics activities because her planning is based on the relational notion where she considers what the pupils need rather than good activities;
- will not trial some of the *3Cs* activities because of a perception that the mathematics is too difficult;
- will have positive attitudes to many of the *3Cs* activities because of their hands-on nature;

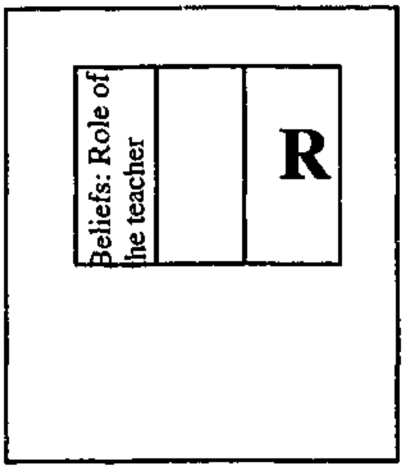
In regard to the *3Cs* teaching strategies content Tasha:

- is likely to trial the teaching strategies from the *3Cs* program because they correspond to her relational beliefs about teaching and learning;
- is likely to adapt activities or use different contexts to those used in the *3Cs* program because of the way that she fits much of her mathematics instruction into class themes;

In regard to the *3Cs* constructivist notions content Tasha:

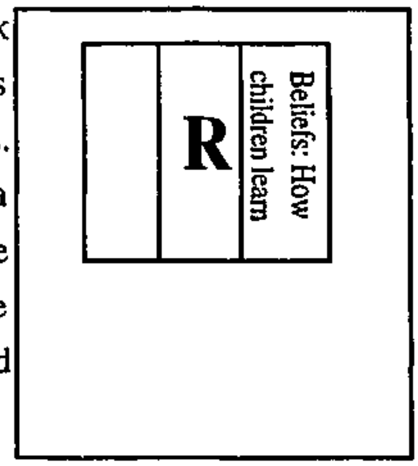
- may trial those *3Cs* activities where constructivist discussion took place because this matches her relational beliefs about teaching and learning;

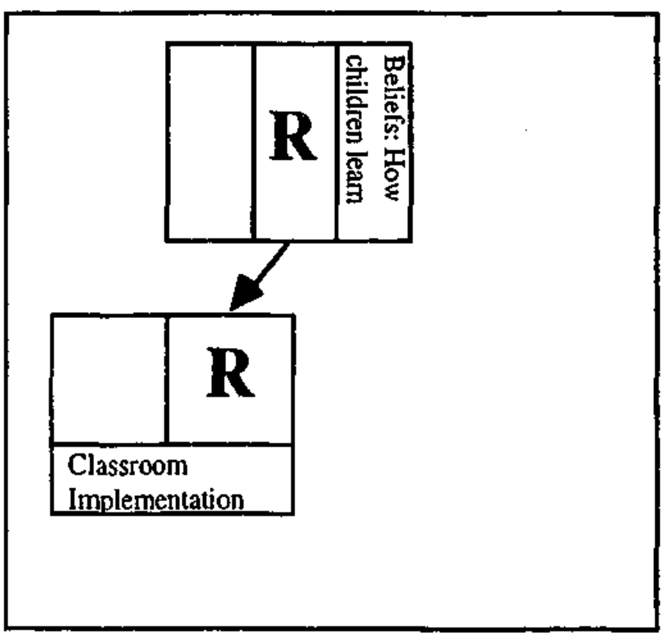
Prediction - reaction to features of effective professional development



Tasha believes that the role of the teacher is as a facilitator. She argues that she is not the only source of information but that the children in her class also have a role in explaining and questioning. She implements these beliefs. It seems plausible that she would prefer a professional development presenter that has the same philosophy and practice and acts as a role model for how Tasha would want to take an activity in her grade.

Because Tasha believes that it is best for children to work collaboratively it could be assumed that she will prefer this approach also with professional development workshops. Thus Tasha is likely to agree that going together with a group from her school would be a feature of effective professional development. She may also value workshopping hands-on activities in small groups and listening to the ideas offered by other teachers.





Tasha values the place of reflection in learning and puts this into practice with her class. Because of this she is also most likely to value reflection in her own learning. This could mean that she would believe that completing professional development over an extended period of time to be effective. She may also have a long term view of her professional growth and realise that making change is a long term process.

Summary

In regard to features of effective professional development that provide procedures for support and collaboration Tasha:

- will prefer to attend professional development with a group from her school because of her relational beliefs about collaborative learning;

- is likely to be positive towards the 'facilitator-type' approach taken by the *3Cs* presenter because of her relational beliefs about the role of a teacher;
- is likely to value listening to the discussion from other teachers because of her relational beliefs about how children learn;

In regard to features of effective professional development that provide a teacher-centered focus for content and organization Tasha:

- will probably support the strategy of workshopping activities in a hands-on way because of her relational beliefs about how children learn;
- may regard 'ownership' and 'issues of concern' as features of effective professional development because of his relational beliefs about how children learn;

In regard to features of effective professional development that provide opportunities for observing outcomes and reflection Tasha:

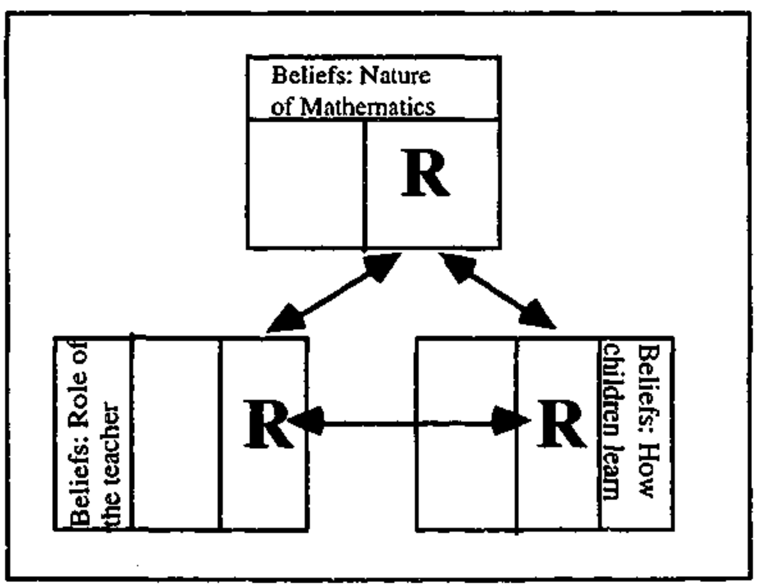
- may believe that professional development is best conducted over an extended period of time because she values reflection as part of the learning process;
- is likely to value classroom trialling because she values reflection as part of the learning process;

In regard to features of effective professional development that provide a philosophy on teacher change Tasha:

- may have a long term view of her professional growth and realise that it could be a long term process because of her relational beliefs pertaining to reflection.

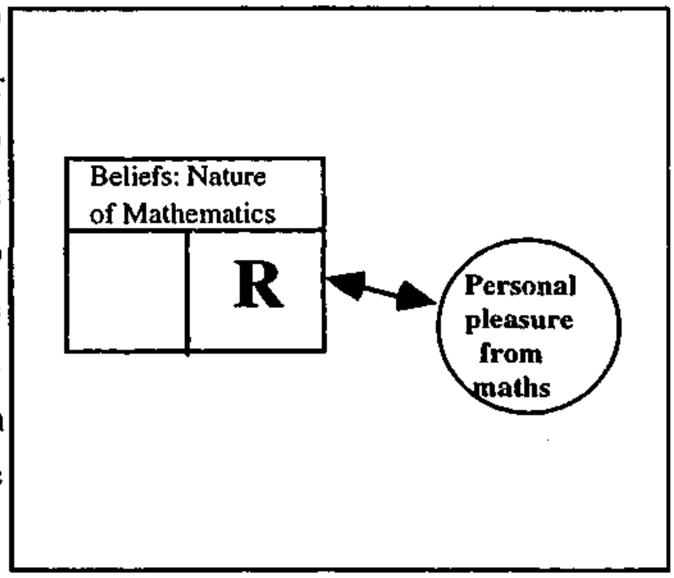
Gerry – PD prediction

Prediction - trialling of *3Cs* content

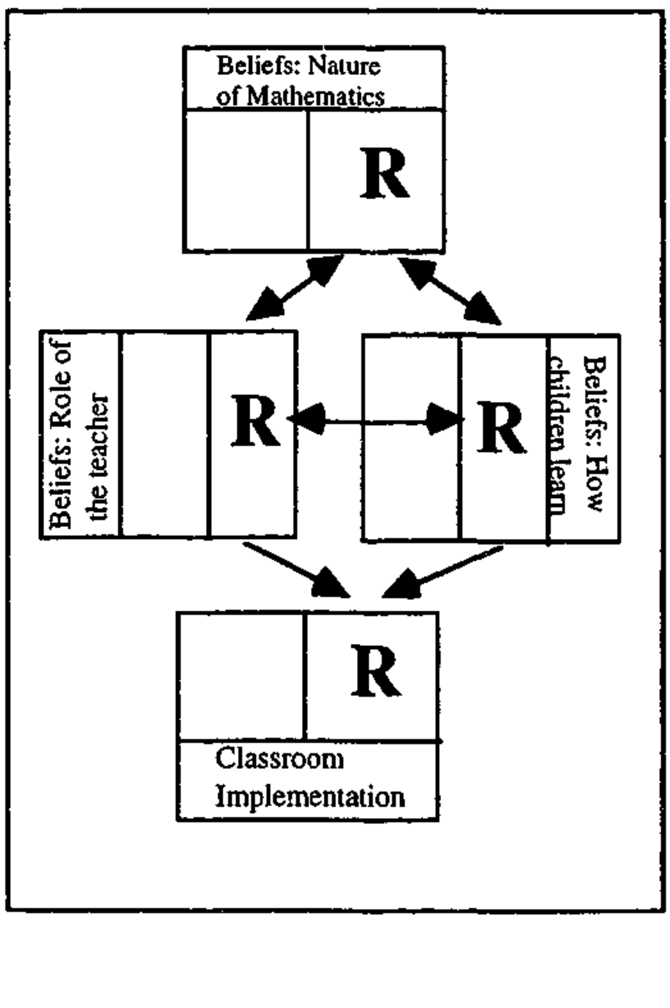


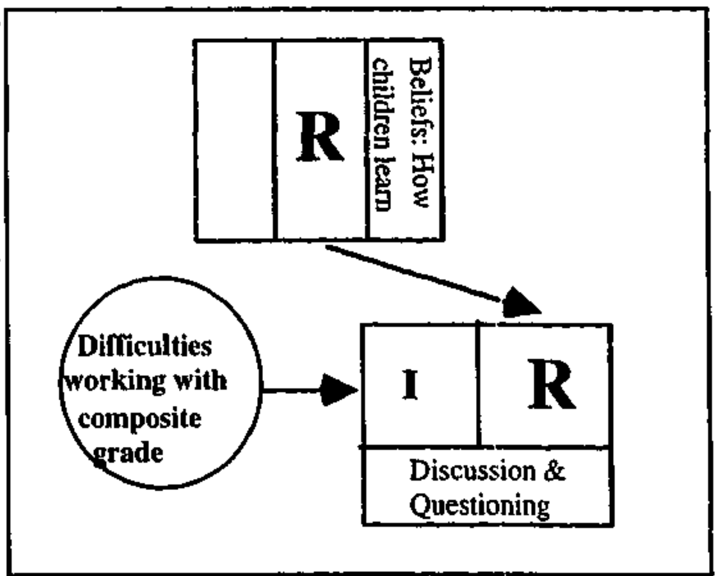
It would be expected that Gerry's relational beliefs should fit with the *3Cs* program with its emphasis on exploration of chance concepts, strategies to enhance pupil-pupil discussion, and constructivist notions. So it would be expected that Gerry would most likely trial many of the *3Cs* activities. Because Gerry deals with mathematics in a confident way he is likely to agree that the inclusion of chance activities in the curriculum can lead to a rich mathematics experience where concepts other than Chance can be included.

The mathematics context in the *3Cs* program was Chance. Because Gerry gains pleasure from personal problem solving he is likely to become engaged with many of the *3Cs* activities, especially those activities that involved in-depth exploration and those that had an element of 'conflict' inherent in their presentation [for example, 'Dicetracks' (refer to page A-7) and 'Rolling two yellows' (refer to page A-11 & A-19)]. Gerry is more likely to attempt those activities in which he becomes personally engaged. Since Chance has only been recently included in the primary curriculum the activities are likely to be new to Gerry.



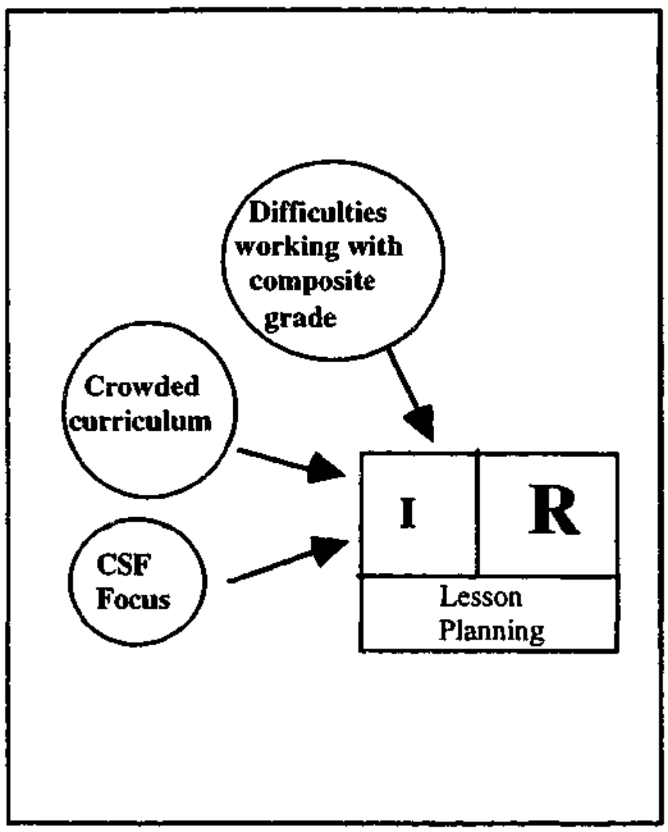
Gerry's relational beliefs have resulted in classroom implementation that is along relational lines. This should enable Gerry to readily incorporate the *3Cs* activities into his teaching approach. Gerry's belief on providing a context for mathematics learning was not particularly strong. He agreed that other curriculum areas such as science made use of mathematics but did not necessarily envisage that mathematics lessons could fit into an overall classroom theme. With the two observed lessons, although a context was provided for each lesson, neither context fitted into any general theme occurring in the classroom at that time. Thus Gerry appears to plan one-off activities. The Chance activities presented in the *3Cs* program were generally context-free so the ideas of working within a theme or integrated unit should not inhibit Gerry from trialling the *3Cs* activities.





Gerry's relational beliefs about how children best learn mathematics have led him to generally implement classroom discussion that builds upon children's ideas. However in practice there was little pupil-pupil discussion planned for or observed and Gerry dominated the giving of explanations. One possible explanation for this is that it was a management strategy to deal with his perceived difficulties in coping with his composite grade. Thus Gerry should relate positively to the strategies presented in the *3Cs* program aimed at enhancing pupil-pupil discussion, but this management constraint may have dampened his enthusiasm for trialling these strategies. The workshop experiences, hearing of the trialling of these strategies from other teachers and especially the group from his school, may provide the encouragement that Gerry needs to implement these strategies.

The *3Cs* program will not have directly addressed the constraints placed on Gerry's planning and classroom implementation. As discussed above Gerry will need to balance his relational beliefs on how children best learn mathematics and the difficulties he has working with a composite grade. The idea of adding the topic of Chance to mathematics instruction may only compound the constraint of the 'crowded curriculum'. Many of the *3Cs* Chance tasks will be appropriate for both years 4 and 5 and this may encourage Gerry to try them. Gerry does not follow a mathematics scheme but takes activities from a number of sources so fitting in the *3Cs* activities should be a viable option for him. Also the idea that Gerry may initiate planning by using good activities may also encourage him to use the activities that were modelled in the *3Cs* workshops.



Summary

In regard to the *3Cs* mathematics content Gerry:

- is likely to trial many *3Cs* activities because of his relational beliefs about the nature of mathematics;
- will not be hindered in trialling *3Cs* activities because of their one-off nature because of his instrumental approach to planning by selecting good activities rather than focussing only on the needs of the children;
- may favour trialling those *3Cs* activities that have engaged him in a personal way because of his enjoyment of problem solving especially those activities that had elements of exploration and 'conflict' in ideas;
- is likely to find that it is difficult to include the topic of Chance in what he already sees as a 'crowded curriculum'.

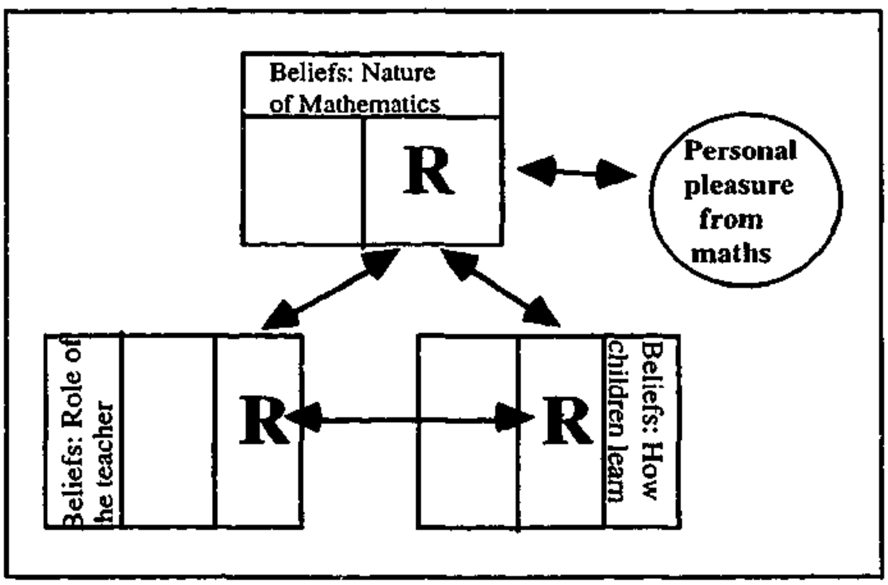
In regard to the *3Cs* teaching strategies content Gerry:

- should readily relate to the strategies aimed at enhancing pupil-pupil discussion because of his relational beliefs but may be reluctant to trial these strategies because of the constraint of working with a composite grade;
- is likely to trial these as the strategies are presented because he will see them as 'good activities', but they will not necessarily be adapted to meet the needs of his pupils;

In regard to the *3Cs* constructivist notions content Gerry:

- should relate to the activities associated with constructivist notions because of his relational beliefs about how children best learn mathematics.

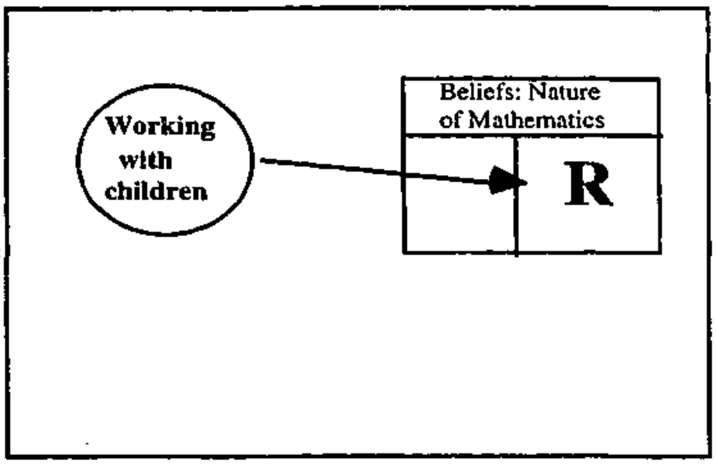
Prediction - reaction to features of effective professional development



Gerry believes that he should act as a facilitator in the classroom. However in practice, even though the lesson is shaped by pupil comments, he is the sole provider of explanations. He is thus likely to respond positively to the facilitator-type approach taken by the

3Cs presenter. And because he enjoys exploring problem solving situations he will appreciate the opportunity to do this on his own and in small groups. If his own personal style of learning is mirrored by his beliefs on how children best learn mathematics he will want to share his ideas with small groups and in large group discussion. He will also appreciate hearing the ideas discussed by other teachers. Because Gerry builds upon the ideas held by his pupils he may value the effective professional development features of 'ownership' and 'issues of concern'.

Because Gerry in the past reflected on what he observed in his classes, made conclusions about what he observed, and formed new beliefs it is most likely that he will value trialling in the classroom and observing the advantages that the activities have on children's learning.



Summary

In regard to features of effective professional development that provide procedures for support and collaboration Gerry:

- is likely to value sharing with others and hearing from other participants at the *3Cs* workshops and to also value working with a group of teachers from his school because of his relational beliefs on collaborative learning;
- is likely to be positive towards the 'facilitator-type' approach taken by the *3Cs* presenter because of his relational beliefs about the role of the teacher;
- is likely to value listening to the discussion from other teachers because of his relational beliefs about how children learn;

In regard to features of effective professional development that provide a teacher-centered focus for content and organization Gerry:

- will appreciate being able to undertake hands-on activities and small group discussions in workshops because of his relational beliefs about how children learn mathematics and because he gains pleasure from solving problems;
- may regard 'ownership' and 'issues of concern' as features of effective professional development because of his relational beliefs about how children learn;

In regard to features of effective professional development that provide opportunities for observing outcomes and reflection Gerry:

- will value trialling in the classroom and reflecting on the advantages of the activities and strategies for his pupils because of his past reflective practice;
- is likely to place importance on the value of professional development taking place over an extended period of time because he is a reflective learner;

In regard to features of effective professional development that provide a philosophy on teacher change Gerry:

- may see professional development as a long term process because he is a reflective learner.

Summary

This chapter has made 'professional development predictions' for each case study teacher based on investigation of their classroom practice and beliefs. Chapter 7 will make further analysis of each case study teacher in regard to their actual reaction to the *3Cs* program and to features of effective professional development. The actual reactions will be compared to the predictions.

CHAPTER 7

CASE STUDIES – REACTION TO PROFESSIONAL DEVELOPMENT

INTRODUCTION

This chapter continues the analysis of the case studies in two sections: reaction to content and attitudes to effective features. The focus of Chapter 7 is based on the case study teachers' reaction to the *3Cs: Chance, Constructivism and Collaboration (3Cs)* program content and organization. For each case study teacher the outline begins with a section investigating the *3Cs* content that was either selected or not selected for trialling or further consideration. The data for this is drawn from the classroom observation/s that were made after the completion of the *3Cs* program; interviews 3, 4 and 5; and comments made in the *3Cs* workshops. With the observed lessons the teachers were asked to use something that interested them as a result of the *3Cs* program, either in content or teaching strategy. Classification of the workshop activities into either 'Mathematics content', or 'Teaching strategies', or 'Constructivist notions' categories, which was developed in Chapter 3, will be used for analysis in this section. Discussion on content trialling makes use of the three insights that were used for discussion on beliefs in Chapter 6.

The following section for each case study teacher considers comments they made in interviews about their attitude towards features of professional development. These comments are considered under the four themes developed in Chapter 2. A summary is presented in table format.

At the end of both sections for each case study teacher, a comparison is made using the findings with the 'PD predictions' developed at the end of Chapter 6. The purpose of this comparison is to establish a further listing of insights as a basis for more generalized discussion and analysis for the whole cohort of teachers.

Throughout the discussion some references are made to activities from the *3Cs* program and the reader is then referred to specific pages in Appendix A. Some tables accompany the text comments while other tables referred to are included in Appendix C.

DEIDRE

Reactions to *3Cs* Content

Deidre: Trialling summary

The *3Cs* activities that Deidre trialled or did not trial are listed in Table C.1 (Appendix C). The listing clearly shows that she trialled *3Cs* activities from all three components. The information indicates that Deidre mainly trialled activities that were workshopped rather than those only presented in the handouts. And Deidre confirmed this approach.

> Reading about it, won't tell you how to use it and how it works. You tend to try things more that you've seen, tried yourself or someone's told you about rather than found in a book. (Interview 3)

This strategy appeared to match her philosophy on learning.

> I don't believe you can learn things by someone telling you about them. You've got to do it. (Interview 5)

Lack of time was given as the reason for not reading or referring to the handouts.

> It is probably just time more than anything else. A few early on I read. (Interview 4)

The listing in Table C.1 also indicates that Deidre only trialled activities from the first three workshops and not from workshops 4, 5 and 6. This might relate to how her 3/4 team organized the mathematics strands for particular terms. Number was taken throughout the year but the other strands were only given a term's focus. Chance and data was allocated to term 3 so the first 3 workshop sessions fitted in with the term 3 planning.

Deidre: Role of the pupils in the learning process

In chapter 6 it was noted that Deidre had relational beliefs about how children learn mathematics but that these were a reflection of her general beliefs about children's learning because they were not implemented in mathematics sessions. As well, her instrumental classroom approach was supported by instrumental beliefs about the nature of mathematics and the role of the teacher. *3Cs* would be confirming of her beliefs about children's learning but would challenge her instrumental beliefs.

There are some indications that Deidre gave pupils a greater role in the learning process through questioning and allowing children to share their ideas. However, these activities were not observed, so it is not clear how Deidre handled the discussion in the class. With the 'Your Choice' game (A-17) she commented:

> That was good because then we got into a discussion on, "Well you kept red all the time". "Why do you keep red all of the time?" "Why don't you swap it for green?" (Interview 3)

Deidre had expected the 'tennis clothes' problem (A-30) to be solved using cut-outs of the clothing and the development of a multiplication rule so she was surprised by the pupil's solution process and allowed them to share it with the class.

> I was surprised because very quickly you know four or five of those bright kids used arrows, this T-shirt, this shorts, this shorts, this shorts, and this T-shirt, this shorts, this shorts, this shorts. And they had done it within half a second and a lot of the others had to be shown that. But then that was valuable too because they showed the others how they worked it so now they have got that strategy to work things out. (Interview 4)

Deidre was asked if she felt that the *3Cs* program had encouraged her to think more about how children learn mathematics. She did not see this as a change in thinking but that she had never really thought about it before. She noted that the group of teachers at her school involved in the *3Cs* program had talked about these questions raised in the interviews but stressed that it was watching how an activity developed in the classroom that assisted her to formalise her beliefs about how children learn mathematics.

> Well probably the activities again because you need to come back and apply them and see how the kids will think about it. I don't think anybody standing up and telling you how kids think about it is going to help. It might make you think about it and think about going back and trying it. But you need to listen to the kids to see how they're thinking. I probably listen to them more. (Interview 4)

Some of Deidre's comments suggest that she makes decisions on what mathematics is appropriate for her pupils to the extent where she would not take risks in teaching that might lead to the children exploring and generating ideas or struggling with problems. With the activity where each child had a chance word on a flashcard and they had to organise themselves into order from least chance through to most chance Deidre altered the task.

> I didn't put some of [the words] in. I didn't have as many as we had when we did it [in the workshop] just to make it a bit easier for them. I found out of most of the things that they found that more difficult than anything else. (Interview 3)

Although Deidre was familiar with the use of two-way charts she chose not to try the *3Cs* activity that generated the notion of two-way charts.

> I had probably thought if teachers can't work it out and my year ten son's been shown how to do this at school maybe it is a bit of a hard concept for grade three/four. I mean in the whole group of teachers I was the only one who had it right. And I think in my whole class there was only about two or three that would understand this. (Interview 4)

During the discussion in the *3Cs* workshop following the completion of this activity Karen said that Grade 3s wouldn't manage two-way charts because they are too complex. Deidre replied:

> I wouldn't think that they are too complex but I don't know that they'd believe on a piece of paper like that because you told them. (*3Cs* session 2 transcript)

This comment reinforces the notion that she views the role of the teacher as explainer rather than facilitator.

Deidre's surface-level beliefs about how children learn have encouraged her to allow pupils to share ideas. However it seems that she generally prefers to maintain control of a lesson and so makes decisions on what her pupils should be challenged by and the level of this challenge.

Deidre: Purpose of teaching mathematics

In chapter 6 it was concluded that Deidre believed that the purpose of teaching mathematics was the acquisition of a set of rules and that mastery of these rules was important. These were a reflection of her instrumental view on the nature of mathematics and were observable in her classroom practice.

Because of limitations to Deidre's time only one post-*3Cs* classroom observation was possible. The introductory discussion was based on the chances of the weather forecast being correct. As the lesson occurred on the day after the Melbourne Cup Holiday Deidre planned as a major focus for the session an activity that made use of the Melbourne Cup as a context. Deidre was requested to give a lesson that arose from some activity from the *3Cs* workshops and saw this as a lesson on Chance. In fact the main part of the lesson had learning outcomes for number as the children had to do doubling and halving to work out the possible winnings for each horse running in the Melbourne Cup according to the odds taken from the newspaper. Even though Deidre planned a lesson based on two relevant contexts the way she presented the number task involved the pupils following the instrumental procedures she outlined.

Deidre felt that she had never really considered why there was a need to teach Chance but that *3Cs* had encouraged her to reflect on that and that the trialling of activities and observing the pupil's thinking was the feature that provided this encouragement.

Deidre: I probably hadn't thought about [the purpose of teaching chance]. See I told you that you had made me think about things that I never really had thought about. I had my own views if somebody had asked me. But I had probably never really thought about it in terms of why you should teach kids chance and what they get out of.

Ron: So what aspects of the PD sessions might have made you think about it?

Deidre: I think trialling the activities and seeing how kids think and see how they assume that it is six for example, six is the hardest dice to throw when we know it is not. So them trialling and them coming to realise that chance plays a part in all of those things and it is not always easy to predict. (Interview 5)

This reaction fits with Deidre having different views about Chance compared to other mathematics topics where in Chapter 6 it was noted that she saw Chance as 'more of a knowledge' rather than a 'skill they need practice at'.

Deidre's view that the purpose of teaching mathematics is for the pupils to learn set rules was still prominent in this observation.

Deidre: Dealing with mathematics and pedagogy

Even though Deidre exhibits relational beliefs about the way children learn mathematics these beliefs are not implemented because of her dominant instrumental beliefs about the nature of mathematics and the role of the teacher.

Deidre believed that pupils learnt best in collaboration and she was asked if she had made any change to the way in which she allowed children to work in groups because of the *3Cs* program. She commented:

> No I don't think so. I mean we always did maths and a lot of other things as group things and I always encourage them to work together. You know to talk to each other about it. So no I don't think so. (Interview 4)

This comment is interesting as pupil collaboration was certainly not a feature of any observed lessons. Deidre still probably has a view of group work as an organizational feature rather than something that aids learning and construction of knowledge.

For Deidre the over-riding outcome from the *3Cs* program was gaining a bank of activities for Chance.

> I don't think I have learnt anything about Chance itself but I certainly have a bigger repertoire of activities to do. So you are more inclined to do it but I don't know that confidence is the word. More inclined to do it and with more activities you're more likely to do it. (Interview 4)

This view is consistent with what she saw as her professional development needs prior to the start of the *3Cs* program.

> If I was going to a maths in-service I'd say it was something where I know I'm going to come back with lots of different practical activities that I can use. (Interview 2)

When asked what changes she had made to her teaching as a result of the *3Cs* program Deidre noted that she was including more Chance activities and added:

> I have never done as much or talked about [Chance] as much. So I'd say talking about it and the language that goes with it and covering it better. (Interview 4)

In the Chapter 6 analysis it appeared that Deidre might plan lessons by working from the pupils needs rather by starting with good activities. So if Deidre views the desired outcome of professional development as gaining a bank of activities a contradiction presents itself. It is possible that because the topic of Chance is new to the primary mathematics curriculum that teachers' initial reaction is to find activities for classroom implementation and as these are assimilated into their teaching repertoire then they will begin to focus on the needs that children have in this topic. This outcome would be consistent with Deidre's comment about 'covering it better'.

Deidre probably did not trial any activities where she felt uncomfortable with the mathematics involved.

> Deidre: I had never heard of that stem and leaf [plot]. I mean when she did it you understood OK what she was doing.
>
> Ron: Have you thought of using stem and leaf plots with your kids?
>
> Deidre: No, I thought that's an awful complicated thing to do. (Interview 4)

Deidre's immediate colleague, Megan, encouraged her to use two of the three of collaborative strategies that she trialled. The 'Snakes & Ladders' activity (A-30) was completed in conjunction with Megan's 3/4 grade in the neighbouring classroom. One grade became snake experts and the other grade became ladders experts before a pupil from each grade was teamed up together to construct a Snakes and Ladders board. Deidre noted that she had previously used the jigsaw strategy in language lessons but not previously in mathematics.

Megan became most enthusiastic about using clue-cards after trialling the ones presented in the *3Cs* workshops. Her enthusiasm for this strategy encouraged the other teachers in the 3/4 team to try the strategy.

> Yes I have got a set, over there. I haven't done the ice-cream one [A-35] yet because I know Megan was doing it yesterday. And I will try it after she has finished with it. (Interview 4)

Deidre: Summary - trialling *3Cs* content

As a result of the *3Cs* program in regard to mathematics content Deidre:

- trialled activities that had mathematics content and may have viewed the mathematics (chance) as the important strand in the *3Cs* program although in comparison to other *3Cs* participants the number of activities trialled was low;
- may have valued the mathematics activities that led to a formulation of a process or a rule, thus mirroring her preferred ways of doing mathematics;
- altered several tasks to make them easier;
- did not attempt mathematics activities that appeared too complex, where the complexity was judged by participant's and her own reactions rather than considering if pupils could solve them in less formal ways;

As a result of the *3Cs* program in regard to teaching strategies content Deidre:

- attempted some of the collaborative strategies although the trialling of the collaborative strategies may have been encouraged by her team teaching colleagues;

As a result of the *3Cs* program in regard to constructivist notions content Deidre:

- did not appear to value/implement the discussion on constructivist notions, although she judged the trialling of activities by observing the pupils' thinking;

As a result of the *3Cs* program in regard to other trialling aspects Deidre:

- read very few of the handouts and suggested that time was the factor for this;
- trialled mainly workshopped activities;
- only trialled activities from sessions 1, 2 and 3 because this fitted the way in which her team organised the mathematics curriculum.

Deidre: Comparison of PD prediction and *3Cs* trialling

Table 7.1 compares the two 'Content' summary lists made in the PD prediction in Chapter 6 and the summary list above. The points that match in both lists are connected by a two-way arrow.

PD prediction In summary Deidre:		Trialling *3Cs* content As a result of the *3Cs* program Deidre:
Mathematics content		Mathematics content
• may trial few mathematics content activities because the ones presented in the *3Cs* workshops do not generally match her deep-seated instrumental beliefs in the nature of mathematics nor the way in which she prefers to deal with mathematics; • may trial a low amount of mathematics content activities because of lack of interest in mathematics problems;	↔	• trialled activities that had mathematics content and may have viewed the mathematics (chance) as the important strand in the *3Cs* program although in comparison to other *3Cs* participants the number of activities trialled was low;
• will favour, because of her instrumental beliefs, those mathematics activities that result in pupils being shown how to do set procedures or learn rules;	↔	• may have valued the mathematics activities that led to a formulation of a process or a rule, thus mirroring her preferred ways of doing mathematics;
• is likely to adapt the modelling of the mathematics activities so that they reflect her preferred instrumental style of teaching;	↔	• altered several tasks to make them easier; • did not attempt mathematics activities that appeared too complex, where the complexity was judged by participant's and her own reactions rather than considering if pupils could solve them in less formal ways;
• may find it difficult to balance whether she trials the 'one-off type' mathematics activities advocated. It will be easy to incorporate such activities because most of her mathematics instruction is context free and when team planning takes place activities and ideas are drawn from a number of resources. But it may be difficult to include one-off activities from the *3Cs* program because she plans having in mind the pupils' needs and not the effectiveness of the activities;		

Teaching strategies • may trial activities because of the support and enthusiasm her colleagues have although the confidence that she has in her instrumental classroom approach will be difficult to counter; • could be reluctant to trial the collaborative strategies because they do not match her beliefs about the role of the teacher. On the other hand may be tempted to trial them because they match her relational beliefs about how children best learn mathematics;	↔	Teaching strategies • attempted some of the collaborative strategies, although the trialling of the collaborative strategies may have been encouraged by her team teaching colleagues;
Constructivist notions • could be reluctant to trial the *3Cs* activities involving constructivist notions because they do not match her beliefs about the role of the teacher although she may be tempted to trial them because they match her relational beliefs about how children best learn mathematics.	↔	Constructivist notions • did not appear to value/implement the discussion on constructivist notions, although she judged the trialling of activities by observing the pupils' thinking;
Other		Other • read very few of the handouts and suggested that time was the factor for this; • trialled mainly workshopped activities; • only trialled activities from sessions 1, 2 and 3 because this fitted the way in which her team organised the mathematics curriculum.

Table 7.1: Deidre's content trialling comparison – PD prediction and *3Cs* trialling

Attitudes to features of professional development

Deidre: Providing procedures for support and collaboration

In the third interview Deidre was asked how important it was for her to attend the *3Cs* sessions with a group of teachers. She replied:

> I think everything that you can do with at least one other person is far more valuable than going on your own, because you all pick up things individually. I think it's been much better that the four of us [her 3/4 team] went because then we all tried different things in a different order and then told the others how it worked. (Interview 3)

The reason given for trying activities in a different order and sharing the outcome had already been suggested by Deidre in an earlier part of the same interview. Deidre was asked if the group was good at sharing. She said:

> I think I'd tried the Acey-Duecy first and I said, "Well try that, it went really good" and they said, "How did you do it." So, if someone's done something before you have ..... for example, Megan made up all the language cards and we all just used those rather than just making up our own. (Interview 3)

When Deidre was asked to choose the most important professional development feature for her between 'going as a group' or 'trialling in the classroom' she chose 'going as a group'.

> Going with a group. I think that people learn better in groups than on their own. I mean that is not always true. Some people are individuals that like the way that they learn. And everybody has their own learning styles. But generally I think people learn more from the discussion you gain out of things. And if no one else has been with you well who are you going to talk about it with. (Interview 3)

Even though returning to school and sharing between her immediate 3/4 level colleagues was a strong feature there was little or no sharing with the other two teachers that attended and similarly with the staff as a whole.

On the 'End of Session 5' evaluation sheet Deidre was asked if she thought that professional development was best if your Principal was supportive. She definitely agreed with this but noted that professional development should occur in school time taking into account after hours professional development on workload. When asked about her own Principal's support she noted that she always asked how it went and that she had provided the afternoon tea when the sessions were held at her school. Deidre added that her Principal had not allowed extra time for the researcher's interview time.

Deidre made a comment that she felt that she was compelled to attend the professional development. It was not clear as to who was responsible for making the decision that a group would attend the *3Cs* program but Deidre's initial reaction was to suggest that the decision had come from the Principal although she shifted in this thought during discussion.

> Deidre: The fact that we were compelled to do it . Wasn't given to us by choice. It was just something that you feel like something that oh I have to do this. So, I had a negative attitude to start with. But it's been worth while for me.
>
> Ron: When you say that you where compelled to do it, who compelled you to do it?

Deidre: Oh, we were just told, "Here you are, you are doing this".

Ron: By the Principal?

Deidre: I don't know if that's where it came from in the first place. Someone said it was brought up at a staff meeting through the maths committee which I'm on but I didn't remember anything about it. So I don't know whether it did go to the maths committee or whether maybe the maths committee organiser had the stuff from you and passed it directly onto the principal who decided that this would be a good idea. (Interview 3)

For Deidre a good professional development presenter needs to be knowledgeable, enthusiastic and have the ability to include participants.

> Somebody that is enthusiastic for a start and knows what they're talking about. You have to be able to ask them anything and they will know or to be able to find out because if they don't know about it they can't tell you. So they have to be at a higher level of understanding or at least on the same level as the people. So, enthusiastic, to know what they're doing and to make it interesting and to involve everybody in it. (Interview 5)

When Deidre was asked what a worst case scenario would be for professional development she concentrated on the qualities of the presenter. The worst case professional development would be taken by a presenter that presented only theoretical ideas and dominated the proceedings. The comment also reinforces the idea that Deidre judges worthwhile professional development by its practical nature.

> Where they talk at you the whole time and you're supposed to take notes that you will never ever look at again. Someone that you think this person doesn't really know what they're talking about or they may know what they're talking about but it's going right over your head. You're thinking that's fine but how am I going to use it. OK I understand the theory and there's a certain place for theory behind things. You need to come away with something that you can use and it's valuable to you. (Interview 1)

Deidre noted that one of the gains she made from the *3Cs* program was observing the problem-solving methods and noting the mathematical knowledge of the other participants. When asked whether any of her own mathematical competence in Chance had changed as a result of the professional development workshops she replied:

> Ah, well maybe the way other people work things out. Because I tend to stick to ..... well I know the formula. I'm good at remembering things like that so I think, "OK I know how to do that, you multiply them or you add them or whatever". But I found it interesting to see the way other people work things out. They probably gave me more ways to think about it instead of just thinking well I know how to do that so I'll just do it. (Interview 3)

Deidre was asked to comment on why the participants did not like being organised by the *3Cs* presenter into varying working groups. She said:

> I don't think it is just teachers, I think it is everybody. Even kids do it. I think it is just a security thing. You like to stay with a group that you belong to. (Interview 5)

However Deidre did agree that it would be of value for the presenter to mix the participants into differing groups and justified this by saying:

> Because for example I know, the six of us who know each other fairly well and have worked together for a fair bit of time. And you know their views and you know their ideas and because you all share everything you have probably got a wide bank of activities and ideas and things to try. But other people outside try different things. So it would be a good idea to get other ideas from other people. (Interview 5)

Deidre: Providing a teacher-centered focus for content and organization

From the list of effective professional development features Deidre selected 'addresses issues of concern asked by the teachers themselves' as one that was important to her, although not the most important. She reasoned that this feature was important to her by linking it to her own needs.

> Well if you are confused about something, unsure if you don't know enough about it you can't teach it to the children. I might go and do some PD on computers because I know very little about it. So I might say, "Oh I know nothing and I need to teach the kids how to use a computer, how a CD ROM works" and I don't know so I would choose to go. If something came up I would choose to go and do that because it is going to be an advantage to the kids in the end. So that would be my need. (Interview 5)

It was important to Deidre that the content of the workshops contained practical activities that she could use in her classroom.

> And we've got a lot of practical stuff that you can use with kids and that's why most teachers do PDs, or this sort of PD. There's no point doing PD if you bring nothing out of it. So long as you've got something out of it. Either something you've gained in knowledge or something you can use with the kids. (Interview 3)

On a number of 'End of session' evaluation sheets Deidre referred to the activities presented in the workshop:

> I don't have a large repertoire of chance activities so all new ideas are valuable. (Session 1)
>
> [I have extended my personal understanding in chance from] the various activities. (Session 2)
>
> [Over the six workshops] the new range of practical activities [has been of the greatest value to me because] new activities are always great to try. (Session 6)

Deidre felt that it was important for her to actually do the activities in the workshops and not just be told about the ideas. She gave two reasons for this: firstly to ascertain the appropriateness of the activity for her own class, and secondly that you personally learn more effectively by doing.

> Oh no they have to try them. I think. Well you do not know how it is going to work, if it is going to be appropriate for the kids that you are teaching, the grade level you are teaching. And I don't believe you can learn things by someone telling you about them. You've got to do it. (Interview 5)

However Deidre noted on the 'End of session 5' evaluation sheet that 'adults don't enjoy role play'.

Deidre: Providing opportunities for observing outcomes and reflection

Deidre believed that trailing activities between sessions was important so that she could return to the next workshop session and be able to discuss it with other participants. She also felt that she understood the activity more if she had trialled it with children.

> You need to try something out. You can't go back and discuss how it worked, how it didn't work if you hadn't tried it. And it gives you a better understanding even if you understand what the concept is and what you are really trying to get at. Doing it with kids makes it clearer. Then you find out the things that work and the things that don't work. (Interview 3)

It has already been noted that one of the changes that Deidre made as a result of the *3Cs* program was that she now at least held an opinion about how children learn Chance. When asked what aspect of the professional development helped her to arrive at this conclusion she referred to the importance of the trialling in the classroom.

When asked to select the most important professional development feature from a list of features Deidre selected 'seeing advantages for their pupils'. When asked why she said:

> Seeing advantages for their pupils. ..... Because it is the whole purpose of teaching. So if there is no advantage for the student it was useless. PD that's like about *Course Advice* and about *CSF*, it has got to be an advantage to students in the end. Then otherwise why do it. (Interview 5)

There are several instances which give examples of Deidre's comment noting the value to her of observing pupil reaction during trialling. For example, there was an earlier reference to the pupil input noted when Deidre trialled the 'tennis clothes' problem and how she used this input as a form of measure of success of the activity. As well, in pinpointing how she decides whether or not the activities trialled were successful, she said:

> The discussion probably that comes up afterwards. That's what I found with most of the things. Like with the language of chance ..... the discussion that comes up about the sort of language you use and what it means. And they often use it but haven't thought about what it

> actually means. And about discussing the dice. Is there more of a chance of one number or one colour coming up? I don't think they ever really thought about it. (Interview 3)

Although Deidre found the *3Cs* workshops beneficial she felt that teachers after-school time was already burdened with meetings and professional development activity and time constraints were paramount. When Deidre was asked to select the least important feature from a list of effective features the one she chose was 'Over an extended period of time'.

> Least. Probably that one, well it depends on what it is. Sometimes if it is over an extended period of time by the time you get to the end you've lost the beginning of it. We have done a few things like that, 'Frameworks and Assessment and Reporting' and we did 'Frameworks and Literacy' and they went over eighteen weeks for every second week and a by the time you got to the end of it you were sick to death of it. Whereas if you had even longer sessions in a shorter amount of time it's of more benefit. (Interview 5)

When asked her reaction to this feature and the *3Cs* program she replied:

> Yeah, probably because I think by the end I mean I was thinking, "Oh no, not again tonight". It is the time factor. Working in schools teachers just don't have enough time. If your stuff had been the only or one of the only things or the only thing in third term we were doing no one would have minded. But it was just like: "Oh no, I've got to do more". (Interview 5)

On the 'End of session 6' evaluation sheet Deidre wrote in response to the spacing and timing of workshops: "Advantage is that you aren't committed every Thursday but they have dragged out too long and people lose interest".

Deidre: Providing a philosophy on teacher change

As already noted the time constraints appeared to be an important factor in Deidre's consideration in regard to attendance at professional development. When this is linked with the comments on feeling compelled to attend the *3Cs* program it is evident that Deidre was not committed to this specific program and perhaps did not regard it in terms of an on-going process of personal professional development.

> Well one I didn't like the idea of giving up two hours of my time of a night to start with. So I probably had a negative feeling about it [*3Cs*] in the first place. (Interview 3)

However, putting this aside, Deidre did make comment that the *3Cs* program was beneficial to her and that she made changes in her beliefs and practice.

> So, I had a negative attitude to start with, but I don't now, so it's been worthwhile for me. (Interview 3)

Deidre: Summary - Professional development features

Deidre chose 'groups of teachers' as a most important positive feature of effective professional development because each team member could note and/or remember differing parts of the presentation and because trialling could occur in a different order and thus facilitate more meaningful sharing. Although Deidre generally believed that it was preferred to have a supportive Principal she noted that either the Principal or other senior teacher had overloaded the staff with professional development. Deidre thought that it was good for teachers at workshops to be able to share problem solving methods because it assisted her to consider methods that she would never have considered.

Deidre chose 'Issues of concern' as an important positive feature by linking it to her own professional development needs. Deidre thought that it was best to actually complete activities in workshops rather than be left to read about them or just be told about them. In this way she could check the appropriateness of the activity for her own grade and she could personally learn about the activity by doing it herself.

Understanding of an activity was enhanced if you were given the opportunity to trial the activity in the classroom. So 'Researching in classrooms' was an important feature for Deidre because it prepared you for the next workshop. Deidre felt that 'Seeing advantages for children' as an important feature as she regarded this as the whole purpose for teaching. The feature 'Over an extended period of time' was viewed as a negative feature because she felt that teachers were already overloaded with professional development and meetings. As well, Deidre believed that continuity was lost if the workshops were spread over too great a time.

Table 7.2 summarises Deidre's beliefs about features of professional development.

	Feature	High priority	Low priority	No comment recorded
Players	Groups of teachers	*		
	Supportive principal	•		
	Facilitator seen as part of the team			•
	Further points •Noting the problem-solving methods and mathematical knowledge of the other participants	•		
	•A PD presenter who is knowledgeable, enthusiastic and able to include participants	•		
	•A PD presenter who provides practical activities rather than concentrates on theoretical issues	*		
Organisation	Conducted in school setting			•
	School-wide effort			•
	Variety of approaches			•
	Issues of concern	•		
	Ownership			•
	Further points •To actually do activities in the PD workshops	•		
	•Having appropriate activities, and specifically relevant to year level	•		
Outcomes	Researching in classrooms	•		
	Seeing advantages for children	•		
	Extended Time		*	
Making change	Commitment			•
	Long term plan			•

Table 7.2: Summary of Deidre' beliefs related to features of effective professional development
(* = highest and lowest priority)

In regard to features of effective professional development that provide procedures for support and collaboration Deidre:

- felt that 'Going as a group of teachers' was a very important feature of effective professional development because colleagues could meaningfully share trialling and also collectively remember the ideas and activities presented;
- believed that it was an advantage to have a supportive Principal;
- valued participant sharing at workshops because she could observe how other teachers solved mathematical problems;
- preferred a presenter who was knowledgeable, enthusiastic, able to include all participants and provided practical activities rather than concentrate on theoretical issues:

In regard to features of effective professional development that provide a teacher-centered focus for content and organization Deidre:

- felt that it was essential to have hands-on activities in workshops because she could check out the appropriateness of an activity for her pupils as well as learn about the activity first hand;
- argued that 'Issues of concern' needed to be addressed and linked this to her own personal professional development needs;

In regard to features of effective professional development that provide opportunities for observing outcomes and reflection Deidre:

- felt that 'Seeing advantages for children' was a very important feature of effective professional development because she viewed that as the whole purpose of professional development;
- considered that 'Researching in classrooms' was useful to prepare the teacher for the next workshop;
- considered that professional development conducted 'Over an extended period of time' was a negative feature because it added to her sense of being overloaded and because it lost continuity;

In regard to features of effective professional development in other aspects Deidre:

- thought that teachers were overloaded with after-school activity and resented pressure to be even more involved.

Deidre: Comparison of PD prediction and *3Cs summary*

Table 7.3 compares the two 'Profesional development features' lists developed in the PD prediction in Chapter 6 and the summary list above. The points that match in both lists are connected by a two-way arrow.

PD prediction In summary Deidre:		*3Cs* discussion In summary Deidre:
Providing procedures for support and collaboration		Providing procedures for support and collaboration
• is likely to value attending the *3Cs* prgram with her team-teaching colleagues based on her relational beliefs about how children learn mathematics and because of the importance that the group places on joint planning;	↔	• felt that 'Going as a group of teachers' was a very important feature of effective professional development because colleagues could meaningfully share trialling and also collectively remember the ideas and activities presented;
		• believed that it was an advantage to have a 'Supportive Pprincipal';
• could be frustrated by the relational/constructivist approach taken by the *3Cs* presenter because of her instrumental beliefs that a teacher has an explainer role. Her relational beliefs about how children learn best may lead her to appreciate the presenter's facilitation of small group discussion and hands-on activities;		
		• preferred a presenter who was knowledgeable, enthusiastic, able to include all participants and provided practical activities rather than concentrate on theoretical issues;
• is likely to value listening to the discussion from other teachers because of her relational beliefs about how children learn;	↔	• valued participant sharing at workshops because she could observe how other teachers solved mathematical problems;
Providing a teacher-centered focus for content and organization		Providing a teacher-centered focus for content and organization
		• felt that it was essential to have hands-on activities in workshops because she could check out the appropriateness of an activity for her pupils as well as learn about the activity first hand;
• is likely to place a low priority on the professional development features of 'ownership' and 'issues of concern recognised by the teachers themselves' based on her instrumental belief on the role that children play in the learning process;	↔	• argued that 'Issues of concern' needed to be addressed and linked this to her own personal professional development needs;

Providing opportunities for observing outcomes and reflection • may have a limited view of the idea of 'reseaching in classrooms' but could judge the success of the outcome on either instrumental or relational terms;	↔	Providing opportunities for observing outcomes and reflection • considered that 'Researching in classrooms' was useful to prepare the teacher for the next workshop;
		• felt that 'Seeing advantages for children' was a very important feature of effective professional development because she viewed that as the whole purpose of professional development;
• may prefer the *3Cs* program to have been conducted over a much shorter period of time because her beliefs do not translate into giving pupils reflection time;	↔	• considered that professional development conducted 'Over an extended period of time' was a negative feature because it added to her sense of being overloaded and because it lost continuity;
Providing a philosophy on teacher change • will probably not have a long term view of her professional development needs because she has instrumental views on the value of reflection.		
Other		Other • thought that teachers were overloaded with after-school activity and resented pressure to be even more involved;

Table 7.3: Deidre's 'Effective features' comparison – PD prediction and *3Cs* discussion

MALCOLM

Reactions to *3Cs* Content

Malcolm: Trialling summary

A summary of Malcolm's trialling can be found in table C.2 (Appendix C). The summary shows that he trialled *3Cs* activities from all three content aspects. He trialled more 'mathematics content' activities than most *3Cs* participants and all bar one of the teaching strategies. Activities from every session, except session 5, were reported as trialled.

Although Malcolm appears to have mainly trialled workshopped activities he does claim that he used the handouts. He was asked what would make him choose to read an article. He replied:

> I read things for information I guess. And ideas. I have used ideas out of the notes that we have got in that book. So I might pick up the whole folder and I will flick through it and say, "Oh I haven't tried this yet" or "this looks interesting". (Interview 4)

Malcolm: Role that pupils play in the learning process

The scenario put forward in Chapter 6 was that Malcolm had surface-level relational beliefs about how children learn mathematics but that these were dominated by deep-level instrumental beliefs about the role of the teacher that in turn led to an instrumental classroom approach in terms of questioning and discussion, teaching style, and pupil mode. He believed that group work had advantages, but did not see these advantages as pertaining to pupils sharing mathematical ideas. The intention of the *3Cs* program was to move teachers towards relational classroom practice and activities were modelled in a way that encouraged collaborative sharing and solving of problems.

When Malcolm discussed the success in much of his trialling he referred to the amount of pupil language and discussion that was produced. For example, Malcolm was asked to name an activity from the first three *3Cs* workshops that had been successful in his classroom. He chose the activity where a random selector was made to fit specified theoretical percentages of probability (page A-24). His reason for the choice of this activity was based upon the discussion that occurred.

> Just talking about the language of probability because [making the random generators] really got a lot of them talking. The discussion was quite high especially within the groups. (Interview 3)

When Malcolm discussed the benefits of the trialled teaching strategies, Think-pair-share (A-11) and Questioner-tag (A-50), he referred to the amount of pupil discussion that was generated.

> Trialling things in the classroom has shown that there's been discussion, there's been the maths language and the sharing of ideas and the kids have been good with that. (Interview 4)

What actually took place when these lessons were implemented? For Classroom Observation 4 Malcolm used the clue cards from *3Cs* Activity 3-4 (A-36) and generally implemented the activity along the same lines as was undertaken in the workshop. Following the 'expert group' discussion and then the 'home group' discussions, each 'home group' reported their answer and the reasons for it to the rest of the class. Malcolm paraphrased each of the group's responses and then gave a very lengthy series of explanations to which few students paid attention. At the end of this discussion he said:

> Now that we've discussed the clues again if you think that maybe you are wrong or that you think you'd like to change your results discuss it with your table again. If you believe that you are right just keep the same methods you have. If you believe that you are wrong just draw the next net. Have a discussion with your group. (Classroom observation 4 transcription)

The groups briefly discussed their ideas again, but most stayed with their original thinking. Until Malcolm's concluding summary the jigsaw approach had been followed appropriately and Malcolm had acted as a facilitator, maximising the amount of pupil-pupil discussion. But in the last part of the session Malcolm took a more dominating explainer role.

It appears that Malcolm's surface-level relational beliefs about how children learn mathematics have encouraged him to trial the collaborative teaching strategies as modelled in *3Cs* only to a certain extent. However, his deep-seated instrumental beliefs on the role of the teacher still dominate what he perceives as the role of the teacher.

Malcolm: Purpose for teaching mathematics

In Chapter 6 it was noted that Malcolm had relational beliefs about the nature of mathematics and that he saw the purpose for learning mathematics as the acquisition of thinking skills and for decision-making in life. The types of problems and investigations presented in *3Cs* should have confirmed these beliefs and Malcolm would have been encouraged by the way they were presented. This would have been made easier by the enjoyment Malcolm gained from problem-solving. He did choose *3Cs* activities for trialling based upon his enjoyment of the activity during the *3Cs* workshop.

> I found them [the two lessons given for classroom observations] interesting when we did them as a group of adults and I knew that the kids would find them interesting and on task. It is far

> better than filling the board with maths sums and saying, "Here come and do these". (Interview 4)

Malcolm's confidence was also noticeable in the way that he handled the *3Cs* mathematics content trialling. With some of these activities he improved the activity with some modification or extra inclusion, or he extended the activity, or he made connections to other activities that had already been completed.

The lesson based upon the M&M's activity (A-76) was structured differently by Malcolm. This was observed by the researcher as Classroom Observation 3. The lesson was generally conducted in the same way as was undertaken in the *3Cs* workshop but Malcolm did use different-sized groupings in the class to determine sampling results. This adaption proved very interesting as when the most popular colour was tallied for individual pupil's samples, 'table group' samples and 'half grade' samples the results varied. This approach provided a most valuable dimension to the activity, one that would not have occurred if the *3Cs* approach had been strictly followed.

The clue cards activity (A-36) was observed by the researcher as Classroom Observation 4. This activity centered around various results obtained by the rolling of coloured dice. The same clues were used as those in the workshop and the same teaching approach was generally used. However the 'expert groups' reported on the findings and coloured in a net according to the decisions they had made as an expert group before they returned to their 'home groups'. This addition added a worthwhile discussion element into the activity. In the interview discussion Malcolm spoke about the follow-up to this lesson that made use of spinners

> It was basically design a spinner that would give you a twenty-five percent chance of spinning a red or one in four chances. So we were looking at ratios. We were looking at percentages and things like that. (Interview 4)

Malcolm trialled the Dicetracks game (A-7) and also added extension activities.

> Yes we actually made our own games. We also did this with the spinners as well once we had made our spinners. We also made a spinner track basically once again only two colours but I got them to do a track and trial it a couple of times and try and make it fair and things like that. (Interview 4)

Malcolm did not trial 'Hat, scarf and belt' (A-38) but made connections to previously completed activities that he viewed as similar.

> We did one earlier in the year, this is before the PD and it was out of the Course Advice. That was the 'Cabbage Patch' which was a very similar thing but it wasn't using dice or anything. It was just looking at the possible combinations, yeah. (Interview 4)

Malcolm may have been reluctant to trial mathematics activities where the mathematics was open-ended or did not follow the usual 'rules'. For example, Malcolm did not trial the 'Toss of Luck' game (page A-27).

> The only reason for that, I guess with kids is, that they would find excuses why, as soon as you had bottle tops, coins and whatever I just felt like for this grade level that probably this is no good. As for the coloured dice they thought yeah it is more familiar to them. So no I didn't try it. (Interview 4)

When Malcolm was questioned further on this and asked if he thought that the underlying mathematics was not appropriate for Year 6 he replied:

> I just felt that for grade six it is easy to stick to the known. I know that we are talking about random [generators] and what might work and what might not work. I don't know what they would actually get out of it. When they make a dice they actually know that a dice rolls and there is six chances to come here and I have got three chances out of six. But with a drawing pin for me they sort of, you have to sort of say what have they got out of it? (Interview 4)

This suggests that Malcolm believes that a more definitive result mathematically is more important than an exploration of concepts; concepts that he may not have had sufficient control over for him to be able to take the lead in explanation of what occurred.

Malcolm: Dealing with mathematics and pedagogy

In Chapter 6 it was noted that Malcolm had relational beliefs about the nature of mathematics but that these were not fully implemented in the classroom because of his dominant instrumental beliefs about the role of the teacher. These instrumental beliefs were recently being challenged and it would be expected that *3Cs* could further support his developing relational beliefs related to classroom practice. In this discussion it has been demonstrated that Malcolm was encouraged to trial many of the *3Cs* activities because of his relational beliefs about the nature of mathematics, along with his enjoyment and confidence in mathematics. However he has made choices about which activities to trial based upon a notion of mathematics where the results and processes are clear and readily explainable. That is, his instrumental beliefs about the role of the teacher are still dominating what occurs in the classroom. The same result happened when Malcolm trialled activities involving collaborative teaching strategies. He was attracted to these strategies because of his emerging relational beliefs about how children learn mathematics.

The strategies were implemented appropriately, except as a conclusion Malcolm took over the explainer role and de-valued the input that the pupils had given.

It is clear that Malcolm was generally quite innovative in the way he modified and extended the 'mathematics content' *3Cs* activities. He also trialled an activity that contained mathematics that was new to him. He had trialled the activity using two-way charts (A-19) and when asked if the idea of using a two-way table was new to him he replied:

> Yes it was new because I looked at it as doing a diagram not a chart. Like a tree diagram where you have branches saying if this happens this this and these are the options for that one and then if this one happens you have these chances. (Interview 3)

Malcolm trialled all bar one of the collaborative teaching strategies but when he was asked if the strategies workshopped in the *3Cs* program were new to him he noted that he had been using the strategies in other curriculum areas but had not thought to implement them in mathematics.

> They are new to me ..... and I've been introduced to something very similar through a language activity that we did one time. A very similar sort of strategy but probably haven't transferred it over to maths. And seeing something done in the area of maths, "Why didn't I think of that". I've done it with language activities and I've done it with general studies type things but I've never done it with Maths. (Interview 3)

In other interview comments Malcolm specifically referred to both the think-pair-share strategy and the clue-cards approach as being successful for him.

> There is a lot of language in Maths and that's how I find these sorts of problems. The kids have to talk to each other. The kids have to bounce ideas off each other. (Interview 4)

Malcolm experienced this outcome as well when the strategies were modelled at the *3Cs* workshops and the experience may well have been the deciding factor for classroom trialling of the strategy.

> We actually listened to each other. They are saying this and we are saying that and actually ..... the ideas are bounced off each other too. (*3Cs* session 2 transcript)

But Malcolm had not extended their use into activities other than those presented at the *3Cs* workshops. He referred to needing 'the right sort of activity' and that 'decimal fractions and percentages' were not the right sort of topics for use with these collaborative teaching strategies (Interviews 3 & 4).

Malcolm was able to be innovative with the 'mathematics content' activities because of his relational beliefs on the nature of mathematics, enjoyment and confidence, but he has demonstrated that he was not able to be innovative in the same way in relation to the 'teaching strategies' content. This result may be due to the balancing of surface-level relational beliefs he holds about how children learn mathematics and the deep-level instrumental beliefs held about the role of the teacher.

Malcolm: Summary - trialling *3Cs* content

As a result of the *3Cs* program in regard to mathematics content Malcolm:

- trialled a large number of the mathematics activities;
- justified the choice and success of many of the trialled activities because the use of mathematical language, pupil-pupil discussion and inclusion of social dimensions were foci;
- was quite selective in the activities chosen for trialling ensuring that the mathematics outcomes and the actual activity were suitable for his year level;
- altered some activities to make the underlying mathematics less open-ended;
- developed extensions to some mathematics activities so as to provide richer mathematical outcomes for year 6 level;
- was confident in the way that he could make connections between the mathematical outcomes of several *3Cs* activities with tasks that he had previously completed with his class;

As a result of the *3Cs* program in regard to teaching strategies content Malcolm:

- trialled all bar one of the teaching strategies;
- was interested in trialling these strategies because of his interest in developing pupil-pupil discussion and observing children's communication skills;
- followed the way in which these strategies had been workshopped but possibly found it difficult to completely remove himself from an explainer role;

As a result of the *3Cs* program in regard to constructivist notions content Malcolm:

- trialled some of the activities that focussed on pupil's construction of mathematical concepts;
- became interested in these activities because he wondered what his pupils reactions or responses would be;

As a result of the *3Cs* program in regard to other trialling aspects Malcolm:

- was not prepared to compromise some of the external constraints such as being CSF-focussed in order to take on board new ideas, although the large amount of trialled activities suggests that this impact was limited;
- mainly trialled workshopped activities, but noted that he did make use of the handouts;
- trailed activities from each workshop, bar session 5.

Malcolm: Comparison of PD prediction and *3Cs* trialling

Table 7.4 compares the two 'Content' summary lists made in the PD prediction in Chapter 6 and the summary list above. The points that match in both lists are connected by a two-way arrow.

PD prediction In summary Malcolm:		Trialling *3Cs* content As a result of the *3Cs* program Malcolm:
Mathematics content: • is likely to trial many of the mathematics activities because of his beliefs about the nature of mathematics; • may trial many mathematics activities because he has instrumental beliefs on selecting good activities rather than planning with pupils' needs as important;	↔	Mathematics content: • trialled a large number of the mathematics activities;
• will choose to trial mathematics activities because of personal interest and confidence in mathematics ability;	↔	• developed extensions to some mathematics activities so as to provide richer mathematical outcomes for year 6 lev[illegible] • was confident in the way that he could make connections between the mathematical outcomes of several *3Cs* activities with tasks that he had previously completed with his class;
• may trial some mathematics activities because the approaches modelled in *3Cs* workshops confirm his newly-found relational beliefs, particularly those in relation to the use of group work;	↔	• justified the choice and success of many of the trialled mathematics activities because the use of mathematical language, pupil-pupil discussion and inclusion of social dimensions were foci;
• will most probably select activities for trialling that fit in with recognisable CSF outcomes because of planning based on a CSF focus;	↔	• was quite selective in the activities chosen for trialling ensuring that the mathematics outcomes and the actual activity were suitable for his year level;
• may implement some activities in a different way to the *3Cs* modelling so as to accommodate his instrumental beliefs and practice;	↔	• altered some activities to make the underlying mathematics less open-ended;
Teaching strategies content: • is likely to trial many of the teaching strategies because of his interest recently aroused in the use of group work;	↔	Teaching strategies content: • trialled all bar one of the teaching strategies; • was interested in trialling these strategies because of his interest in developing pupil-pupil discussion and observing children's communication skills;

• will most likely plan these as they were modelled in the *3Cs* workshops, but their actual implementation may be more along an instrumental approach;	• followed the way in which these strategies had been workshopped but possibly found it difficult to completely remove himself from an explainer role;
Constructivist notions content: • is likely to trial many of the activities which focussed on constructivist notions because of his interest in mathematics and the relational beliefs about how children bes' learn mathematics, although this may be limited by his instrumental beliefs about the role of the teacher;	Constructivist notions content: • trialled some of the activities that focussed on pupil's construction of mathematical concepts; • became interested in these activities because he wondered what his pupils reactions or responses would be;
Other: • may restrict his trialling because of his CSF focus;	Other: • was not prepared to compromise some of the external constraints such as being CSF-focussed in order to take on board new ideas, although the large amount of trialled activities suggests that this impact was limited;
	• mainly trialled workshopped activities but noted that he did make use of the handouts;
• is likely to trial activities from throughout the *3Cs* program because it is appropriate for him to fit one-off activities into his planning. In general he prefers not to work in themes.	• trailed activities from each workshop, bar session 5.

Table 7.4: Malcolm's content trialling comparison - PD prediction and *3Cs* trialling

Attitudes to features of professional development

Malcolm: Providing procedures for support and collaboration

When Malcolm was asked to select the most important feature for effective professional development he chose two features: 'Seeing advantages for pupils' and 'Attending with a group of teachers'. He justified the choice of the latter feature by saying:

> I have been to some PDs where I have been by myself and to be honest you don't enjoy them as much. When there is a group you tend to be able to bounce ideas off, you discuss them when you come back to school, you re-inforce it a little bit. We went [last week] to an inservice on using the *Maths Course Advice* and it is interesting because when we came back although we had been to the same PD we'd each come back with a different message. (Interview 5)

Malcolm was asked if he had been discussing the *3Cs* activities with his immediate colleagues who had also been attending and he replied:

> I have actually found that especially prior to the day that you are due to come in or prior to the next PD that's when most of the talk happens because people say, "Have you done that thing [from *3Cs*]?" Some of us say, "Yeah I've done mine, and I did this and this" and "Yes it does create discussion". It's usually a last minute discussion probably not straight after we'd done the activity. Although Merrilyn and I because we work in rooms very close together I say, "Well I did this today and you should give it a try. It is really good" or "This is how I did it. How are you going to approach yours?" So Merrilyn and I probably discuss it pretty well straight after. (Interview 3)

And when Malcolm was asked for a positive event resulting from the *3Cs* sessions he said:

> I guess the positive event that I found was the way people talked about it the next day, like talking to the people from [Spinebill Way School] who were actually at those PD sessions. They all had very positive responses to the PD. (Interview 5)

If Malcolm values going to professional development with a group one of the outcomes should be that he has trialled many of the same activities as his colleagues. At Spinebill Way Primary School the four teachers that attended *3Cs* trialled a total of twenty different 'mathematics content' activities with just over half of these activities being trialled by at least two of the teachers. Table 7.5 summarises the trialling of mathematics content activities.

	Malcolm	Neva	Helen	Gerry
Number of 'mathematics content' activities trialled	10	13	8	7
Percentage of trialled activities that were also trialled by at least one colleague	80	88	71	69
Percentage of trialled activities that were also trialled by at least two colleagues	67	63	43	38

Table 7.5: Summary of 'mathematics content' activities trialling at Spinebill Way Primary School

There is no direct evidence that Malcolm's trialling of activities where one or more of the teachers trialled the same activity was due to the fact that they attended *3Cs* as a group and subsequently shared their classroom experiences with each other. However this analysis would suggest that the professional development feature 'Attending as a group of teachers' was a substantial component in trialling at Spinebill Way School and that Malcolm gained most from this, either as the instigator of much of the trialling at his school or as the benefactor of others' trialling.

Neva was asked if she had become more aware of her colleagues' beliefs towards mathematics and chance as a result of attending *3Cs* and her reply confirms that there had been discussion with Malcolm. Although they all attended session 5 Neva was then away from the school for an extended period of time and absent for the time immediately following sessions 5 and for session 6 where the sharing of trialling from session 5 would have occurred. This series of absences may explain that without Neva's influence either as an instigator or as a good listener, why Malcolm did not trial session 5 activities.

Malcolm noted that he found valuable the interaction at the *3Cs* sessions.

> Sometimes you do your thing in a class room with thirty kids and it's very hard to keep up with everything. With the PD it gives you that opportunity to see things working and see other people. Like even in the PD listening to the discussions there, listening to the comments there and what people are saying in the PD. (Interview 3)

But he preferred the *3Cs* activities to be workshopped with the colleagues from his own school rather than mixing the teachers from different schools.

> I think I would have preferred that people would have made their own [table groupings]. If it looked as if people were being left out then you might need to step in. But I think right from day one when we first moved in everybody seemed to move into a group and we were happy. There was a lot of discussion, there was a lot of interaction and probably it would have been easier just to let it be. (Interview 5)

From the list of features of effective professional development Malcolm chose two that were of low priority: 'conducted in a school setting' and 'supportive Principal'. His comments for choosing 'supportive Principal' were:

> It is nice if you have got a supportive Principal but I don't think it is a must. I mean if you want to do a PD or you want to improve your skills you do it. Obviously a supportive Principal will mean the Principal will pay for it. If you don't have a supportive Principal means you are going to pay for it. We pay for lots of ours so I don't think that it's that important. (Interview 5)

Malcolm was asked to describe a worst case scenario for professional development. He said:

> Probably a long PD with a speaker who spoke the whole time and had no breaks. That's the worst scenario. I know teachers moan when they say I want you to do that activity, but it does break up the day. (Interview 2)

Malcolm was asked what qualities he expected in a good professional development presenter. He replied:

> I expect them not to be too serious. In most cases and even if you go to management training and things like that they tell you that things have got to be a little bit light-hearted. You can't take yourself too seriously. You've got to know your stuff. You've got to be knowledgeable

but you have got to be able to read your audience a little bit too and be able to bend a little bit with your audience. I think a good presenter can sense what the audience or where the audience is coming from and has the ability to probably pull the audience together a little bit. (Interview 5)

Malcolm was asked to rate the *3Cs* presenter on how she was able to 'read the audience' and 'pull things together'. He replied:

I think she was really easy going especially in a couple of incidents where she was obviously trying to get a point across. I think it was with the children one [Activity 5-1, page A-58, Step 3] where they were trying to decide if you had a boy and then what were the chances of getting another boy. I could see where she was coming from but nobody would except what she was saying and I think she handled that really well. In the end she had to back off and say, "Well look obviously we are not getting anywhere here but it's something we need to have a think about". I thought she presented very well. I thought under the circumstances, because I think that we are all aware that she was sort of going along with somebody else's notes, your notes in a lot of cases and yet she held it together really well. So I thought that she did very well. Very easy going. You can relate to her and I think she answered most questions very well. ..... And of course she put up with my one liners, yeah. (Interview 5)

Malcolm: Providing a teacher-centered focus for content and organization

Malcolm chose 'Conducted in a school setting' as of low importance, equally to 'Supportive Principal', but noted that he preferred not to travel too far.

Local would be preferable. Program at a local setting but not in my school. If it is somewhere fairly easy to get to because most of them now are after school anyway. (Interview 5)

With the PD program *Maths Making Links* Malcolm valued the resources that were shared by and distributed to participants.

[*Maths Making Links*] was good because we ended up getting a book of mathematical links and the different areas and a copy of all the activities that all the people did. We had to share an activity from the Course Advice in measurement and come back and explain how it went and talk about the successes you had. (Interview 2)

Malcolm judged the success of the *3Cs* workshops for his immediate colleagues by the fact that the two-hour workshop passed quickly.

I've quite enjoyed it and I think you'll find the same with everybody [else at Spinebill Way]. I've got a lot of positive feedback. They sort of think that everything flows and that you really don't feel that you've spent much time in there and that's always a good indicator for teachers. If they said the time went quick it's a good indicator. (Interview 3)

In addition Malcolm preferred to workshop activities rather than sit listening to a presenter.

> I like to try [activities in workshops] although I complain about it all the time. I think teachers are the same. As soon as they say, "All right I want everybody to get up" and you say, "Oh no". This is so childish, but I think if you were made to sit there and listen and have everything explained to you with actually not even getting up, you'd say, "God we sat there for two hours listening to that person drone on". I would rather get up and do something. (Interview 5)

He added that his preference was to workshop activities as a group and not have the pressure of completing an activity in front of his peers.

> I don't like being the focus. I mean if it is the whole group of us doing something that's fine. If it is just me having to stand out there then I sort of feel a little bit threatened by that but I don't mind doing group activities like when we tried to get in a line when we had all the words for probability [Activity 1-2, page A-4]. (Interview 5)

Malcolm: Providing opportunities for observing outcomes and reflection

It has already been noted in reporting Malcolm's reaction to trialling the 'think-pair-share' strategy that he found it valuable to observe the 'dynamics of [his] grade and see the communication skills of some pupils' (Interview 3) and 'I got a lot of information from that by just listening to the groups' (Interview 4) when trialling the 'clue cards' strategy. It was also the classroom trialling that encouraged informal discussion between Malcolm and his immediate colleagues.

> And some of them say: "Well we're going to do the coin tosses and we're going to do this one and were going to do that one". And there's a lot of discussion about which one they are going to do or which one they tried and how it worked out. (Interview 3)

When Malcolm was asked what had been the greatest value of the six *3Cs* workshops he replied:

> Doing activities in the classroom. (End of session questionnaire 6)

There are many comments throughout the interviews which demonstrate that Malcolm judged the success of his *3Cs* trialling by the perceived advantages it had for his pupils' learning. Malcolm was asked to pinpoint some strategy from the *3Cs* program that had impacted on his teaching.

> I feel that I'm getting more out of it now than I was to start with. I mean I would often run Chance and Data activities in the classroom but I probably didn't focus on what they were getting out of it than what I probably am now. ..... Those things might have happened before but I don't think I was equipped to focus on it as much as what I am now. I think that is where

In addition Malcolm preferred to workshop activities rather than sit listening to a presenter.

I like to try [activities in workshops] although I complain about it all the time. I think teachers are the same. As soon as they say, "All right I want everybody to get up" and you say, "Oh no". This is so childish, but I think if you were made to sit there and listen and have everything explained to you with actually not even getting up, you'd say, "God we sat there for two hours listening to that person drone on". I would rather get up and do something. (Interview 5)

He added that his preference was to workshop activities as a group and not have the pressure of completing an activity in front of his peers.

I don't like being the focus. I mean if it is the whole group of us doing something that's fine. If it is just me having to stand out there then I sort of feel a little bit threatened by that but I don't mind doing group activities like when we tried to get in a line when we had all the words for probability [Activity 1-2, page A-4]. (Interview 5)

Malcolm: Providing opportunities for observing outcomes and reflection

It has already been noted in reporting Malcolm's reaction to trialling the 'think-pair-share' strategy that he found it valuable to observe the 'dynamics of [his] grade and see the communication skills of some pupils' (Interview 3) and 'I got a lot of information from that by just listening to the groups' (Interview 4) when trialling the 'clue cards' strategy. It was also the classroom trialling that encouraged informal discussion between Malcolm and his immediate colleagues.

And some of them say: "Well we're going to do the coin tosses and we're going to do this one and were going to do that one". And there's a lot of discussion about which one they are going to do or which one they tried and how it worked out. (Interview 3)

When Malcolm was asked what had been the greatest value of the six *3Cs* workshops he replied:

Doing activities in the classroom. (End of session questionnaire 6)

There are many comments throughout the interviews which demonstrate that Malcolm judged the success of his *3Cs* trialling by the perceived advantages it had for his pupils' learning. Malcolm was asked to pinpoint some strategy from the *3Cs* program that had impacted on his teaching.

I feel that I'm getting more out of it now than I was to start with. I mean I would often run Chance and Data activities in the classroom but I probably didn't focus on what they were getting out of it than what I probably am now. ..... Those things might have happened before but I don't think I was equipped to focus on it as much as what I am now. I think that is where

> the PD has helped a lot. I have been able to focus on what [the pupils are getting out of [an activity]. (Interview 4)

Much of the change to which Malcolm referred was in relation to the pupil-pupil discussions that occurred.

> When you had a tag questioner (refer A-50) it was amazing just watching the kids go back to their group, give the answer and then chatter, chatter, chatter. (Interview 5)

These examples demonstrate that Malcolm observed advantages for his pupils from him attending the *3Cs* program. These conclusions were reinforced when he selected 'seeing advantages for pupils' as of high priority in the list of features for effective professional development (equally selected with 'attending as a group of teachers').

> When we do a PD well basically it's to use in our classrooms and to teach our students some sort of skill. I mean that is what we are in business for really. We are not doing it for the money and we're not doing it for the kudos or any of those sort of things. (Interview 5)

Malcolm made a comment in regard to *Maths Making Links* about professional development conducted over an extended period of time. He commented:

> With [*Maths Making Links*] we had to actually look back and trial an activity in our classroom and [consider] how it would work. I think, although teachers are very busy people, it's very hard to keep yourself going for that amount of time. ..... It went for six weeks I think. It might have been even more. (Interview 2)

Malcolm also commented about the spacing and timing of the *3Cs* workshops. He said:

> One week spacing was not enough time to trial activities. (End of session questionnaire 6)

(Note: A one week spacing occurred once. In all other instances there was at least a fortnight between workshop sessions).

Malcolm: Providing a philosophy on teacher change

There were no points relevant to this category in the interviews.

Malcolm: Summary - Professional development features

Malcolm selected 'Attending as a group of teachers' as high priority from the list of features of effective professional development. He saw this feature as important because it led to collegial discussion and provided a group of 'mentors' for other staff. Malcolm found the interaction with other teachers, both from his own school and from other schools, as an important component of good professional development because it was informative to hear other people's views and ideas. However, he preferred to undertake workshop activities with the group from his own school because of the supportive environment this provided. He did not view the feature of 'Supportive Principal' very highly and judged this on the notion of the Principal providing the funds for attending professional development. His worst case scenario of professional development concerned a presenter lecturing the whole time without breaks for participant activity. Malcolm felt that a good presenter was one who would not be too serious, read the audience, be knowledgeable and answer questions, and keep the workshop together.

The feature 'Conducted in a school setting' was chosen by Malcolm as of low priority provided that he did not have to travel a long distance to the venue. Malcolm valued handouts as a teaching resource. Malcolm thought that it was important for the workshop session to be structured in a way so that there was opportunity for interaction between participants and that it was important for hands-on activities to be included. This type of structure, according to Malcolm, allowed workshops to flow and for the time to appear to pass quickly. He found the video snippets a useful medium to create interest and that workshop activities needed to be worthwhile.

Malcolm selected 'Seeing advantages for pupils' as of high priority from the list of features and there were many comments which emphasised this aspect as a factor for his positive reaction to trialling of activities. The trialling of activities was important to Malcolm because it allowed him to listen to pupils' comments, to note participation level, and to ascertain pupil reactions. These classroom reactions provided him with personal motivation and formed the basis for much of the informal discussion with colleagues about the *3Cs* program. Malcolm felt that it was difficult to maintain participant interest with professional development that was conducted over an extended period of time.

Table 7.6 summarises Malcolm's beliefs about features for effective professional development.

	Feature	High priority	Low priority	No comment recorded
Players	Groups of teachers	*		
	Supportive principal		*	
	Facilitator part of the team			•
	Further points •Preference to work with colleagues that he knows	•		
	•Participant interaction important factor	•		
	•PD presenter who does not lecture the whole time	•		
	•PD presenter who was not too serious, could read the audience, be knowledgable and answer questions, and keep the workshop together	•		
Organisation	Conducted in school setting		*	
	School-wide effort			•
	Variety of approaches	•		
	Issues of concern			•
	Ownership			•
	Further points •To workshop activities at PD	•		
	•To collect printed resources	•		
	•Appropriate pacing so as to maintain interest	•		
	•Video snippets a good motivator for trailling	•		
	•Organization needs to provide for participant interaction	•		
Outcomes	Researching in classrooms	•		
	Seeing advantages for children	*		
	Extended Time		•	
Making change	Commitment			•
	Long term plan			•

Table 7.6: Summary of Malcolm's beliefs related to features of effective professional development (* = highest and lowest priority)

In regard to features of effective professional development that provide procedures for support and collaboration Malcolm:

- believed that it was of value to attend professional development with a group of colleagues because this led to collegial discussion and provided 'mentors' for other teachers;
- thought that it was important for participant interaction to occur in workshops so that ideas and views were shared;
- preferred to undertake workshop activities with his own school colleagues because of the support they provided;
- selected the feature 'Supportive Principal' as of low priority and based this decision on the idea that the Principal's role was to provide funds to attend professional development;
- argued that professional development where the presenter lectured the whole time was a worst case scenario;
- commented that a good presenter was one who was not too serious, could read the audience, be knowledgable and answer questions, and keep the workshop together;

In regard to features of effective professional development that provide a teacher-centered focus for content and organization Malcolm:

- chose 'Conducted in a school setting' as a feature of low priority, provided that the venue was within reasonable travelling time;
- valued handouts as a useful resource;
- felt that it was appropriate to be involved in hands-on activities in workshop sessions;
- believed that variety in presentation was essential to assist the flow of the presentation;
- believed that successful professional development needed to present worthwhile classroom activities;
- thought that the use of video snippets of pupil discussion was valuable;
- believed that the structure of workshops needed participant interaction;

In regard to features of effective professional development that provide opportunities for observing outcomes and reflection Malcolm:

- valued the idea of researching in classrooms so that he could monitor pupil discussion and reaction;
- chose the feature 'Seeing advantages for pupils' as of high priority;

- thought that it was difficult to maintain interest with professional development conducted over an extended period of time.

Malcolm: Comparison of PD prediction and *3Cs* summary

Table 7.7 compares the two 'Professional development features' summary lists made in the PD prediction in Chapter 6 and the summary list above for Malcolm. The points that match in both lists are connected by a two-way arrow. Any opposing points are connected by a negated arrow.

PD prediction In summary Malcolm:	*3Cs* discussion In summary Malcolm:
Providing procedures for support and collaboration • will value attending professional development with other teachers from his school because it mirrors the use of pupil-pupil collaboration in the classroom but because of contradictions in beliefs this aspect may not be of highest priority;	Providing procedures for support and collaboration • believed that it was of value to attend professional development with a group of colleagues because this led to collegial discussion and provided 'mentors' for other teachers;
	• preferred to undertake workshop activities with his own school colleagues because of the support they provided;
	• selected the feature 'Supportive Principal' as of low priority and based this decision on the idea that the Principal's role was to provide funds to attend professional development;
• may prefer a professional development presenter who uses an explainer role because this matches his instrumental beliefs about the role of the teacher;	• argued that professional development where the presenter lectured the whole time was a worst case scenario;
	• commented that a good presenter was one who was not too serious, could read the audience, be knowledgable and answer questions, and keep the workshop together
• is likely to value listening to the discussion from other teachers because of his relational beliefs about how children learn;	• thought that it was important for participant interaction to occur in workshops so that ideas and views were shared;
Providing a teacher-centered focus for content and organization	Providing a teacher-centered focus for content and organization • chose 'Conducted in a school setting' as a feature of low priority, provided that the venue was within reasonable travelling time;

• is likely to place a low priority on the professional development features of 'ownership' and 'issues of concern recognised by the teachers themselves' based on his instrumental belief about the role that children play in the learning process;		
		• valued handouts as a useful resource;
• will appreciate being able to undertake hands-on activities and small group discussion in workshops because this matches his relational beliefs about how children best learn mathematics;	↔	• felt that it was appropriate to be involved in hands-on activities in workshop sessions; • believed that the structure of workshops needed participant interaction;
		• believed that variety in presentation was essential to assist the flow of the presentation;
		• believed that successful professional development needed to present worthwhile classroom activities;
		• thought that the use of video snippets of pupil discussion was valuable;
Providing opportunities for observing outcomes and reflection • will probably see that there are limited benefits for trialling in the classroom because he may not value the use of reflection time in his own teaching;	↮	Providing opportunities for observing outcomes and reflection • valued the idea of researching in classrooms so that he could monitor pupil discussion and reaction;
		• chose the feature 'Seeing advantages for pupils' as of high priority.
• has a preference against professional development being conducted over an extended period of time because he does not value reflection time for his pupils;	↔	• thought that it was difficult to maintain interest with professional development conducted over an extended period of time;
Providing a philosophy on teacher change • may not value that there needs to be a personal long term plan for professional development because he may not value the use of reflection time in his own teaching.		Providing a philosophy on teacher change

Table 7. 7: Malcolm's 'effective features' comparison - PD prediction and *3Cs* discussion

TASHA

Reactions to *3Cs* Content

Tasha: Trialling summary

Table C.3 (Appendix C) summarises Tasha's *3Cs* trialling. The summary indicates that she trialled very few *3Cs* activities and then essentially only the 'teaching strategies' content activities. Tasha missed workshop sessions 4 and 5.

Tasha: Role that pupils play in the learning process

From Chapter 6 it was noted that Tasha demonstrated a very strong relational classroom practice in all three aspects considered and that her beliefs about the role of the teacher and about how children learn mathematics were also relational. Because of this combination she already values the role that pupils can play in the learning process so *3Cs*, in this respect, should have been a confirming experience. When asked if the *3Cs* program had encouraged change in her group work approaches she said that she had already been 'doing a lot of group work, a lot of talking and discussing' and that *3Cs* had been a 'confirming experience' (Interview 4).

Tasha frequently referred to the *3Cs* collaborative strategies as useful and always justified her comments by the impact it would have on pupils' learning. On the End of Session 1 questionnaire (A-13) participants were asked to rank five foci from Session 1 in order of usefulness to them. Tasha chose as the most important focus 'Think-pair-share as a strategy to promote collaboration' and ranked 'Activities using biased dice' as the least important. The reasons that she gave were that 'Think-pair-share was an effective strategy that enables children to develop their thoughts [and activities using biased dice] is not as important as developing children's thinking' (End of Session 1 questionnaire). Tasha referred to the Clue Cards strategy (A-35) as 'A good strategy to get children thinking about the answer by interpreting the information' and suggested that the clue cards were 'Great activities to trial in the classroom' (End of Session 3 questionnaire).

When Tasha was asked which was the most worthwhile collaborative strategy she chose the co-operative role play modelled in session 5. She had previously used co-operative groups but in a different way:

> They were based mainly around the team projects. At the moment they're on recycling and they have got ten teams and each team has two managers. So they are working in a different aspect, so they have got to work together. They are given specific roles but not categorised.

> Not, you're the recorder, you're this, you're that, but it's more like the team manager to run it and then everybody has a teaching responsibility. Maths activity groups where it's mixed ability and they basically act as tutors for each other. (Interview 4)

Tasha chose this strategy as the most worthwhile because it was new to her and even though she had heard of the strategy she did not know how to implement it in the classroom.

> [I knew of the idea of co-operative roles] but I just never took it on board. I hadn't seen anything to show me, I mean I knew the value of it, but I hadn't seen anything to show me what was happening underneath it all. (Interview 4)

Tasha was the only *3Cs* participant to trial this strategy in their classroom.

Tasha: Purpose for teaching mathematics

It was noted in chapter 6 that Tasha saw the purpose of teaching mathematics as the mastery of skills and facts, matching her instrumental views on the nature of mathematics. It was also noted that her pre-*3Cs* views about Chance tended to be relational although by the middle of the *3Cs* program she made a comment that contradicted this. By the end of the *3Cs* program she said that her understanding of Chance had improved.

> I understand [Chance and Data] better than I did before. Trying to achieve the data, and collecting data [was OK] but I didn't really have an understanding of the Chance part of it ..... probability and things like that. So, I am probably bringing more of that in ..... talking about the chance of something happening tomorrow. (Interview 4)

It thus appears that the *3Cs* program brought a change in Tasha's understanding about Chance. She felt that gaining a better understanding of Chance concepts was a high professional development priority, and that after the *3Cs* program she saw that Chance was easier to understand and could be included in informal classroom discussion. She now realised that the teaching of Chance was more important and purposeful than she had previously thought. However she did not trial any 'mathematics content' activities, with the main reason being given that they did not fit her current classroom themes (further discussed in the next section).

Tasha: Dealing with mathematics and pedagogy

In Chapter 6 it was noted that Tasha placed an emphasis on the use of putting mathematics learning into contexts through her thematic approach, on pupil involvement whether it was through the use of hands-on activities or purposeful classroom discussion. Tasha appears to be limited or constrained with the mathematics she is prepared to implement in her classroom because of a perceived lack of understanding or unfamiliarity with some mathematics topics.

3Cs should have been confirming on her classroom teaching approach and supportive for the development of her mathematics knowledge. Midway through the *3Cs* sessions program when she was asked which of the three main aspects was fulfilling her professional development needs she chose 'teaching strategies which encourage children to talk about their mathematics' in preference to the mathematics discipline aspect of 'chance activities'.

> I don't think we get them to talk enough to how [the mathematics] relates to them and how they think it fits into the world around them. Because if it's not brought back to them they can't relate to it at all. So I do think that is the most important to talk about. And also just so that they feel confident enough to do it. They're talking about it, they're gaining confidence in it which means they can develop their mathematical understanding and they can participate in activities. (Interview 3)

And Tasha also noted that improving her mathematics knowledge had been a positive outcome from the *3Cs* program.

> Probably more than anything the activities. How easy it was. ..... [I see it as a positive] because I thought [Chance and Data] was really hard. Chance and Data was hard but once you started learning more about it you found it a bit easier. (Interview 5)

Prior to the start of the *3Cs* program Tasha identified Mathematics discipline as a professional development need.

> Probably chance [laughs]. That would be a big one and also maybe Maths tools and procedures because that's a bit fudgy for me. (Interview 2)

So why did Tasha not trail 'mathematics content' activities? When questioned in interview Tasha could remember many of the *3Cs* activities and describe them in detail. Her reasons for not trialling these activities were exemplified when she gave the following as a reason for not having trialled Dicetracks (A-7).

> I'm not the type to just slot something in because I think it's fantastic or I really like it. I usually know that it is there and so that when the idea comes up again I can slot it in but my program is pretty full and it doesn't leave much ground to trial things. ..... All my maths is integrated. But that's also the approach that we have to take, so yeah, so it is integrated and that makes sense to me, and to fit something in that doesn't fit ..... well the kids ask, "Why are we doing this?". And to say well I want to see how you go but they say, "What's the point of it all?". (Interview 4)

Tasha is an innovative teacher and adapted the collaborative strategies to fit her lessons. For example, Tasha did not use the think-pair-share strategy with the workshopped activity (A-11) or with any of the suggested activities (A-14), but with an activity already referred to that involved the class in small groups developing definitions of various spatial terms. Tasha also noted that she used the strategy in other curriculum areas.

> [Think-pair-share has] actually worked quite well because the children realise then that their thoughts are just as important as what ..... as what everybody else's are and that there are differences. But that hasn't just been in Maths so I've used that across all areas. (Interview 3)

So why was she unable to do the same adaptation with the mathematics activities? Games such as 'Dicetracks' and 'Toss of Luck' could be difficult to adapt to a thematic approach but notions of middle measures and sampling should fit well with a thematic approach, particularly at year 5/6. The teaching strategies she claims were a 'confirming experience' (Interview 4) for her, so it can probably be assumed that she did not have the confidence or the background discipline knowledge to do the same with the mathematics activities. Her comment for not using the stem and leaf plot activity (A-48) confirms this idea.

> No [I haven't tried that in my class]. No not that one, oh no. I would probably have to do a lot more on that for me to understand it. (Interview 4)

And she also said:

> I think I would have liked there to have been a little bit more explanation as well as activities to have some kind of background knowledge about [Chance]. Some of the stuff went way over my head. (Interview 5)

However Classroom Observation 3 shows that Tasha does have the depth of mathematics knowledge to develop lessons and to include components as a lesson progresses. The workshop discussion and video snippet for the 'Lucky Die' activity (page A-12) would appear to have been the stimulus for Tasha's planning of the lesson undertaken in Classroom Observation 3, although the activity also complemented a theme based around the notion of 'luck' that Tasha was carrying out with her class. Many other *3Cs* participants trialled the same activity. In every observed situation the class data collection of rolling a die a number of times resulted in the number six having fewer rolls than all of the other numbers. This confirmed each class's generally held belief that six was the hardest number to roll. And in one classroom observation the children all chorused: "We told you so!". In each instance the lesson was stopped with the teacher unable to think of a way to resolve the situation. However, Tasha's approach was quite different to these other teachers. It involved the use of informal language, pupil-pupil discussion, written reflection and whole class discussion of their ideas. The pupils had to write down which number would come up the most, why and how many times out of 20. Then in pairs they tallied the results of 20 rolls. The pupils worked quite seriously on this task, particularly the written part with some quite 'good' suggestions as to why. The class discussed ways they could increase or decrease the chances of rolling their selected number. Suggestions for increasing included magic, concentration, reverse psychology, lucky charms, singing to it, and the way the die was rolled. For decreasing the chances pupils suggested relying on outside sources or cheating. Then there was some final discussion centered around the notion of 'luck'. Tasha's aim for the lesson was to understand that ' an outside influence [does not] affect the dice' (Interview 4).

Tasha was asked whether she thought that she had achieved her aim and she replied:

> I think they sort of understood that but they still thought that you could do other things because that's what they traditionally believe. We actually finished off the [activity] and got them to do it again and see if they got the same amount of rolls and if the number came up the same as the previous session. (Interview 4)

Tasha had justification for being able to more easily include teaching strategies in her planning in comparison to the inclusion of mathematics content activities.

> [I chose activities for trialling] by what's going on in my room at the moment. Well if I'm doing something on ..... say we're looking at the chance of something and we're looking at the terminology that we use for it then I would fit that in with an activity, an oral language activity. So I'd use the strategy but I'd take parts of it to fit it in. I don't take the whole thing and say right I am going to put you in here. I take parts of it to fit it in with what I am doing at the moment because I can't chop and change what I am doing with [the pupils]. Like our focus this term is three dimensional space and measurement. So to bring something in that's completely different from that is not following on from what I am focusing on. But I'll use strategies in there or it might come up incidentally. So I don't take the whole thing and bring it in but I take bits and pieces of it. ..... Sometimes the way that other people do them or the activities as a whole doesn't really suit ..... suit what you want to put into the lesson or put in with the kids or even just considering what the kids want. I mean they might not even want to know that and so you've got to try and fit it in with what they do want to know. (Interview 3)

Tasha: Summary - trialling *3Cs* content

As a result of the *3Cs* program in regard to mathematics content Tasha:

- did not trial any of the 'mathematics content' activities citing lack of time and thematic approach as the reasons, but the main reasons may have been a lack of confidence and discipline knowledge;
- explained that her thematic approach was the reason for not trialling mathematics activities;
- the lack of trialling any of the 'mathematics content' activities may have been due to a lack of confidence and discipline knowledge;
- included the informal Chance ideas (such as the Chance language) in incidental teaching;

As a result of the *3Cs* program in regard to teaching strategies content Tasha:

- trialled two of the teaching strategies, but adapted them to fit her current planning;

As a result of the *3Cs* program in regard to constructivist notions content Tasha:

- trialled only one activity from the 'Constructivist' list and this trial took place for the final observation.

Tasha: Comparison of PD prediction and *3Cs* trialling

Table 7.8 compares the two 'Content' summary lists made in the PD prediction in Chapter 6 and the summary list above. The points that match in both lists are connected by a two-way arrow.

PD prediction In summary Tasha:		Trialling *3Cs* content As a result of the *3Cs* program Tasha:
Mathematics activities content • will favour those activities that fit in with her current themes because she believes that teachers need to provide a context for mathematics activities; • may trail few mathematics activities because of her instrumental beliefs about the nature of mathematics; • could be reluctant to trial the one-off type mathematics activities because her planning is based on the relational notion where she considers what the pupils need rather than good activities;	↔	Mathematics activities content • did not trial any of the 'mathematics content' activities citing lack of time and thematic approach as the reasons, but the main reasons may have been a lack of confidence and discipline knowledge; • explained that her thematic approach was the reason for not trialling mathematics activities;
• will not trial some of the *3Cs* activities because of a perception that the mathematics is too difficult.	↔	• the lack of trialling any of the 'mathematics content' activities may have been due to a lack of confidence and discipline knowledge;
• will have positive attitudes to many of the *3Cs* activities because of their hands-on nature;		
		• included the informal Chance ideas (such as the Chance language) in incidental teaching;
Teaching strategies content • is likely to trial the teaching strategies from the *3Cs* program because they correspond to her relational beliefs about teaching and learning; • is likely to adapt activities or use different contexts to those used in the *3Cs* program because of the way that she fits much of her mathematics instruction into class themes;	↔	Teaching strategies content • trialled two of the teaching strategies, but adapted them to fit her current planning;
Constructivist notions content		Constructivist notions content • trialled only one activity from the 'Constructivist' list and this trial took place for the final observation;
• may trial those *3Cs* activities where constructivist discussion took place because this matches her relational beliefs about teaching and learning;		

Table 7.8: Tasha's content trialling comparison - PD prediction and *3Cs* trialling

Attitudes to features of professional development

Tasha: Providing procedures for support and collaboration

Tasha was asked how important it was for her to go to the professional development sessions with a group of teachers from her school as opposed to attending alone and she replied:

> I believe it's extremely important [to attend as a group]. I'd prefer to do PD with a group of people rather than on my own because then you're bringing back not only your idea on how things are done but you are bringing back five other people's ideas as well. So they may do something one way and you might do it another but you have got two different ideas based on the same thing that are coming out. (Interview 3)

However, Tasha noted that she had little discussion with her immediate 5/6 colleagues about the *3Cs* activities.

> No [Nora and I haven't shared much of what resulted from the PD sessions]. Nora will tell me what she's doing or what she has done and how successful it was but it terms of saying, "Well here is a fantastic idea why don't you run with it". No. (Interview 3)

There was much more reported sharing with Tasha's 3/4 colleagues who attended the *3Cs* workshops.

> [The 3/4 teachers have] shared quite a bit. I actually probably share a lot with them too. If they've got a great activity then they'll pass it on to everyone and that's good. Yes it has been useful, yeah. Even in just talking about how they did something or making up cards and saying, "Look here's the cards, use these". Just things like that to help you with it or "I did something really great you know that will work really great with your kids because it was a bit too hard for mine" or things like that. (Interview 3)

At *3Cs* workshops the participants tended to sit together in their school groups. In several workshop sessions the presenter organised activities in way that broke up these school groups and the teachers worked and talked with those from other schools. When Tasha was asked about this action, she said:

> I am not comfortable, I hate it. It's OK to say that you should interact but it is generally difficult when you are going into a PD session and you don't know what it is going to be like. And if it is boring you don't want to be sitting with people that you don't know. I'm more comfortable with the people I know rather than the people I don't know. I don't mind working with people but sitting with them I think that is personal choice. (Interview 5)

When Tasha was asked what she regarded as qualities of a good presenter, she said:

> Humour. Someone who keeps you entertained so that you actually enjoy what you listen to. (Interview 5)

And when asked to rate the *3Cs* presenter on 'humour level' she replied:

> Low. I found her to be extremely dry. And I found myself tuning out quite a bit. I'd just tune out because it gets to be the same and if you want something different every week not the same thing over and over you don't want to be sitting listening to [the same stuff]. Not the same stuff but the same type of presentation happening every week. (Interview 5)

Tasha: Providing a teacher-centered focus for content and organisation

Tasha valued being an active participant in workshop sessions as the following interview comment suggests:

> [I think teachers like to try activities in workshops] because then you get personal knowledge of what it is all about. (Interview 5)

And when Tasha explained why, as a result of the *3Cs* program, she had gained a greater understanding of Chance she suggested:

> Participation in the [workshop] activities and that you always say, "Well just give me this experience", and then it happens. So, that word participation. (Interview 5)

Tasha was asked if the *3Cs* workshops encouraged her to reflect on the way children learn. She replied:

> Probably in the way that I teach maths really. Some of [the pupils] are very expanding ..... the ones who see the point. So it is more of the development of thinking and how deeply they think or how thoughtful they are. And also it sort of tells you a bit about how they are learning too. If they sort of except the first answer that is presented to them without going back and trying it again then you pretty much know that they are the type of child that you need to encourage to go back and keep doing more. (Interview 4)

When Tasha was asked what aspect of the *3Cs* program encouraged her to think about this, she said:

> I suppose it was more the video that probably started the whole thing. I mean it was participating in activities and looking at it from a child's point of view and looking at at it from what you want them to get out of it. (Interview 4)

As already noted Tasha claimed that *3Cs* had impacted on her own teaching approach and specifically in her understanding of Chance and how she could deal with it in the classroom. When she was asked what aspect in the *3Cs* program assisted to produce this change, she said:

> Probably how we were taught. I probably considered that I didn't have any idea as how to approach it and so doing the PD enabled me to see that there were easy ways. Taking an idea and making it grow to fit your grade. (Interview 4)

Tasha: Providing opportunities for observing outcomes and reflection

When Tasha was asked to compare the two features, 'attending professional development with a group of teachers' and 'trialling activities between sessions', she felt that the latter was the more important for effective professional development.

> For me I would have to say the trialling, I think trialling [the activities] is probably more important than going off in a group. Because you can go off in a group and if you are not trialling them or if you are not thinking about that constantly and if you are not trying to take bits and pieces to put in your program then you are not really using what you have learnt. You've got to come back and internalise it and try to fit it in to what you are doing in here and practice it because if you don't it's not meaningful. It's done nothing for you. (Interview 3)

It was previously noted that Tasha felt that the length of the professional development should be matched to its content or aims. She concluded that comment by saying that 'with a one-off one I would like follow-up' (Interview 2). When asked what she meant by 'follow-up' she replied:

> Something to try back in the classroom. It's good to hear [presenters] talk but I'd like to work with something that we're going to try. It's like the CAPC course, like every week I've got something new that I can come back and do in the classroom with the kids. (Interview 2)

Tasha referred to this approach as 'something that makes me learn' (Interview 2)

However Tasha qualified the importance of the feature, 'trialling in the classroom', in relation to her reaction to the *3Cs* program by noting:

> To be quite honest I don't have the time sometimes [for trialling activities]. I mean being up here [in year 5/6] it is extremely hectic and if it dosen't fit in with my program I can't justify just fitting it in for the sake of fitting it in. So to sort of balance that out I try to take things like strategies out of it to put in. So yeah it is important to trial it but at times the opportunities to do that are very limited. So you've just got to make sure that you've got your file with all of your things in there so when you do need it you can pull it out and say, "Oh I remember that" and do it that way. (Interview 3)

When Tasha was asked to select the most important feature out of eight features for effective professional development she chose 'seeing advantages for pupils'. She gave as her reason for this selection:

> Of the PD that we do, a lot of my PD I do I am doing it to further my own knowledge but also to see how it is going to benefit my kids. (Interview 5)

When Tasha was asked for some aspect that she saw as negative about the *3Cs* program she answered:

> Probably the length of time it was over. I found that really quite long. Especially every two weeks that it started to drag things out quite a bit and you could see this with plenty of other people. And I was really tired so I wasn't concentrating. (Interview 5)

And when Tasha was asked to select the least important feature of effective professional development from a range of features she chose 'Takes place over an extended period of time' with the explanation that 'it is not relevant to the PD' (Interview 5). This notion was reinforced when Tasha was discussing the previous professional developments she had completed and she was asked whether she preferred one-off professional development or a professional development program conducted over an extended period of time. She replied:

> I think it depends upon the content. I don't mind either way. I don't mind doing a course, 'cos I ..... sometimes it's given on certain topics and to have it over a period of time so that you can explore each. We like the CAPC. That's really good because we get the opportunity to play on the computer as well as learn about different things. But the one-off ones, ... I think it all depends on the content. With the one-off one I would like follow-up so that we don't lose ..... even having something and then let's meet to see how it goes. (Interview 2)

Tasha: Providing a philosophy on teacher change

There were no points relevant to this category in the interviews.

Tasha: Summary - Professional development features

Tasha believed that it was of value to attend professional development with a group of teacher colleagues because of the sharing that can take place. However, in reality she shared very little with her immediate colleagues or those in the school who did not attend the *3Cs* program, although there was sharing with the group from the middle level section of the school who did attend *3Cs*. In this group three out of four of them were also beginning teachers and within a similar age group as Tasha. Tasha preferred to complete activities with her collegial group rather than with teachers she did not know even though she realised that it could be more productive. Tasha preferred a professional development presenter who could add in humour to the presentation. She argued that this approach would maintain her interest. Her comment on this aspect suggests that there was also a feeling that there needed to be variety in presentation.

Tasha believed that it was important for participants to be activiely involved in workshops, to experience an appropriate model of teaching, and that knowledge of resources was important. Tasha thought that it was important for workshop participants to be involved in activities and to be able to experience the actual modelling of appropriate classroom practice. The use of video showing children's explanations was an important motivator that led to trialling.

Tasha chose 'seeing advantages for pupils' as the most important feature of effective professional development. She also felt that 'trialling activities between sessions' was important, but that the need for trialling should not drive lesson planning. She thought that the best way to tie in trialling activities was that if they did not directly fit into planning that parts of the activity could be used or that the activity could be modified to fit. Tasha believed that the length of any professional development activity be matched to the content (aims) of that professional development and that running professional development 'over an extended period of time' is not an important feature of effective professional development. Tasha did see the value of revisiting workshop sessions once trialling had taken place. However, for Tasha, in the specific case of *3Cs*, the workshops were conducted over a period of time that was too long.

Table 7.9 summarises Tasha's beliefs about features for effective professional development.

	Feature	High priority	Low priority	No comment recorded
Providing procedures for support and collaboration	Groups of teachers	•		
	Supportive principal			•
	Facilitator seen as part of the team			•
	Further points •Preference to work with colleagues that she knows	•		
	•A pd presenter who is able to add humour into the presentation and can possibly vary presentation style.	•		
Organisation	Conducted in school setting			•
	School-wide effort			•
	Variety of approaches			•
	Issues of concern			•
	Ownership			•
	Further points •To actually do activities in the pd workshops	•		
	•To experience an appropriate teaching model	•		
	•To gain knowledge of resources	•		
Outcomes	Researching in classrooms	•		
	Seeing advantages for children	*		
	Extended Time		*	
	Further points •To not allow trialling of activities to drive lesson planning	•		
Making change	Commitment			•
	Long term plan			•

Table 7.9: Summary of Tasha's beliefs related to features of effective professional development (KEY: +ve = sees this as important in a positive way; -ve = sees this as important in a negative way; * = highest and lowest priority)

In regard to features of effective professional development that provide procedures for support and collaboration Tasha:

- believed that it was of value to attend professional development with a group of colleagues;
- preferred to complete workshop activities with those with whom she felt most comfortable;
- felt that a presenter needed to add humour to the presentation in order to maintain interest or variety;

In regard to features of effective professional development that provide a teacher-centered focus for content and organization Tasha:

- believed that participants should be actively engaged during workshops;
- valued being able to experience an appropriate model of teaching;
- found it important to become knowledgeable about the existence of resources;

In regard to features of effective professional development that provide opportunities for observing outcomes and reflection Tasha:

- believed that the feature 'over an extended period of time' was of a low priority and that the length of any professional development should be matched with its intentions;
- believed that there was value in having a reflection session as follow-up to any professional development;
- believed that the feature 'seeing advantages for pupils' as of the highest priority;
- viewed the feature 'trialling activities between sessions' as important but that it should not drive lesson planning.

Tasha: Comparison of PD prediction and *3Cs* summary

Table 7.10 compares the two 'Professional development features' summary lists made in the PD prediction in Chapter 6 and the summary list above. The points that match in both lists are connected by a two-way arrow. Any points that have opposing views have negated arrows.

PD prediction In summary Tasha:	*3Cs* discussion In summary Tasha:
Providing procedures for support and collaboration • will prefer to attend professional development with a group from her school because of her relational beliefs about collaborative learning;	Providing procedures for support and collaboration • believed that it was of value to attend professional development with a group of colleagues; • preferred to complete workshop activities with those she felt most comfortable with;
• is likely to be positive towards the 'facilitator-type' approach taken by the *3Cs* presenter because of her relational beliefs about the role of a teacher;	
	• felt that a presenter needed to add humour to the presentation in order to maintain interest or variety;
• is likely to value listening to the discussion from other teachers because of her relational beliefs about how children learn;	• preferred to complete workshop activities with those with whom she felt most comfortable;
Providing a teacher-centered focus for content and organization • may regard 'ownership' and 'issues of concern' as features of effective professional development because of her relational beliefs on how children learn;	Providing a teacher-centered focus for content and organization
• will probably support the strategy of workshopping activities in a hands-on way because of her relational beliefs about how children learn;	• believed that participants should be actively engaged during workshops;
	• valued being able to experience an appropriate model of teaching;
	• found it important to become knowledgable about the existence of resources;
Providing opportunities for observing outcomes and reflection	Providing opportunities for observing outcomes and reflection • believed that the feature 'seeing advantages for pupils' as of the highest priority;
• is likely to value classroom trialling because she values reflection as part of the learning process;	• viewed the feature 'trialling activities between sessions' as important but that it should not drive lesson planning;

• may believe that professional development is best conducted over an extended period of time because she values reflection as part of the learning process;	• believed that the feature 'over an extended period of time' was of a low priority and that the length of any professional development should be matched with its intentions; • believed that there was value in having a reflection session as follow-up to any professional development;
Providing a philosophy on teacher change • may have a long term view of her professional growth and realise that it could be a long term process because of her relational beliefs pertaining to reflection.	Providing a philosophy on teacher change

Table 7.10: Tasha's 'effective features' comparison - PD prediction and *3Cs* discussion

GERRY

Reactions to *3Cs* Content

Gerry: Trialling summary

A summary of Gerry's *3Cs* trialling is listed in Table C.4 (Appendix C) and indicates that he trialled a good number of *3Cs* activities from each of the three content areas and from most workshop sessions. When Gerry was asked how he selected *3Cs* ideas for trialling he replied:

> Just basically read it through. Well first of all I've got the memory of what we have actually done and they are usually something that I will try or I won't try. But if I am looking for something else I'll then look through the notes. I picture it in my mind actually happening I guess. I can almost play a video in my mind of the class and the potential hazards. (Interview 3)

Gerry: Role that pupils play in the learning process

Gerry generally implemented a relational approach to classroom practice supported by his relational beliefs about the role of the teacher and about how children learn mathematics. Gerry valued the role that pupils could play in the learning process although several external constraints limited his preferred approach.

Gerry obviously valued the collaborative strategies as he trialled four of them. For example, he said that he used the think-pair-share strategy a number of times and that he applied it to mathematics activities other than those modelled at *3Cs* as well as using the strategy in other curriculum areas.

> I used [think-pair-share] reasonably regularly with different things [such as other mathematics topics and language]. Just you know discussing and sharing up and pairing. I think you've got to try to adapt it depending on how things are going. (Interview 4)

However, he did express some concerns about these strategies, showing that he judged these strategies on whether they enhanced pupil understanding or not.

> [When using the Jigsaw strategy] not a lot of positive development came when the expert groups met. Weaker children found it overwhelming. (End of Session 3 questionnaire)

When asked for any specific changes that he had made it was the collaborative teaching strategies that produced this change. Gerry said:

> Setting the class out into ..... I felt that it was putting them into tables of four and six which I did. Certainly when I did the Clue Cards and some of the other activities where they had to rotate around. And certainly you need to be flexible with table setting. (Interview 4)

At the time of Classroom Observation 3 Gerry changed his classroom furniture from rows facing the chalkboard to an arrangement where the pupils could readily discuss problems in groups of four or six.

Gerry: Purpose for teaching mathematics

In chapter 6 it was noted that Gerry saw the purpose of teaching mathematics as meaningful exploration of concepts. This approach was also exemplified with the trialling of *3Cs* activities. For example, with Dicetracks (A-7) Gerry claimed:

> I don't know if [the pupils] could see the ratio all that clearly. It's something that you need to do over and over and over to really get some sort of pattern to it. (Interview 4)

And with the M&M's sampling activity (A-76) he commented:

> We did [trial that activity] and that was interesting. They were amazed that there were more of one colour than another. And initially they thought that was the way they fall into the bag. But then when we sort of looked at a number of the bags they could see that there was some sort of a pattern. And that did surprise them. And then they came up with ideas of why it might have been different colours. (Interview 4)

Gerry also trialled sampling activities. One was based on collecting data about the pupils' TV watching habits. He talked about how he was now able to make meaningful connections between the data collection and probability questions.

> We did the TV sampling of who watched what at a given time. And the probability of kids of a certain age watching certain things a lot more ..... the types of shows that they watch. (Interview 4)

Gerry: Dealing with mathematics and pedagogy

Gerry dealt in a confident way with mathematics and he indicated a personal interest in problem solving. His pedagogical beliefs and approach were relational.

Gerry's personal interest in mathematics provided an incentive for what he chose to trial. Included in the handouts for *3Cs* Session 5 there were items on the AFL football finals taken from *The Age* and to accompany this activity were lesson notes *Final five* and an updated chart showing how the current finals system worked with eight teams (page A-72). At this particular time in the school year places in the final eight were still undecided with only two rounds to be completed and ten teams still having the opportunity to be in the final eight. Thus for those interested in the AFL this time was quite exciting. Gerry obviously had quite an interest in football and decided to trial a 'Final eight' lesson with his class. His year 10 son was also completing a project on this topic for school.

> The whole finals structure I found interesting mainly because I was barracking for one of the teams in it and I wanted to see how the pattern sort of went. (Interview 4)

Gerry's personal interest in mathematics also encouraged him to trial Dicetracks (A-7).

> Actually throwing the coloured dice and so on and working out their own tracks was really interesting. I found that very interesting the night [*3Cs* session 1] that we did it working out the various odds of it coming up. (Interview 3)

Gerry was able to give alternative mathematical explanations if the pupils showed that they did not understand. During Classroom Observation 4 involving the 'Random Walk' activity (A-70) a number of the children revealed difficulty relating the 'direction key' to what they actually had to do. So for awhile many children in the class were fairly confused. Because of the confusion Gerry then gradually improved his explanations.

> The numbers you've put on the hexagon whatever they might be. You don't have to have them in any particular order but once you've chosen it's like a direction. This one a three I could call north, so whenever I roll a three I go one position north. Six, I could call south so every time I throw a six I go one position south. Four is north-east, so every time I throw a four I go north-east one direction. Five, would be south-east. (Classroom observation 4)

This explanation seemed to help a lot, and when Gerry helped individual children he used this directional language. And when games were played on the square grid Gerry explained the 'direction key' again using his analagy with north (1, 2 or 3 on the die), south (5), east (4) and west (6).

Gerry was also able to make use of some of the *3Cs* mathematics in other activities. He had not tried with his class the 'Rolling two yellows' activity (A-11 & A-19) but made use of the two-way chart for other activities, including the tossing of two coins.

> Tossing two heads. Heads and Tails. We actually did do that the other day and that was quite good fun. And we tabulated. Once again it didn't have any direct relationship to what the actual ratio of chance would be but we discussed how many we would have to throw before we got some sort of reasonable [result]. (Interview 4)

Although Gerry took risks with mathematics activities and used techniques in other situations he may not have had the confidence to be innovative in the use of collaborative strategies. He successfully used Clue Cards (A-35) in his teaching, but when asked if he had written his own clue cards he replied:

> No. And that is something I really should do in a planning meeting with Neva because that's what we really need to get to - writing your own clues that are at what you are doing at that particular time. (Interview 4)

When Gerry talked about trialling Dicetracks (A-7) much of the discussion centered on the thinking and ideas that the children used.

> It was interesting to see how kids saw it differently and came around to the thinking that one particular colour had more of a chance than others. Well a lot of the younger ones, because I have got a four-five assumed the short track was going to be the best way to go initially. And then when the short track didn't win the first time they instantly changed over so it was like they were sort of following their tails if you know what I mean. They weren't really trying to work out a sort of a pattern or system. Which ever one won last time they assumed that it was the most likely one to come up. (Interview 3)

Gerry conducted whole class discussion on the 'Green and White containers' activity (A-54) and noted his interest in the children's thinking.

> We did that and [the pupils] initially went for the top one [the 2/4 combination] and it, oddly enough, it seemed more often than not it did come up more. So I think the deduction was that the more of one particular ..... I mean you have got four in there compared to only two and it seems to be coming up more often ..... so even though they could see what the ratio was they may not have seen it as exactly the same but they knew it was pretty close. (Interview 4)

Gerry: Summary - trialling *3Cs* content

As a result of the *3Cs* program in regard to mathematics content Gerry:

- trialled a large number of the 3Cs activities;
- trialled activities in which he had a personal interest in the underlying mathematics;
- attempted activities in a way that drew out, through pupil discovery, the mathematical process, pattern or rule;

As a result of the *3Cs* program in regard to teaching strategies content Gerry:

- trialled all bar one of the collaborative teaching strategies;

As a result of the *3Cs* program in regard to constructivist notions content Gerry:

- found the children's thinking processes interesting, particularly with those activities where the *3Cs* discussion had focussed on this factor;

As a result of the *3Cs* program in regard to other trialling aspects Gerry:

- was more likely to trial activities that had been workshopped, although several activities that were given as handouts were also trialled;

- judged the worth of an activity by his pupils' reactions, especially if he thought they had found it fun.

Gerry: Comparison of PD prediction and *3Cs* trialling

Table 7.11 compares the two 'Content' summary lists made in the PD prediction in Chapter 6 and the summary list above. The points that match in both lists are connected by a two-way arrow.

PD prediction In summary Gerry:		Trialling *3Cs* content As a result of the *3Cs* program Gerry:
Mathematics activities content • is likely to trial many *3Cs* activities because of his relational beliefs about the nature of mathematics; • will not be hindered in trialling *3Cs* activities because of their one-off nature because of his instrumental approach to planning by selecting good activities rather than focusing only on the needs of the children;	↔	Mathematics activities content • trialled a large number of the *3Cs* activities; • attempted activities in a way that drew out, through pupil discovery, the mathematical process, pattern or rule;
• may favour trialling those *3Cs* activities that have engaged him in a personal way because of his enjoyment of problem solving especially those activities that had elements of exploration and 'conflict' in ideas;	↔	• trialled activities in which he had a personal interest in the underlying mathematics;
• is likely to find that it is difficult to include the topic of Chance in what he already sees as a 'crowded curriculum'.		
Teaching strategies content • should readily relate to the strategies aimed at enhancing pupil-pupil discussion because of his relational beliefs but may be reluctant to trial these strategies because of the constraint of working with a composite grade; • is likely to trial these as the strategies are presented because he will see them as 'good activities', but they will not necessarily be adapted to meet the needs of his pupils;	↔	Teaching strategies content • trialled all bar one of the collaborative teaching strategies;
Constructivist notions content • should relate to the activities associated with constructivist notions because of his relational beliefs about how children best learn mathematics;	↔	Constructivist notions content • judged the worth of an activity by his pupils' reactions, especially if he thought they had found it fun; • found the children's thinking processes interesting, particularly with those activities where the *3Cs* discussion had focussed on this factor;
Other		Other • was more likely to trial activities that had been workshopped, although several activities that were given as handouts were also trialled.

Table 7.11: Gerry's content trialling comparison - PD prediction and *3Cs* trialling

Attitudes to features of professional development

Gerry: Providing procedures for support and collaboration

Gerry was asked if he had been sharing the *3Cs* ideas with other teachers at the school. There were four other teachers who attended from Spinebill Way Primary School and two of these teachers taught at the same level as Gerry. He commented:

> Well you see Neva and Helen are in my Grade Five team so when we have had our planning meeting there is always a section for Chance and Data so we do share what has been done [at *3Cs*]. We are lucky probably to be in that group with our planning session once a week because we are pretty much on the same wave length because we've all had the same pd. (Interview 3)

However, when Gerry was shown a list of features of effective professional development the feature 'involves groups of teachers from a school' was not chosen as most or least important. This response may be connected to the fact that Gerry's classroom was some distance from the other Year 5 classes and also a result of having to deal with two levels of planning meetings - year 4 and year 5. This latter idea is reinforced by the approach Gerry took with his year 4 colleagues who were not attending the *3Cs* program.

> I have a grade four planning meeting but I haven't conversed as much with the grade fours in [Chance and Data] because I'd have to go through the explanation. (Interview 3)

Gerry stated that it was important for the Principal to be supportive of professional development and that his Principal had shown the support that he would expect.

> Yes [professional development is best when the Principal is supportive] because they assist financially, with time and with encouragement. (End of session 5 questionnaire)

When Gerry was asked what qualities made a good professional development presenter he replied:

> Somebody that gets on well with people. Somebody that's well prepared and knows what they want to get out of each session. Somebody who can get things moving without sort of rushing things. Timing I think is probably a key. Somebody who looks like they are interested. (Interview 5)

In giving the *3Cs* presenter a rating against these criteria Gerry noted:

> I think that she was very well prepared. I think maybe at times she was a little apprehensive. She wasn't actually sure what was going on. I think that is fine anyway given that she was in a situation like we are often with our grade. She wasn't exactly sure what was going to happen and how things were going to eventuate. (Interview 5)

Gerry described a Curriculum Day activity that he had attended in the year prior to the *3Cs* program where he was impressed with the style of the presenter. When asked to clarify this he replied:

> I think he kept bringing up things that were relevant to me and presenting it in an interesting way without being too tedious in the length of time spent on each particular topic. (Interview 2)

In comparing this presenter's approach to that of the *3Cs* presenter Gerry said:

> I think she changed activities regularly. We were actively involved. There were times where we were actually listening and reflecting. I think she balanced it pretty well. (Interview 5)

Gerry felt that was it useful to hear what other teachers were doing.

> It's good to know what other people are doing. The way that their experiences with kids have worked. (Interview 5)

He also felt that it was useful to mix the school groups, rather than always sit together.

> It keeps you on your toes a little more than sitting in a [familiar] group. (Interview 4)

And he claimed that this was a factor in his re-awakening of the benefits for his pupils to be able to talk in small groups.

Gerry: Providing a teacher-centered focus for content and organization

From all the features for effective professional development Gerry chose 'conducted in a school setting' as the lowest priority.

> I don't know if it really matters where the program is conducted. It's probably relevant but it is probably not the most relevant. I think you can have a very successful program in different settings. (Interview 5)

Gerry commented about the *3Cs* program and indicated that he preferred variety in presentation. He said:

> [The workshops are] interesting. I find we have enough time to talk and enough time to do. They've been good fun. I mean, often with PD I go to if the balance is not right, particularly after school, between talking and doing and interacting and so on it can be quite tedious. (Interview 3)

Gerry suggested that the *3Cs* handouts were useful.

> With our planning like I was talking about before we have on our planning sheet an area marked data and we always refer to [the *3Cs*] booklet. (Interview 4)

Gerry also noted that 'the resources for the future' was the aspect that had been of the greatest value to him over the six *3Cs* workshops (End of Session 6 questionnaire).

When Gerry was asked if he preferred to hear about the activities or to workshop them he replied:

> I like actually trying them out because I think you really don't know how you react to or the children react until you have really done it. You know you can hear about different things and you might imagine in your head how it's going to go. But you don't know the pitfalls. You don't know the problems you might have in actually verbalising instructions and so on until you have actually done them. (Interview 5)

Gerry: Providing opportunities for observing outcomes and reflection

By the time of classroom observation 3 Gerry had re-arranged the classroom furniture so that the pupils could work in small groups. Gerry noted that this was an outcome for him of the *3Cs* program. He claimed that this rearrangement of the classroom furniture was 'more of a re-awakening [of the need to have] a balance between group work and individual work and whole class work' (Interview 4) rather than a change in beliefs and practice. When Gerry was asked what the stimulus for this was in the *3Cs* program he replied:

> Trying some of the things that obviously had to be done in groups and the physical setting of the tables and so on just required you to have them in groups of four and six. (Interview 4)

When Gerry was asked for one positive outcome from the *3Cs* sessions he said:

> Group settings. Setting groups to different situations. So moving your tables regularly and being adaptable to the given tasks that you want the kids to do. (Interview 5)

Also, when asked what it was that had encouraged this change he said:

> Just the general development as I went through the different activities. Yes, as I am doing the different tasks with the children would they work better in different situations. (Interview 5)

Gerry was shown a list of features of effective professional development. He selected as the most important one 'seeing advantages for pupils'. He said:

> Well I think it's basically that's my role in the school ..... to improve the education of the students. I think that's always been appropriate. The other things here [in the list of effective features] are obviously important to the overall success but that's got to be the main focus. (Interview 5)

Gerry felt that workshopping the activities in the *3Cs* sessions was the key to his decision as to whether the activities were of advantage to his pupils.

> Well doing activities that the kids are going to do I suppose. We are actually experiencing so we are putting ourselves in place of the pupils and we are actually seeing how they are going to react to the different situations. (Interview 5)

Gerry commented upon the timing of the *3Cs* program:

> [Each session has been] about the right length of time for the evening and [the sessions] have been fairly well spaced. (Interview 5)

On the 'End of Session 6 questionnaire' (A-89) Gerry noted that the spacing/timing of the *3Cs* workshops was 'good' because it 'Generally gave you a chance to trial activities' (End of Session 6 questionnaire). It was noted on the 'End of Session 4 questionnaire' (A-55) that there had been a long break between sessions 3 and 4 and Gerry was asked for his thoughts on the advantages and disadvantages of such a long break. For advantages he wrote 'Rest' and 'Extra chance to try things' and for disadvantages 'Lose continuity' (End of Session 4 questionnaire). He was unsure as to whether the advantages outweighed the disadvantages or not.

Gerry: Providing a philosophy on teacher change

There were no points relevant to this category recorded in the interviews.

Gerry: Summary - Professional development features

Although Gerry discussed the *3Cs* activities with his colleagues that attended he indicated that 'going with a group of teachers' did not rate as a feature of high priority. There was no reported input from Gerry into teaching Chance and Data at the year 4 level as a result of *3Cs*. Gerry felt that a Principal needed to show support for teachers attending professional development and he appreciated the support that his own Principal had given. Gerry believes that a professional development presenter needs to be organised, have appropriate pacing skills, vary the presentation style, and confident with content. Timing of activities and discussion appeared to be paramount for Gerry. Gerry appreciated being able to listen to the ideas of teachers from other schools.

He also thought that it was important to have variety in the type of activities being presented at a workshop and a pace that maintained interest. Gerry valued the handouts from each session and in fact rated this resource as one of the main outcomes of the *3Cs* program for him. Gerry preferred to workshop activities rather than just hear about them because you can better gauge your reaction and have a greater appreciation as to whether the activity will be suitable for your class. Gerry regarded the feature 'conducted in school setting' as of low priority.

Gerry rated the notion of trialling activities in the classroom as important and it was this factor that he indicated as responsible for producing a change in his current practice.

Gerry chose the feature 'seeing advantages for pupils' as of the highest priority because he viewed that as his role as a teacher. Gerry felt that the spacing of the *3Cs* workshop sessions over the two terms and the length of each workshop was appropriate.

Table 7.12 summarises Gerry's beliefs about features for effective professional development.

	Feature	High priority	Low priority	No comment recorded
Players	Groups of teachers	•		
	Supportive principal	•		
	Facilitator seen as part of the team			•
	Further points •Listening and sharing with other participants	•		
	•A PD presenter who is organised, has appropriate pacing skills, varies presentation style, and demonstrates confidence in content.	•		
Organisation	Conducted in school setting		*	
	School-wide effort			•
	Variety of approaches	•		
	Issues of concern			•
	Ownership			•
	Further points •To actually do activities in the pd workshops	•		
	•Appropriate pacing so as to maintain interest	•		
	•Useful handouts	•		
Outcomes	Researching in classrooms	•		
	Seeing advantages for children	*		
	Extended Time	•		
Making change	Commitment			•
	Long term plan			•

Table 7.12: Summary of Gerry's beliefs related to features of effective professional development (KEY* = highest and lowest priority)

In regard to features of effective professional development that provide procedures for support and collaboration Gerry:

- found it useful in team planning to be with colleagues who had attended the *3Cs* program;
- felt that it was important to have Principal support for professional development attendance;
- believed that an effective presenter was organised, had appropriate pacing skills, varied style and was seen to be confident with content;

In regard to features of effective professional development that provide a teacher-centered focus for content and organization Gerry:

- benefitted from effective timing and variety of presentation;
- valued the handouts as an important future resource;
- preferred to workshop activities rather than just hear about them because it would assist him in deciding whether to run with the activity with his pupils;
- believed that 'conducted in school setting' was a low priority feature for effective professional development;

In regard to features of effective professional development that provide opportunities for observing outcomes and reflection Gerry:

- regarded the trailing of activities in the classroom as important for successful professional development;
- believed that 'seeing advantages for pupils' as the most important feature of effective professional development;
- thought that it was appropriate to have workshops spaced out in order to have time to trial activities.

Gerry: Comparison of PD prediction and *3Cs* summary

Table 7.13 compares the two 'Professional development features' summary lists made in the PD prediction in Chapter 6 and the summary list above. The points that match in both lists are connected by a two-way arrow.

PD prediction In summary Gerry:		*3Cs* discussion In summary Gerry:
Providing procedures for support and collaboration • is likely to value sharing with others and hearing from other participants at the *3Cs* workshops and to also value working with a group of teachers from his school because of his relational beliefs on collaborative learning;	↔	Providing procedures for support and collaboration • found it useful in team planning to be with colleagues who had attended the *3Cs* program;
		• felt that it was important to have Principal support for professional development attendance;
		• believed that an effective presenter was organised, had appropriate pacing skills, varied style and was seen to be confident with content;
• is likely to be positive towards the 'facilitator-type' approach taken by the *3Cs* presenter because of his beliefs about the role of the teacher;		
• is likely to value listening to the discussions from other teachers because of his relational beliefs about how children learn;		
Providing a teacher-centered focus for content and organization		Providing a teacher-centered focus for content and organization • benefitted from effective timing and variety of presentation;
		• valued the handouts as an important future resource;
• will appreciate being able to undertake hands-on activities and small group discussion in workshops because of his relational beliefs on how children learn mathematics and because he gains pleasure from solving problems;	↔	• preferred to workshop activities rather than just hear about them because it would assist him in deciding whether to run with the activity with his pupils;
• may regard 'ownership' and 'issues of concern' as features of effective professional development because of his relational beliefs on how children learn;		
		• believed that 'conducted in school setting was a low priority feature for effective professional development;

Providing opportunities for observing outcomes and reflection • will value trialling in the classroom and reflecting on the advantages of the activities and strategies for his pupils because of his past reflective practice;	Providing opportunities for observing outcomes and reflection • regarded the trailing of activities in the classroom as important for successful professional development;
	• believed that 'seeing advantages for pupils' as the most important feature of effective professional development;
• is likely to place importance on the value of professional development taking place over an extended period of time because he is a reflective learner;	• thought that it was appropriate to have workshops spaced out in order to have time to trial activities;
Providing a philosophy on teacher change • may see professional development as a long term process because he is a reflective learner.	Providing a philosophy on teacher change

Table 7.13: Gerry's 'effective features' comparison - PD prediction and *3Cs* discussion

INSIGHTS AND SUMMARY

Insights – Chapter 7

The following insights need to be read in conjunction with the *3Cs: Chance, Constructivism & Collaboration* context. The PD program *3Cs* presented content and a style of classroom practice that was generally consistent with relational beliefs. Mathematics activities were modelled taking into account most aspects of relational practice and beliefs. However, in attempting to cover all primary school year levels (in particular years 2 to 6), as well as considering beliefs about how children learn mathematics and including collaborative strategies, a range of mathematics activities were selected. These activities tended to be one-off and even though a real world context may have been mentioned for some of them the nature of the activities could been seen as instrumental, that is, not providing a consistent approach to placing the activities in a context. The presentation of one-off type activities may also lead the teacher to conclude that classroom activities are chosen on the basis of being good activities rather than based on the learning needs of pupils. This approach would be an instrumental classroom practice although the *3Cs* discussion on the benefits of collaborative strategies and constructivist notions should have provided a counter to this instrumental approach.

Insight 7.1: Ascertaining the beliefs, attitudes and practice profile of a teacher is a most complex task.

This Insight confirms Insights 5.1, 6.1 and 6.2 with the additional component of attitudes to effective professional development.

Insights from *3Cs* content trialling predictions and observations

---

Insight 7.2: Relational beliefs on the nature of mathematics encouraged increased trialling of 'mathematics content' activities.

Both Deidre and Tasha revealed instrumental beliefs about the nature of mathematics and trialled few of the relational-type *3Cs* activities. This outcome is in contrast to Malcolm and Gerry who exhibited relational beliefs about the nature of mathematics and trialled a large number of activities. This contrast was predicted. Connected to having relational beliefs about the nature of mathematics was also the factor of having greater confidence in mathematics ability and interest in mathematical problems. Both Malcolm and Gerry showed confidence and interest. This confidence and interest could be wholly or partly the reason for their higher trialling of activities.

Insight 7.3: Classroom practice which reflects an instrumental view of the role of the teacher leads to making judgements about and adaptation of activities presented in a relational way that in turn result in making classroom implementation of these activities closer to instrumental practice.

Both Deidre and Malcolm had instrumental beliefs about the role of the teacher and both of them adapted the *3Cs* activities or made judgements about trialling the *3Cs* activities. These adaptations and judgements were based on their instrumental beliefs. For Deidre they were based on her instrumental beliefs about both the nature of mathematics and the role of the teacher. For Malcolm they were based on his instrumental beliefs about the role of the teacher. Both of these situations were predicted.

The converse to this insight would state '*3Cs* participants with relational beliefs about the role of the teacher would implement the *3Cs* activities in the relational way that they were modelled'. This analysis is difficult to assess for Tasha and Gerry. Tasha did not implement any 'mathematics content' activities because of her relational beliefs on providing a context, although the workshopped activities had an impact on her incidental teaching. Gerry trialled one workshopped activity that was generally implemented as it was modelled in the *3Cs* program.

Insight 7.4: Instrumental/relational differences on 'lesson initiation' provide a predictor on the extent of 3Cs trialling.

Deidre and Tasha had a relational approach for selecting classroom activities and the one-off nature of the *3Cs* activities may have been a factor for the low number of mathematics activities trialled. In contrast, both Malcolm and Gerry exhibited an instrumental approach to classroom planning by selecting good activities. Because of this approach they did not feel restricted in what they chose for classroom trialling.

Insight 7.5: Relational beliefs about 'How children learn mathematics – pupil mode' are a good predictor of trialling of collaborative strategies regardless of whether the teacher's classroom practice is instrumental or relational.

The four case study teachers had relational beliefs about 'pupil mode' and they all trialled some of the collaborative strategies. The beliefs about 'pupil mode' that Tasha and Gerry held were directly attributed to mathematics learning and put into practice. The beliefs that Malcolm held were newly-developed beliefs and Deidre may have generalized her beliefs from how she viewed children's learning in other curriculum areas. Neither Deidre nor Malcolm implemented these relational beliefs about pupil mode in classroom practice, but they did take on board the trialling of the *3Cs* collaborative strategies.

Insight 7.6: Teachers, regardless of whether they implement instrumental or relational classroom practice, are interested in children's reaction and thinking when they trial activities and this emphasis could be because they have relational beliefs about 'How children learn mathematics'.

Deidre, Malcolm and Gerry all stated that they were interested in trialling the *3Cs* activities so that they could observe the reaction and thinking of their class. This interest is probably connected to their relational beliefs about how children learn mathematics even though Deidre and Malcolm did not implement these relational beliefs.

Insight 7.7: Teachers implement workshopped activities rather than those activities described in a handout.

Deidre, Malcolm and Gerry all noted that they implemented workshopped activities in preference to those only described in the handouts.

Insights from predictions and comments on features of effective professional development

Insight 7.8: The case study teachers regardless of their classroom approach believed that 'Attending professional development as a group' was an effective feature of professional development. This emphasis may be linked to their relational beliefs about 'How children learn mathematics'.

The four case study teachers all preferred to attend professional development with a group of their colleagues. Reasons given included 'collectively remember ideas', 'collegial discussion', 'providing mentors'. All these notions match the reasons for implementing group work in the classroom.

Insight 7.9: Even though the 3Cs program was specifically about collaboration, constructing knowledge and providing opportunities for reflection for primary pupils, none of the case study teachers mentioned that the presenter used these same techniques to enhance the understanding of the participants.

The case study teachers had very definite views on the role of an effective professional development presenter, but this did not include a modeling role. A presenter with such a role would be providing another reflective mechanism for participants to consider.

Insight 7.10: Teachers preferred workshops that had active participation and this could be driven by their relational beliefs about how children learn mathematics even though they may not implement these beliefs in their own classroom.

Active participation could involve many aspects – whole group discussion, solving problems together in small groups or using manipulatives. All the case study teachers preferred to be active in workshops and they all believed that the use of manipulatives enhanced the learning of mathematics and that pupils should be involved in small group discussion.

Insight 7.11: Case study reaction to the feature 'conducted over an extended period of time' could be predicted according to instrumental/relational differences in beliefs and practice related to 'How children learn mathematics'.

The two instrumental teachers did not favour completing professional development over an extended period of time. The relational teachers varied on this point. Tasha thought that the PD program *3Cs* went for too long, but made the comment that the length of professional development should be related to the content nature or purpose of the professional development. This is probably a relational view. Gerry thought that the length of *3Cs* was appropriate. One of the reasons for structuring professional development over an extended period of time is to allow time for reflection. This approach is analogous to providing time in the classroom for pupil reflection.

Insight 7.12: 'Seeing advantages for pupils' was given high priority by all teachers, regardless of their classroom approach. This support may be linked to their relational beliefs about 'How children learn mathematics'.

All the case study teachers judged *3Cs* by the advantages it had for their pupils. This pupil-centered focus could be related to beliefs about 'How children learn mathematics'.

Insight 7.13: All case study teachers valued classroom trialling between workshop sessions. This support could not be attributed to instrumental/relational differences in beliefs and practice about 'How children learn mathematics'.

It had been predicted that only the 'mainly relational' teachers would value the feature of classroom trialling between workshop sessions because of their relational beliefs in regard to providing time for reflection for their class. However, this prediction was not validated by the case study analysis.

Insight 7.14: Participants valued talking and listening to teachers from other schools, but preferred to undertake workshop activities with the group from their own school.

The case study teachers preferred to attend professional development with a group of colleagues from their school. In the case of the PD program *3Cs* they had a negative attitude towards being requested to work in groups that included teachers from other schools.

SUMMARY

This chapter has considered the reaction of the *3Cs* participants to the workshop content and to features of professional development. Comparison of the findings has been made to predictions established in Chapter 6. These predictions were based upon possible connections from beliefs and practice. The insights arising from this process will be used as a basis for further discussion in the next chapter. This further discussion will relate to the whole cohort of *3Cs* participants and the research questions for this study.

CHAPTER 8

FURTHER ANALYSIS, DISCUSSION, FINDINGS AND EMERGING THEMES

INTRODUCTION

Purpose of this chapter

The purpose of this chapter is to develop a set of findings consistent with the research questions for this study. The research questions are:

- How are the attitudes of primary teachers towards recognized features of effective professional development influenced by their beliefs about the nature of mathematics, the role of the teacher, and/or how children learn mathematics?
- How are the attitudes of primary teachers towards recognized features of effective professional development influenced by their classroom practice?
- How is the reaction to and classroom implementation of the content of a short course professional development experience by primary teachers influenced by their beliefs about the nature of mathematics, the role of the teacher, and/or how children learn mathematics?
- How is the reaction to and classroom implementation of the content of a short course professional development experience by primary teachers influenced by their classroom practice? (From Chapter 4, page 87)

In regards to data analysis this study has so far analysed the classroom practice of seventeen of the teachers who undertook the *3Cs* professional development (Chapter 5). To achieve this SCAN and Transcripts analyses were devised in order to categorize the teachers as either 'instrumental' or 'relational' in terms of the way they handled classroom discussion. An amalgamation of the two resulting 'instrumental-relational' continua allowed for the selection of four representative teachers: a beginning 'mainly instrumental' teacher (Deidre), an experienced 'mainly instrumental' teacher (Malcolm), a beginning 'mainly relational' teacher (Tasha), and an experienced 'mainly relational' teacher (Gerry).

This analysis led to the development of Insights 5.1 to 5.5 that focussed on differences between instrumental and relational practice. In Chapter 6 case studies of the four representative teachers were presented. These case studies focused on describing each teacher's classroom practice and then gave a possible explanation for their practice. This analysis and discussion led to the development of a 'beliefs and practice' profile for each case study teacher. The profile also included any impinging influences and constraints. This analysis and discussion led to a listing of further Insights related to instrumental and relational differences (Insights 6.1 to 6.10). The profiles were then used to make predictions based on the research questions. The case studies were continued in Chapter 7 with an account of each teacher's reaction to the content of the *3Cs* workshops and their attitudes to features of effective professional development. This data was then compared to the predictions made at the end of Chapter 6. Commonalities noted in the comparison were listed as Insights 7.1 to 7.14. This set of Insights focussed on the research questions.

In order to develop a set of findings consistent with the research questions for this study the Insights developed in Chapters 5, 6 and 7 will act as starting points for further exploration. This analysis and discussion will involve the whole cohort of teachers who undertook the *3Cs* professional development (excluding those two teachers whose observations and interviews were technically problematic). To compliment this further analysis and discussion links to relevant references from the literature will be made. The insights are starting points for discussion and they may be confirmed, modified or refuted by the further analysis and discussion. Several of the Tables referred to are in Appendix D.

The Insights

The following Insights have been made as a result of the analysis of data in Chapters 5, 6 and 7. The full list of Insights is included here because in some discussion some points will be supported by reference to Insights that are not the major point of discussion.

Insights from Chapter 5

Insight 5.1: Teachers do not fit into neat boxes

Insight 5.2: Analysis of classroom discussion transcripts is an appropriate means for classifying teachers

Insight 5.3: 'Instrumental' and 'relational' teachers can be distinguished in the way they perceive the role that pupils can play in the learning process

Insight 5.4: 'Instrumental' and 'relational' teachers classroom practice indicates that they have different views on the purpose of learning mathematics

Insight 5.5: Perceived or actual 'Relational' beliefs on pedagogy may not necessarily translate into relational practice in teaching mathematics

Insights from Chapter 6

Insight 6.1: Classroom practice results from a balancing out of deep-seated and surface level beliefs.

Insight 6.2: Each teacher has their own unique I/R profile and explanation for their resulting classroom practice

Insight 6.3: 'Instrumental' and 'relational' teachers do not necessarily have corresponding beliefs on the nature of mathematics

Insight 6.4: Deep-seated beliefs are likely to result from past school experiences

Insight 6.5: Teaching experience is a contributor to shifting instrumental beliefs and practice towards relational beliefs and practice

Insight 6.6: Enjoyment or pleasure from solving mathematical problems may lead to relational beliefs on the nature of mathematics

Insight 6.7: Confidence in mathematical ability can reinforce instrumental beliefs on the nature of mathematics

Insight 6.8: External factors and constraints generally produce instrumental classroom practice

Insights from Chapter 7

Insight 7.1: Ascertaining the beliefs, attitudes and practice profile of a teacher is a most complex task

Insight 7.2: Relational beliefs on the nature of mathematics encouraged increased trialling of 'mathematics content' activities.

Insight 7.3: Classroom practice which reflects an instrumental view of the role of the teacher leads to making judgements about and adaptation of activities presented in a relational way that in turn result in making classroom implementation of these activities closer to instrumental practice.

Insight 7.4: Instrumental/relational differences on 'lesson initiation' provide a predictor on the extent of *3Cs* trialling

Insight 7.5: Relational beliefs on 'How children learn mathematics – pupil mode' are a good predictor of trialling of collaborative strategies regardless of whether the teacher's classroom practice is instrumental or relational

Insight 7.6: Teachers, regardless of whether they implement instrumental or relational classroom practice, are interested in children's reaction and thinking when they trial activities and this emphasis could be because they have relational beliefs about 'How children learn mathematics'.

Insight 7.7: Teachers implement workshopped activities rather than activities described in a handout

Insight 7.8: The case study teachers regardless of their classroom approach saw 'Attending professional development was a group' as an effective feature of professional development. This emphasis may be linked to their relational belief about 'How children learn mathematics'.

Insight 7.9: Even though the *3Cs* program was specifically about collaboration, constructing knowledge and providing opportunities for reflection for primary pupils, none of the case study teachers mentioned that the presenter modelled these same techniques to enhance the understanding of the participants.

Insight 7.10: Teachers preferred workshops that had active participation and this could be driven by their relational beliefs about how children learn mathematics even though they may not implement these beliefs in their own classroom.

Insight 7.11: Case study reaction to the feature 'conducted over an extended period of time' could be predicted according to instrumental/relational differences in beliefs and practice related to 'How children learn mathematics'.

Insight 7.12: 'Seeing advantages for pupils' was given high priority by all teachers regardless of their classroom approach. This support may be linked to their relational beliefs about 'How children learn mathematics'.

Insight 7.13: All case study teachers valued classroom trialling between workshop sessions. This support could not be attributed to instrumental/relational differences in beliefs and practice about 'How children learn mathematics'.

Insight 7.14: Participants valued talking and listening to teachers from other schools, but preferred to undertake workshop activities with the group from their own school.

The teachers in this study

Because this chapter deals with analysis of the whole cohort of teachers who undertook the *3Cs* workshops this section briefly re-visits the classifications made for the sixteen primary teachers to be used in the analysis and discussion for this study. In Chapter 5 their classroom practice was investigated mainly through analysis of the way in which they handled classroom discussion. As a result of this investigation the teachers were placed into three broad categories: instrumental, relational, and neither clearly instrumental or relational. The criteria for these broad categories were generated in the 'Teacher beliefs and practice' section of the literature review. As well the teachers were also distinguish as beginning or experienced teachers according to years of teaching experience. Table 8.1 contains a matrix naming each teacher in the six categories that resulted.

	Classification according to SCAN and transcripts analyses		
	Instrumental	Not clearly instrumental or relational	Relational
Experienced Teachers	Malcolm Dianna	Nora Karen	Gerry Teresa Helen Neva Bianca Kaye
Beginning Teachers	Deidre Sally Trevor Olivia	Megan	Tasha

Table 8.1: Matrix showing profile of case study teachers according to analysis of the way in which they handled classroom discussion

The case study analysis confirmed this categorization for each of the case study teachers. In the following discussion these categorizations for the teachers will be used unless otherwise stated.

An overview of attitudes to features of effective professional development

The following section covers the analysis of eight features of effective professional development considered by all participants. As part of interview 5 each participant was asked to select from the list of eight features the one that was most important to them and the one that was least important. From this, three categories resulted: 'highest priority', 'no indication of priority', and 'lowest priority'. The data obtained was used to develop a list that puts the features in order of priority for the overall group of teachers and also their various groupings. A scoring process was developed which allocated '0' to 'lowest priority', '1' to 'no indication', and 2 to 'highest priority'. In the few instances where a teacher could not separate out features the score was distributed in appropriate proportions. This scoring process enabled a ranking of teacher preferences towards features of effective professional development and their placement on a continuum of preference. A ranking ratio could then also be calculated for each feature by dividing the total score for that feature by the greatest total score possible. Table 8.2 shows the ranking of features of effective professional development that resulted for the *3Cs* participants as an overall group (ranking ratio listed in brackets). For the instrumental and relational groupings of teachers the continuum in Table 8.3 resulted and Table 8.4 shows the continuums that developed for the beginning and experienced groupings of teachers.

It is clear from Table 8.2 that the features of effective professional development are apportioned different values by teachers and that the particular groups in this study generally place the features in very similar orders. However, noting overall trends from these results is limited. For example, the instrumental and relational ratings for 'Attending as a group of teachers' might suggest that there was no difference in opinion. However, a breakdown of the results gives a different picture. For the six instrumental teachers, two chose the feature as highest priority, 3 gave 'no indication' and one rated it as of lowest priority. All seven relational teachers gave the feature a 'no indication' rating. In light of this those features that are close to the middle of each continuum may not present clear generalizable trends. Trends resulting from features at either extreme of the continuums offer more reliable findings.

Highest priority	Seeing advantages for pupils (0.78)
	Addressing issues of concern for teachers (0.63)
	Attending professional development as a group of teachers (0.53)
	Researching activities in the classroom (0.52)
	Linked to school-wide effort (0.50)
	Supportive principal (0.45)
	Conducted in a school setting (0.39)
Lowest priority	Conducted over an extended period of time (0.21)

Table 8.2: Ranking given to features of effective professional development by *3Cs* participants.

	Instrumental teachers	Relational teachers
Highest priority	Seeing advantages for pupils (0.75)	Seeing advantages for pupils (0.85)
	Addressing issues of concern for teachers (0.67)	Addressing issues of concern for teachers (0.64)
	Attending professional development as a group of teachers (0.50)	Attending professional development as a group of teachers (0.50)
	Linked to school-wide effort (0.50)	Researching activities in the classroom (0.50)
	Researching activities in the classroom (0.47)	Linked to school-wide effort (0.50)
	Conducted in a school setting (0.43)	Supportive principal (0.50)
	Supportive principal (0.38)	Conducted in a school setting (0.35)
Lowest priority	Conducted over an extended period of time (0.31)	Conducted over an extended period of time (0.14)

Table 8.3: Ranking given to features of effective professional development by *3Cs* instrumental/relational groupings of teachers.

	Beginning teachers	Experienced teachers
Highest priority	Seeing advantages for pupils (0.88)	Seeing advantages for pupils (0.73)
	Addressing issues of concern for teachers (0.63)	Addressing issues of concern for teachers (0.63)
	Linked to school-wide effort (0.50)	Attending professional development as a group of teachers (0.60)
	Supportive principal (0.50)	Linked to school-wide effort (0.55)
	Researching activities in the classroom (0.47)	Researching activities in the classroom (0.50)
	Conducted in a school setting (0.47)	Supportive principal (0.43)
	Attending professional development as a group of teachers (0.42)	Conducted in a school setting (0.33)
Lowest priority	Conducted over an extended period of time (0.14)	Conducted over an extended period of time (0.25)

Table 8.4: Ranking given to features of effective professional development by *3Cs* beginning/experienced groupings of teachers.

Given the statistical limitations of these continua plausible findings could include:

- The feature given the highest rating by all teachers and by each specific grouping of teachers was the features where judgements about the professional development are seen in terms of the advantages it provides for pupils.
- The teachers as a whole as well as each grouping of teachers rated attending professional development over an extended period of time as the least favoured feature.

- The beginning teachers rated the feature where it is advantageous for a group of colleagues to attend professional development lower than did the experienced teachers.
- The majority of teachers rated the features of linking professional development programs to school-wide efforts, the need for a supportive principal, researching activities in classrooms, and conducting professional development in school settings in the 'no indication' category.

FURTHER ANALYSIS AND DISCUSSION

Teacher individuality: Beliefs, practice and professional development

It is clear from the Chapter 5 analysis completed of each teacher's handling of classroom discussion and the outcomes of the Chapter 6 section of the case studies that each teacher has a unique teaching profile (Insights 5.1 and 6.2). The analysis and discussion pertaining to the case study teachers noted that a teacher's classroom practice resulted from a complex balancing out of deep-seated and surface-level beliefs (Insight 6.1), that the deep-seated beliefs may have been established through the teacher's own school experiences (Insight 6.5) and that teaching experience contributes to shifting instrumental beliefs and practice towards relational beliefs and practice (Insight 6.6). The revised model of relationships between beliefs and practice developed by (Raymond, 1997) also includes the notions that the relationships between beliefs and practice are complex, that deep-seated beliefs are the ones more likely to be implemented and that there is a strong influence on beliefs from past school experiences. It may not be surprising then that in this study most of the beginning teachers are also instrumental in their classroom approach and most of the experienced teachers have relational classroom practice.

These Insights are very important in terms of professional development. Consider the following scenario. A beginning teacher because of past school experiences has deep-seated instrumental beliefs on the nature of mathematics, the role of the teacher and how children learn mathematics and the pre-service experiences for this teacher did challenge the deep-seated beliefs held but these challenges have only lead to the development of emerging relational beliefs, beliefs that are very much surface-level. Raymond (1997) notes that pre-service programs have a moderate influence on beliefs and only a slight influence on teaching practice. As a beginning teacher they are over-loaded in preparing lessons, establishing their classroom management techniques, fitting into new routines, conforming to collegial pressures and just generally facing up to the many constraints placed upon innovative teaching and learning practices. They thus implement a 'mainly instrumental' classroom approach (Sullivan, 1989-B and Insight 6.9) because they rely on their deep-seated instrumental beliefs informing their practice (Raymond, 1997; Southwell, 1995). When this beginning teacher attends professional development what will produce teacher change? Although change is validated by observing positive student outcomes (Clarke, 1994) there are two diametrically opposed positions on how this change might occur. One model of teacher change sees that change in beliefs is needed before classroom implementation of the innovation (noted in Clarke, 1994) and an alternative model sees that change in beliefs follows on from classroom implementation (Guskey, 1985). It is interesting to note at this point that the model of the relationships between beliefs and practice espoused by Raymond (1997) shows that there is a reciprocal relationship between beliefs and practice but that the beliefs-to-practice relationship is stronger than the practice-to-beliefs relationship. She also found that a teacher's own classroom experience was the primary influence on beliefs related to learning and teaching. Putting aside the constraints that impinge upon getting started as a teacher will this beginning teacher make change as a result of implementing innovative classroom practice or change in beliefs? It is possible that because of the individuality of teachers some will relate more to the model noted by Clarke and some will relate to Guskey's model.

Teacher reaction and attitude to the content and organizational features of professional development is likely to also be unique and complex (Insight 7.1) in the same way that the pupils in their classrooms are considered as unique individuals. Teaching philosophies encourage teachers to cater for individual differences in their classroom whenever this is appropriate and possible. These insights into teachers suggest that the same philosophy should be applied to teacher learning. When professional development is designed and implemented it should, whenever it is appropriate and possible, cater for the individual differences which exist between teachers.

Beliefs and classroom practice can shape participant reaction to structuring of professional development

Case study teacher reaction to two of the professional development features used to work out the structure of the *3Cs* program could be differentiated according to their beliefs and practice.

Insight 7.8: The case study teachers regardless of their classroom approach saw 'Attending as a group of teachers' was an effective feature of professional development. This may be linked to their relational belief about 'How children learn mathematics'.

Insight 7.11: Case study teacher reaction to the feature 'conducted over an extended period of time' could be predicted according to instrumental/relational differences in beliefs and practice related to 'How children learn mathematics'.

However, for Insight 7.13 the prediction based on instrumental/relational differences did not hold.

Insight 7.13: All case study teachers valued classroom trialling between workshop sessions. This support could not be attributed to instrumental/relational differences in beliefs and practice about 'How children learn mathematics'.

Discussion

Each of these Insights links the reaction to the professional development feature to beliefs and/or practice related to 'How children learn mathematics'. Each link is to a different aspect of 'How children learn mathematics'.

Attending as a group / How children learn mathematics

These findings were reported in the conference paper (Smith, 2000-A) along with some of the following discussion.

Insight 7.8 makes the connection to the relational belief on 'pupil working mode' where teachers believe that pupils learn better by working collaboratively which in turn is played out in the classroom with the use of teaching techniques aimed at promoting pupil-pupil collaboration. The four case study teachers all professed relational beliefs for the 'pupil mode' aspect of 'how children learn mathematics,' however, the two instrumental teachers did not appropriately implement these beliefs in the classroom. This suggests that the 'instrumental teachers' beliefs on 'pupil working mode' were surface-level beliefs and in balancing out these beliefs with other beliefs pupil-pupil collaboration was not implemented in their mathematics teaching (refer to Insights 5.3 and 5.5). It is quite possible that their beliefs on 'pupil working mode' have been derived from beliefs on how children learn best in other subject areas and thus their non-application in mathematics teaching. If the feature of attending professional development as a group of colleagues is linked to these beliefs and/or practice it is to beliefs and not necessarily to practice.

All of the *3Cs* participants (bar one) exhibited relational beliefs on 'pupil working mode' and they justified their beliefs using comments such as 'children can build on what they already know', 'pupils draw ideas from each other' and 'pupils clarify their ideas with their peers' (from Interview 3 data). This justification matches relational notions of teaching and learning and mirrors the advantages for the use of collaborative teaching strategies listed in Chapter 3 (refer to pages 73 and 74). However, from the analysis made in Chapter 5 on the way in which the teachers manage classroom discussion it was clear that only some of the *3Cs* participants implemented these relational beliefs in their teaching.

All the *3Cs* participants valued attending professional development with a group of colleagues from their school as an appropriate professional development feature. The reasons given for valuing this feature were collected from responses to questions in interviews 3 and 5. The reasons given can be grouped together under the classifications of sharing; planning; encouragement to attend and the responsibilities associated with attendance; and attitudinal outcomes. The reasons related to teachers sharing and planning were mentioned the most and are listed in Table D.1 (Appendix D) along with the numbers of teachers referring to that justification and an example interview comment. Overall there are insignificant differences between the teacher groupings and their reasons for valuing 'Attending professional development as a group of teachers' except that the reason 'Leads to greater sharing' was mentioned by all the instrumental teachers but only by four of the seven relational teachers.

Many of the reasons given for valuing 'Attending professional development as a group of teachers' are comparable to the justification the teachers gave for their relational belief on 'pupil working mode' and the list of advantages for the use of collaborative classroom strategies listed in Chapter 3 (see pages 73 and 74). The lists in Table 8.5 offer a few examples of the comparisons that can be made between the teachers justification for valuing attending professional development as a group of colleagues and the advantages for using collaborative classroom techniques.

Reason from Table D.1	Collaborative strategy advantage
Leads to greater sharing	Through communication and collaboration students come to see other ways of conceptualizing and solving problems
Individuals focus on different parts of the professional development which assists sharing	More ideas and different solution approaches are generated
Trialling different activities or the same activity in different ways enriches sharing	Academic achievement is enhanced
Passing on enthusiasm to others	A more positive attitude of mathematics as a subject is developed
Helps to keep you on task for sharing	More time is spent on task

Table 8.5: Comparisons between reasons for 'Attending as a group' and advantages for using collaborative classroom strategies

The list of advantages for the use of collaborative strategies in the classroom is based upon relational ideas so these comparisons are of interest as they suggest that the *3Cs* participants justified their preference for attending professional development as a group of colleagues on the basis of relational-type reasoning. Thus teachers with relational beliefs in terms of 'pupil working mode' regardless of whether they implemented these beliefs in their own teaching used a similar relational-type justification for their own learning and professional development even though these ideas might not match the reflective nature of supporting professional risk taking (Sparks & Loucks-Horsley, 1989), listening and meaningful reflection (Baird, 1991) or using conflict in a productive way (Lieberman, 1986).

However, there may be other underlying reasons for valuing attending professional development as a group of colleagues. All the *3Cs* participants said that they valued hearing the ideas of teachers from different schools (Insight 7.14 and post-*3Cs* Interview data). At the first *3Cs* workshop the teachers from each school sat together. The facilitator and researcher decided that it was beneficial for teachers from different schools to discuss issues and share together. A variety of strategies were put in place at subsequent workshops to encourage this. The majority of participants resented this approach and clearly demonstrated that they preferred to remain together as a school group. Kaye's comment was typical of the responses given by many of the teachers.

> Teachers always resist that. They don't like being told what to do. They are happy to mix in for an activity but when that's over they love to go back to their little spot. I think it's because you don't know what to expect. There is a certain sense of security in sitting with people that you are comfortable with. (Interview 4)

This notion of 'workshop comfort zone' may be a reflection for some teachers of a lack of confidence in mathematical ability and sensing a feeling of being shielded by their close colleagues. This could fit in with other justification for wanting to workshop activities with the group from their own school:

- feeling more relaxed with people that you know;
- working with those that you have already forged a bond with because of your day-to-day association with them;
- coping with new situations when you are tired after a day's work is easier if it is done with people you know.

The 'workshop comfort zone' notion cannot be ascribed to particular *3Cs* participants because the question was asked in a way that gained comments on the *3Cs* participants in general and not necessarily attributable to the actual interviewee.

The reasons listed in Table D.1 for valuing attending professional development as a group of colleagues were collected from questions that required a fairly straightforward single response. When the *3Cs* participants were asked to make a response to a question involving justifying a comparison of two features a different trend was revealed. In interview 3 a question was asked that had two parts. (NOTE: These questions were added into interview 3 after the Spinebill Way teachers had completed the interview so the data only includes twelve of the sixteen *3Cs* participants.) Firstly the teachers were asked if they valued going to professional development as a group and whether they valued classroom trialling as part of professional development and all the teachers noted that they valued both of these features. The next part of the question requested that the interviewees choose one of the features as more important than the other. Interestingly all of the instrumental teachers chose the feature pertaining to attending as a group of teachers and all of the relational teachers chose the feature related to classroom trialling. This distinction was not apparent in the continua developed from the Interview 5 task where insignificant or no difference existed between these two features for both instrumental and relational teachers. The instrumental teachers justified their choice by claiming that trialling could not occur if the group had not firstly been to the professional development. Olivia's comment is typical.

> [Attending as a group is] first because otherwise I wouldn't be coming back and trialling. (Interview 3)

This is an organizational or structural approach in which to consider the value of professional development features, in itself an instrumental approach. Dianna, another instrumental teacher but speaking in her role as mathematics co-ordinator, referred to the feature of attending as a group of teachers as a motivating factor. However,the implication is that this needs to happen first and the trialling will follow.

> Dianna: I think if you do it with a group of teachers it motivates other teachers more so. If you had five teachers wanting something it is a lot stronger than just one or two teachers. So I think it is really important. The aim of the maths co-ordinator is to try and get as many teachers as you can to do something. (Interview 3)

The other instrumental teacher, Deidre, reasoned that this was the way she perceived that she learnt best, that is, learning by talking and listening to others which is relational reasoning.

The reasons given by the relational teachers were quite different because they focussed on making sense out of the content presented in the professional development. Bianca's comment is typical of the response from the relational teachers.

> Because you bring it back to your classroom and you're making sense of what has been told and putting it into practice. And so you can go back and say it works or it doesn't. It's just not theory. (Interview 3)

This reasoning is relational in nature it involves the teachers in reflection about their practice.

All teachers valued attending professional development with a group of their colleagues and on the surface justified their attitude with a relational-type response. But when probed further those teachers who had instrumental classroom practice justified the value of this feature in a practical sense with an instrumental explanation. This feature is recognised as effective because it has been found to encourage professional risk-taking (Sparks & Loucks-Horsley, 1989) and is seen as teachers analysing, evaluating and experimenting with innovation in a collective sense (Fullan, 1995), qualities that are analogous to relational classroom practice and relational beliefs about learning and teaching. If, in reality, the relational teachers have a meaningful understanding of the reasons for the use of this feature then they are likely to gain from attending professional development with a group of colleagues as they will be prepared to actively share their risk-taking with others and to search for improvement in a meaningful way. In contrast if the instrumental teachers have an instrumental view of the relevance of this feature then it is possible that they will not realize the actual benefits of attending professional development with a group of colleagues and view collaboration as reducing preparation time and sharing of resources. This is also mirrored in beliefs about the use of collaborative strategies in the classroom. All teachers professed relational beliefs in the use of pupil-pupil collaboration and the use of small groups in the classroom. Those teachers who taught in a relational way involved their pupils in an active learning approach but those with an instrumental classroom approach did not, in practice, implement these beliefs. This suggests that teachers can justify learning and teaching approaches both at the classroom and the professional development level in a 'politically-correct' way but in reality they may not necessarily have a meaningful appreciation of the real benefit of these approaches.

It appears that teachers, whether they have instrumental or relational beliefs and practice, can justify their valuing of the feature of attending professional development as a group of teachers in relational-like terms. However, there may be further underlying justification related to notions of 'teacher comfort zone' and reflective practice that distinguish instrumental teachers from relational teachers. This feature may in fact be more meaningfully understood and accessed by the teachers who actually implement their relational 'pupil working mode' beliefs in a purposeful way. It has already been mentioned that 'Leads to greater sharing', one of the reasons for valuing this feature, was noted by all the instrumental teachers and could actually mean the need to make only one set of materials and thus decrease the teaching team's workload. This would make this reason a more instrumental-type reason than a reflective or relational-type reason and may explain why the beginning teachers gave this feature a lower rating than the experienced teachers (trend noted from Table 8.4).

There is data from this study that indicates that if certain conditions are in place then the feature pertaining to attending professional development as a group of teachers is enhanced. Face-to-face interaction and group processing need to be in place for collaborative strategies to be successful in the classroom (Johnson, 1989-90). If this was translated to an adult learning level or teacher professional development context then the group that the teacher works closely with is probably the most appropriate group to be with at professional development. In the *3Cs* situation there were three examples which clearly demonstrate this: two where physical and grade separation meant lack of support and decreased classroom trialling and the other a counter example where collegial support acted as an inducement for increased classroom trialling.

Teresa from Wattlebird Rise Primary School taught at Prep level and the other *3Cs* participant from the same school, Karen, taught at Year 3 level. Their classrooms were in different buildings either side of other school buildings. They both noted the ineffectiveness of this situation in regard to sharing with each other.

> Teresa: She is over there and I'm here. We are physically separated and she is really busy and I'm really busy. So you don't get time to sit down and talk to people. I mean we do talk but it's always in snatches. (Interview 3)

> Karen: It would have been good if Kerry [Karen's year 3 colleague] and I had both gone to the [*3Cs*] sessions but she couldn't find the time. That's even better than

> Teresa and I. Teresa's been a great support but the person you're closely working with would be even better. (Interview 5)

Even though Teresa and Karen trialled an average to high number of *3Cs* activities compared to the other participants this communication difficulty is apparent in the extent of the trialling they had in common. The *3Cs* activities were modelled in a way that many of them were suitable to use across all primary school levels but the percentages of activities trialled by both Karen and Teresa is lower than other school groups. Overall Teresa and Karen trialled ten and eleven activities respectively with four of these activities being common to both teachers.

Trevor's situation at Rosella Flats Primary School is also interesting. He was teaching at Year 6 whereas the other two *3Cs* participants from his school, Sally and Dianna, were both teaching Year 2. Their classrooms were also physically separated from his classroom. In Interview 3 Trevor had noted that he thought attending professional development as a group of colleagues was an important feature of professional development.

> Trevor: It's fairly important I think. Whenever an activity comes up we can try that in our class so there is someone to discuss it with. Say if I need something for one of the games from the PD sessions I can see Dianna or Sally or they can see me. So it's good with resourcing. (Interview 3)

However, in Interview 5 Trevor chose this feature as of lowest priority.

> Trevor: I don't think that [groups of teachers] matters. Even though we had three from our school it wouldn't have mattered whether I was the only one there. (Interview 5)

This change of opinion and belief that the feature was of low importance may reflect Trevor's experience. Trevor was in the first year of his first primary teaching appointment and *3Cs* was his first professional development program. There are a number of comments that indicate that there was little sharing either with the other two *3Cs* participants or with Trevor being given the opportunity to share *3Cs* ideas with his immediate colleagues.

A contrasting situation involves the four teachers from Spinebill Way Primary School. They all taught at the year 5/6 level but only had planning meetings at their respective year levels. Three of the teachers, Neva, Helen, and Malcolm, taught in adjacent classrooms but the fourth teacher, Gerry, was located almost at the other end of the school. The level of trialling by Neva and Helen with both trialling twelve activities was very similar to that of Teresa and Karen at Wattlebird Rise. Malcolm trialled 17 activities and Gerry trialled 22 activities. At Spinebill Way two of the activities were trialled by all four teachers, eleven activities by three teachers and seven activities by two teachers. Gerry was the teacher who trialled a number of activities that no one else at his school attempted. The formal and informal contact at Spinebill Way most likely accounts for the fact that so many of the same activities were trialled. This probably supports the notion put forward by Ahlstrand (1994) that teacher collaboration can be either formal or informal in nature and that teachers choose to have discussion at a more informal level than a formal one. However, the physical isolation for Gerry may have meant that he trialled activities but did not share the outcomes of these with his colleagues.

The differences in shared trialling in these three school situations appears to be due to physical and grade level separation rather than factors such as being a 'stuck' or 'moving' school (Fullan, 1995) or working in a competitive or individualistic atmosphere (Johnson, 1987). In the 'Wattlebird Rise and Rosella Flats scenarios' there were no established formal channels for the particular teachers to communicate with each other and the other inherent difficulties led to little informal communication so consequently few activities were commonly trialled. This is in contrast to the 'Spinebill Way scenario' where both formal and informal communication played an important part in the extent of trialling and more so in the number of activities commonly trialled.

Extended time / How children learn mathematics

These findings and some of the following discussion have been reported in the conference paper (Smith, 2000-C).

Insight 7.11 deals with the feature where it is seen as advantageous to conduct professional development over an extended period of time because this is seen to provide time for teachers to reflect on the new ideas being presented. For the prediction made in this study it is linked to the relational 'measure of learning' belief that sees that children need to be placed in a situation 'where they need to struggle with their own constructions of knowledge'. This is played out in the classroom in a number of ways but particularly in the provision of time for reflection and allowing pupils to struggle with problems rather than the teacher intervening. The case study data shows that the two relational teachers had these relational beliefs and generally put them in to practice whereas the instrumental teachers, although not as clearly distinguishable, most likely had instrumental beliefs and practice in this regard. The two 'mainly instrumental' case study teachers were not in favour of this professional development feature citing their reasons as loss of continuity, work overload and difficulty with maintaining interest. The situation for the 'mainly relational' teachers is not as clear. Tasha chose this feature as lowest priority and said that length of professional development needed to match the aims of that professional development – a relational view. Gerry thought the spacing of the *3Cs* workshops was appropriate to allow for classroom trialling and he neither chose this feature as of highest or lowest priority. The prediction for the 'mainly instrumental' teachers was realized but for the relational teachers the prediction was an indication but not as clear-cut.

From Table 8.2 it can be seen that this feature was given the lowest rating by all *3Cs* participants and by each grouping of teachers. It must,however,be remembered that this result may be coloured by the extra time that was taken up with interviews and classroom observations. In general the teachers had a fairly common view that the classroom observations and interviews were fulfilling the research needs of the study and made no contribution to their own professional growth. A third of the teachers said that the classroom observations made them accountable for trialling *3Cs* activities and several teachers noted that the aim of interviews were for the researcher to obtain their ideas. Four of the teachers did note that the interviews had made them think about ideas that they had not previously considered and at Honeyeater Hills Primary School, the school with most of the beginning teachers, the interview questions did generate staffroom discussion and requests to the vice-principal to give her opinion.

When comparing the instrumental/relational and the beginning/experienced groupings in Tables 8.3 and 8.4 the indication is that only a minor difference exists with the relational grouping and the beginning teachers giving this feature the lower rating. At first this seems to be an unusual result because the relational teachers and the experienced teachers are virtually the same group and similarly with the instrumental and beginning groups. The inclusion of the three 'neither instrumental nor relational' teachers into the beginning/experienced data and the choice made by the two 'experienced instrumental' teachers has produced this result.

The justification for the inclusion of this feature in the various models of professional development include the need for 'cyclic notions of change' (Owen, 1988), 'time for classroom practice' (Sparks, 1989), and seeing professional development as a 'process rather than an event' (Guskey, 1995). A measure of the 'Extended time' feature would be the changes in attendance and classroom trialling over the time of the professional development. If the feature is rated as low importance to the *3Cs* participants then it could be expected that attendance and classroom trialling over time would decrease. Attendance for 'all participants' remained high for all sessions except the last one (Table D.2, Appendix D) and for this last session several teachers were reported as being ill and one was on long service leave. When comparing the attendance for sessions 1, 2 and 3 (Term 2) with sessions 4, 5 and 6 (Term 3) the decrease for instrumental teachers and relational teachers is negligent,however,there is a significant comparison for the beginning teachers

(94% to 61%) to the experienced teachers (87% to 90%) (Table D.3, Appendix D). Data based on individual teachers trialling at least one activity per workshop session shows that the amount of trialling for all teachers resulting from sessions 1, 2 and 3 (88%) was substantially greater than that from sessions 4, 5 and 6 (46%) and this pattern exists for each major grouping of teachers with instrumental and beginning groupings showing the greater percentage drop in classroom trialling (Tables D.4 and D.5, Appendix D). The teacher's engagement with *3Cs* shifted from one where attendance and classroom trialling were both dominant (Term 2) to one where attendance was maintained but the extent of classroom trialling decreased substantially (Term 3). Because classroom trialling is an important component of teacher change this evidence indicates that there is an optimal time for professional development. This notion of optimal time could be connected to many factors including the nature of the content or how closely linked the content is to the teachers' current needs.

Attendance without classroom trialling would mean that the professional development would be less reflective in nature. The extent to which classroom trialling is included is dependent on a teacher's current style of practice, that is, a teacher who has relational classroom practice is more likely to find it easier to include relational-type activities into their everyday teaching than teachers who have instrumental classroom practice. It was also noted in the discussion for Insight 7.8 that the relational teachers justified their valuing of classroom trialling with reasons that were connected to reflective practice. So it is probably not surprising that the relational teachers were able to maintain a higher degree of classroom trialling throughout *3Cs* than the instrumental teachers managed. This indicates that in the *3Cs* context the feature where it is considered that there are advantages for conducting professional development over an extended period of time is more suited to a relational teacher's classroom practice where greater risk-taking, moving away from set agendas and being innovative is part of classroom practice. The notion of 'process' referred to by Guskey (1995) includes involvement in reflective practice and acknowledges that meaningful change requires effort and time, personal qualities that may be more attributed to relational rather than instrumental teachers.

Guskey's reference to the need for 'effort and time' is relevant to the context in which *3Cs* took place. Primary teachers in Victoria are currently involved in many after-school meetings and professional development, in classroom preparation beyond the usual school hours and in keeping up with a number of government changes to curriculum and teaching approaches. In response to why this feature was selected as 'lowest priority' Kaye's response encapsulates this busy time for teachers.

> Most of us have neither the time nor the availability to go and be involved. I mean years ago they [professional development over extended periods of time] were great. That was fine but

> not now. There are too many committees, too many afternoon things. Most of us don't get home to seven at night. That's the way it goes. And anything that goes on for more than a week or two that's it because at that time I have got another twenty-five things impinging on that time. (Interview 5)

In summary, for Kaye, the day-to-day issues for her altered very rapidly and if she needed to undertake professional development it needed to be concluded in a short time, that is, to have it completed in more concentrated efforts. Herrington, Sparrow & Swan (1995) in their study into professional development practice noted the same difficulties for teachers.

> Clearly, for many teachers, the commitment to begin thinking about their own teaching and trying out new approaches demanded time that for many was on top of their already heavy commitments. For many teachers there was a strongly-felt pressure that they already had so much to cover in the overcrowded syllabus that they could not find time to think about or fit in any more. (Herrington, Sparrow & Swan, 1995, page 343)

Many of the *3Cs* participants noted the difficulty of finding time to meaningfully include professional development into an already overcrowded day but it is possible that without this external constraint of 'busy-time' they understood the reason for why professional development was best conducted over an extended period of time. Bianca had said:

> It becomes tedious after awhile. [With *3Cs*] you think back and think, "Oh goodness we started that in term two". (Interview 5)

But she qualified her response to take in the notion of the value of having time for reflection.

> I don't know whether [over an extended period of time] could be an advantage because you have got extra time to think about it. (Interview 5)

Classroom trialling / How children learn mathematics

It was predicted that the relational teachers were more likely to value the feature of classroom trialling between workshop sessions than were the instrumental teachers. This was based on the notion that the relational teachers were more likely to include opportunities for their pupils to reflect on what they had been learning and that classroom trialling was a part of professional development reflection. This prediction was proved to be incorrect because the four case study teachers all valued classroom trialling even though two of them taught in an instrumental way. Malcolm's reason for valuing this feature was to monitor pupil discussion and reaction and Deidre's reason was to prepare herself for the next *3Cs* workshop. Malcolm's reason is pupil-centered whereas Deidre's reason focuses on her professional development. Both of these reasons could be seen as relational in approach. Tasha qualified her response by stating that trialling should not drive her program, that is, a relational approach to planning. Gerry noted that his trialling led to changes in classroom layout that meant that the trialling had encouraged him to reflect upon his practice.

The following findings concerning participant reaction to classroom trialling as a structural feature have been noted in previous discussion. We know:

- that all teachers, regardless of their beliefs and practice, claimed to value the feature of classroom trialling (Interview 3 data noted in discussion about Insight 7.8);
- that the relational teachers gave 'relational-type' justification for choosing the feature of classroom trialling as more important to them than attending professional development as a group (Interview 3 data noted in discussion about Insight 7.8);
- that the extent of classroom trialling decreased over the duration of *3Cs* and that this was more noticeable for the beginning and instrumental teachers (Table D.5 and discussion on Insight 7.11);
- that the decrease in *3Cs* classroom trialling over time was in part due to time constraints and the notion that the feature favours reflective classroom practice and is thus more likely to be preferred by relational teachers (Discussion on Insight 7.11).

These findings demonstrate that even though all teachers reacted favourably to the feature of classroom trialling the relational teachers regarded the feature as a more integral part of their reflective practice. In practice this is confirmed by the fact that the relational teachers were more likely to continue with classroom trialling for the duration of the *3Cs* program. A link probably exists between including or valuing reflection in your own learning as an adult and the provision of reflective opportunities in classroom teaching and learning. This further analysis beyond that of the case study teachers rejects the finding in Insight 7.13. In later discussion (refer Insight 7.3) it will be noted that the value, in terms of the *3Cs* intentions, that instrumental teachers gained from classroom trialling may have been limited.

This study found that the recognised features of classroom trialling between workshop sessions, professional development conducted over an extended period of time, and attending professional development with a group of colleagues were connected to reflective practice. Loughran (1994) cites the writing of Dewey and Schon in his discussion on reflective practice. One of the attitudes that Dewey regarded as important for reflective practice was that of open-mindedness where there was a need to be an active listener, open to new ideas and to consider problems in different ways. From Schon's notions Loughran referred to the two forms of reflection – reflection-on-action and reflection-in-action. The first of these is being thoughtful about what you are doing and the latter form refers to dealing with unanticipated difficulties in action. Relational teachers are more likely to relate to reflective practice because they are likely to provide reflection time for their pupils, allow them to struggle with problems, listen to their ideas, facilitate a 'discourse community', and take risks with lesson flow (refer to Chapter 2, pages 34 to 36).

It has already been noted that attending professional development with a group of colleagues encourages 'professional risk-taking' and involves 'analysing, evaluating and experimenting with innovation in a collective sense' (Sparks & Loucks-Horsley, 1989; Fullan, 1995). This professional activity would need time and effort to develop confirming that professional development is a 'process' rather than an 'event' (Guskey, 1995) and is thus supported by the feature that sees that it is an advantage to attend professional development over an extended period of time. An integral part of this 'process' is the place of classroom trialling. It is classroom trialling that provides the context for the individual teacher's 'professional risk-taking' and 'experimenting with innovation' and then for the group of colleagues to assist with 'analysing, and evaluating'. Classroom trialling as a recognised feature of effective professional development includes the notions of giving participants a basis for further discussion (Clarke, 1994), sees that teachers can replicate teaching ideas not previously part of their repertoire (Sparks & Loucks-Horsley, 1990) but requires timely feedback (Owen, Johnson, Clarke, Lovitt & Morony, 1988; Guskey, 1995). This discussion shows that for the outcomes of professional development to be successful then these three features need to come together in an appropriate way. This study would support this because it has shown that if certain conditions are in place then the professional development outcomes are enhanced. These conditions included the existence of channels for meaningful formal and informal communication to be able to take place between those colleagues attending the professional development. Meaningful communication occurred where the teachers met for lesson planning and where the colleague's classrooms were situated physically close to each other.

Beliefs and classroom practice can be a predictor of the extent and value of classroom trialling

The following four insights indicate that beliefs and practice could either encourage or limit the extent of between-sessions classroom trialling:

Insight 7.2: Relational beliefs on the nature of mathematics encouraged increased trialling of 'mathematics content' activities.

Insight 7.3: Classroom practice which reflects an instrumental view of the role of the teacher leads to making judgements about and adaptation of activities presented in a relational way that in turn result in making classroom implementation of these activities closer to instrumental practice.

Insight 7.4: Instrumental/relational differences on 'lesson initiation' provide a predictor on the extent of *3Cs* trialling.

Insight 7.5: Relational beliefs on 'How children learn mathematics – pupil mode' are a good predictor of trialling of collaborative strategies regardless of whether the teacher's classroom practice is instrumental or relational.

Discussion

Teachers with relational beliefs on 'pupil working mode' see that pupils learn better by working collaboratively; teachers with instrumental beliefs on 'pupil working mode' see that pupils learn better by working individually. Teachers with this relational belief are likely to value collaborative teaching strategies and trial them in their classrooms; teachers with an instrumental belief will find the trialling of these strategies problematic. All four case study teachers had relational beliefs on 'pupil working mode' and their trialling of the collaborative teaching strategies was either extensive or represented a high fraction of their total trialling. Deidre and Malcolm did normally not put these beliefs into practice because they may have been surface-level beliefs (Insight 6.1). It could be concluded that these relational beliefs encouraged the case study teachers to trial the workshopped collaborative strategies (Insight 7.5).

It is difficult to make a generalized finding from this situation with the case study teachers because there is no counter example. And in fact all of the *3Cs* participants claimed to value the notion that pupils gain from working collaboratively (from pre-*3Cs* interviews). However,on further analysis of their justification for valuing collaboration an interesting distinction becomes apparent. One set of reasons focussed on organizational criteria such as being useful for when the teacher is not available to help, providing a break from listening to the teacher, being useful for those pupils needing extra help, and only used when the groups of pupils are streamed according to ability. The other set of reasons includes learning to value the ideas of others in a group, clarifying thoughts, exploring the language of mathematics, discovering other pupil's thinking, and sharing ideas and strategies. The first set of reasons tend to be instrumental in nature and the second set of reasons are relational. Most teachers mentioned more than one reason for valuing collaborative teaching techniques but their reasons came from only one of the sets of reasons and not from both. When the teachers were sorted according to these two sets of reasons the teachers in the 'relational grouping', on average, had a slightly higher rate of trialling the collaborative strategies (see Table D.6, Appendix D). It could be concluded that those teachers that justified their 'pupil working mode' beliefs in a relational way were more likely to trial collaborative strategies in their classroom. This is important because classroom trialling experiences may form the basis of meaningful and appropriate teacher decision-making about the value of the professional development outcomes (Insights 6.6, 7.6 and 7.12).

Malcolm and Gerry both had relational beliefs on the nature of mathematics and demonstrated that they enjoyed completing mathematical problems and were confident in doing them. Deidre and Tasha had instrumental beliefs on the nature of mathematics. Deidre was confident with her mathematics ability but noted that she did not enjoy mathematics. Tasha claimed that she enjoyed problem solving but that she was not confident in her mathematical ability. Malcolm and Gerry trialled more 'mathematics content' activities than both Deidre and Tasha and especially Tasha. It was predicted that confidence and interest in mathematical problems might lead to greater trialling of *3Cs* activities, especially those from the 'mathematics content' strand. Confidence and interest appears to come from having relational beliefs on the nature of mathematics (Insight 6.7). Insight 7.2 suggests that there is a connection between the extent of trialling and confidence and enjoyment in mathematics and consequently beliefs in the nature of mathematics.

Responses to the question where the *3Cs* participants were asked to comment on the analogy between learning to ride a bicycle and learning mathematics were used to categorise the teacher's beliefs about the nature of mathematics. This question had been a useful determinant of beliefs for the case study teachers. This analysis resulted in eleven of the *3Cs* participants being classified as having instrumental beliefs on the nature of mathematics and five having relational beliefs. The teachers were listed in order according to the extent of trialling they had undertaken overall as well as in the three distinct content areas. Three tables were then developed that distinguished between teachers with relational/instrumental beliefs on the nature of mathematics (Table D.7, Appendix D); between experienced/beginning teachers (Table D.8, Appendix D); and between teachers with relational/instrumental classroom practice (Table D.9, Appendix D). In comparing these three tables it is clear that beliefs on the nature of mathematics is the only distinction of the three that was a factor for a greater extent of classroom trialling. The five teachers who had relational beliefs on the nature of mathematics were also experienced teachers. On further examination of Table D.8 which distinguishes between experienced and beginning teachers it is worth noting that the eight teachers who undertook the most trialling were experienced except for Deidre who was confident in her mathematics ability. The rest of the beginning teachers are among the eight teachers who did the least trialling along with three experienced teachers. It was observed at both the pre- and post-*3Cs* interviews that two of these three experienced teachers lacked confidence in their ability to solve the mathematical problems presented to them. This further examination reinforces the notion that confidence and enjoyment of mathematical problem solving is most likely a predictor on the extent of trialling *3Cs* activities in the classroom. It is possible that the beginning teachers are still judging the worth of mathematics activities from their past school experiences (Insight 6.5) and in light of this do not feel that they can risk taking such an activity (Insight 6.1). The experienced teachers are more accepting of such activities and possibly prepared to take greater risks (Insight 6.6).

Instrumental practice on lesson planning includes the notion that teachers choose 'good activities' rather than consider the needs of their pupils. Because the *3Cs* activities were often presented as 'one-off' activities in order to create discussion on meaningful teaching and learning approaches as well as mathematical concepts, teachers with an instrumental approach to planning may find it easier to fit the *3Cs* activities into their mathematics lessons. The converse applies for teachers with relational practice on planning. Because they place emphasis on providing activities to cater for the needs of their pupils these teachers will make selection on this basis and this will possibly limit the number of trialled activities. The two case study teachers that had instrumental practice on 'lesson initiation', Malcolm and Gerry, did the most trialling of all the *3Cs* participants. Deidre and particularly Tasha planned according to the needs of their pupils. Deidre trialled an average number of activities and Tasha trialled the least number of all the *3Cs* participants and this could be a reflection of their relational approach to planning (Insight 7.4).

Lesson planning by selecting activities on the needs of pupils ('lesson initiation' – relational) did not mean that *3Cs* activities were not trialled. In fact several of the teachers that planned in this way were among those trialling the most activities. However, on average those teachers that planned by selecting 'good activities' ('lesson initiation – instrumental) in preference to considering the needs of the children ('lesson initiation – relational) did trial more activities although the difference is marginal (refer to Table D.10, Appendix D, for specific data).

Another possible explanation, not noticeable in the case study teachers, is that classroom practice where the teacher makes connections to what else is happening in the classroom (i.e., a relational approach – 'making connections') such as integrated studies or teaching through themes that include mathematics, may also have limited the amount of trialling of *3Cs* activities. No substantial difference was found to exist when the extent of trialling was compared on this instrumental/relational basis (refer to Table D.11, Appendix D, for specific data). The teachers who 'made connections' in their mathematics teaching on average trialled slightly more *3Cs* activities than those that did not 'make connections'. A more evident difference existed for 'lesson initiation' with the teachers who plan instrumentally having a higher extent of trialling.

Even though there may be beliefs and classroom practice that encourage increased trialling of activities it does not necessarily mean that classroom trialling is undertaken in the way intended or modelled. One example that illustrates this is the trialling by Malcolm and Neva of the Jigsaw/Clue Cards activity (A-36). This example and discussion has been the basis for the conference presentation (Smith, 2000-B). Malcolm (Year 6) and Neva (Year 5) had worked closely together at the same year levels in previous years. Their classrooms were next to each other and they regularly discussed their classroom practice. They both chose to do this activity as one of their post-*3Cs* classroom observations and generally followed the plan for the lesson as it was modelled at the *3Cs* workshop. Malcolm's handling of the lesson has already been described, in part, on page 251. However, analysis of the way in which each of them handled the classroom discussion is very different. Dealing with the terminology on the clue cards was managed differently. Malcolm provided the definition of 'net' before the group work started. Neva waited until it had become a group's problem. She did not directly answer their question but made a connection to a previous classroom activity. During group work both teachers moved about the classroom listening and observing. Malcolm made no comment to any of the groups during the small group part of the lesson but Neva used the opportunity during this stage of the lesson to further the students' ideas. Following the presentation of ideas by each group Malcolm proceeded to give a very lengthy explanation of his understanding of each clue. For Neva the groups' reporting back provided her with the opportunity to extend student ideas and seek further clarification. Malcolm maintained control of the process and ideas throughout the lesson whereas Neva allowed students to run with their own ideas. Malcolm has been categorised as 'mainly instrumental' particularly in his classroom practice but when he came to trial this activity that had been modelled using relational practice he reverted to his usual approach to handling classroom discussion. On the other hand Neva who was 'mainly relational' was able to run with this activity in the way it had been intended.

The *3Cs* activities were presented in order to promote a relational approach to classroom practice so any teacher with an instrumental approach to their teaching may find implementation of the activities problematic. These teachers are likely to modify the activities to match their existing classroom practice or unconsciously present the activity in a way that does not recognize any shift in practice towards the approach modelled in the *3Cs* workshops. The two instrumental case study teachers did trial *3Cs* activities in a way that was closer to their usual instrumental approach. As well they were selective in which activities they chose to trial basing the selection on either the mathematical complexity of the task or whether the activity fitted in to their curriculum agenda. The two relational teachers had different perspectives on trialling – Gerry was the *3Cs* participant who did the most trialling and Tasha did the least amount of trialling. Both of them in the trialling implemented the activities in a way that reflected the relational approach modelled in the *3Cs* workshops. This case study finding along with the example of how Neva and Malcolm trialled the same activity does strongly suggest that teachers with instrumental practice are more likely to make judgements about or modify activities presented in a relational way so that they resemble their usual instrumental practice (Insight 7.3).

To investigate Insight 7.3 further a summary of one post-3C's classroom observation for each instrumental and relational teacher (other than the case study teachers) follows. The classification derived in chapter 5 for each teacher is noted in brackets.

Olivia (instrumental classroom practice)

Olivia undertook Activity 3-3 (A-35) that used the Clue Cards problem 'Double header ice-creams'. She placed her class into working groups of four pupils, partly based on ability, explained the task and set the groups to solve the problem. She saw her role as sitting in with each group, particularly the lower ability groups to guide them in their problem solving. She had also produced a worksheet with a number of blank double-header ice-creams – the exact number needed. By working with the groups and providing the worksheet she was not allowing the pupils to freely engage in their own ways for solving the problem. The relational approach modelled in the *3Cs* workshop had been replaced with an instrumental approach.

Trevor (instrumental classroom practice)

Neither of the two post-*3Cs* classroom observations given by Trevor were taken from *3Cs*. Both the lessons observed were more interactive for the pupils than were the pre-*3Cs* observations but Trevor still dominated classroom discussion in the same way as he did in the example in Chapter 5.

Dianna (instrumental classroom practice)

Dianna completed a lesson that had two tasks. Firstly the pupils were asked to think about the outcomes for tossing two coins. This was not directly taken from *3Cs* but there were similar tasks discussed. During the discussion Dianna gave all the explanations, in fact, pupil explanations were ignored. The second task was the game 'Ticking Off' (A-41), an activity provided in handouts not modelled by the presenter. Time ran out for any concluding discussion for this activity.

Sally (instrumental classroom practice)

Sally took a lesson taken from a program text and not from the *3Cs* workshops. The lesson involved keeping a tally of the colours of jellybeans in a packet. The main outcome for Sally seemed to be to encourage the children to record their tallies in "bunches of fives" rather than on any aspect of data or chance. Sally ignored the pupil's ideas and gave her own explanations even when the children reported back at the end of the session.

Helen (relational classroom practice)

Helen began the lesson with a chance game called 'Heads and Tails'. This was followed by a lesson described in a *3Cs* handout (A-56). Even though this main part of the lesson had not been modelled in the *3Cs* program Helen facilitated the classroom discussion in a relational way.

Bianca (relational classroom practice)

Bianca undertook a lesson not from *3Cs* but it did involve consideration of the chances for various colours on spinners that had differing proportions of coloured sectors. Classroom discussion was conducted along relational lines especially accepting the ideas offered by pupils.

Neva (relational classroom practice)

Neva used the jigsaw / clue cards task 'Coloured Dice' (A-36). During the trialling Neva made use of appropriate questioning techniques, wait time, and gave the pupils meaningful challenges during the lesson.

Kaye (relational classroom practice)

Kaye had four groups of pupils working on very different tasks. One of the tasks was 'Random Walk' (A-70). Kaye had obviously not understood the intention of this activity as her comments to those while playing the game suggested that she viewed it as a 'fun game' and the concluding discussion contained no important mathematical outcomes.

Teresa (relational classroom practice)

Teresa undertook an activity using the Questioner Tag collaborative strategy (A-50). To be able to do this with a Year 1 class Teresa had devised her own problem suitable for this level. To try this strategy at Year 1 was certainly risk-taking but the pupils managed the strategy and with appropriate concluding questioning Teresa facilitated some worthwhile outcomes – related to the strategy and also mathematically.

From these brief summaries it seems clear that the instrumental teachers either modified the relational approach modelled in *3Cs* or completed an activity not from *3Cs* even though this had been requested. This has even occurred despite the fact that these instrumental teachers claimed that they had relational beliefs on 'How children learn mathematics' (Insights 5.4, 5.5 and 6.1). Other than Kaye the relational teachers have presented a lesson to their class that used relational approaches whether it was modelled at *3Cs* or taken from the *3Cs* handouts.

Teacher decision-making has a pupil focus

Two insights suggest that teacher decision-making has a pupil focus.

Insight 7.12: 'Seeing advantages for pupils' was given high priority by all teachers regardless of their classroom approach. This support may be linked to their relational beliefs about how children learn mathematics

Insight 7.6: Teachers, regardless of whether they implement instrumental or relational classroom practice, are interested in children's reaction and thinking when they trial activities and this emphasis could be because they have relational beliefs about how children learn mathematics

Discussion

It was predicted that relational teachers would regard the feature where seeing advantages for pupils is a basis for making judgement about professional development as of high priority and that they would judge the success of an activity by their pupil's reactions because they have relational beliefs on how children learn mathematics. All the case study teachers put a high priority on this feature and were interested in their pupil's reaction to trialled activities regardless of their classroom approach. These outcomes may then be connected to beliefs on how children learn mathematics but not necessarily to whether these beliefs are implemented in the classroom.

From Table 8.2 it can be seen that as a group the *3Cs* participants chose the feature 'Seeing advantages for pupils' as of highest priority as did each grouping of teachers. The relational teachers placed a slightly higher priority on it than did the instrumental teachers and the beginning teachers rating was slightly higher than the experienced teachers. No teacher gave the feature a low priority rating.

More than half of the participants chose this feature by claiming that professional development existed to improve the learning outcomes for their pupils, that is, connecting this feature to what they perceived as the main role of a teacher. There was no differentiation in regard to this reason between instrumental/relational, beginning/experienced groupings. Kaye's and Bianca's comments are typical of this reasoning:

> Kaye: That is our primary concern. How you can help the individual kids in your grade to learn. That's what it is all about. (Interview 5)

> Bianca: Well that's why we are here, here for the children. So whatever I learn [from PD] I didn't learn to like do at home. It is to the children's advantage that I did the PD. (Interview 5)

A variation on this reasoning was the notion that professional development was seen as teacher improvement but that this in turn would lead to improvement for learning outcomes for pupils. Helen's and Sally's comments are typical of this justification.

> Helen: To bring you back with fresh ideas and maybe a better way to teaching a concept or for an outcome. I suppose it's for us too but in the long run it's how it effects the kids. (Interview 5)

> Sally: You are doing [professional development] for yourself but you are also doing it to improve your quality of teaching for these kids. (Interview 5)

Four of the teachers referred to a more reflective reason for choosing this feature. This reason included the notion that professional development helped you to fill perceived gaps in your teaching. Two of the teachers, Trevor and Teresa, linked this to the feature that sees that it is an advantage to link the content of professional development to the issues of concern held by teachers.

> Trevor: I think [the purpose of PD] is being able to use it in the classroom so you can give different experiences to your pupils that you might not have had before hand. And that sort of comes after [the feature] 'addressing issues that concern' about something lacking in your teaching and you use PD to fill the gap. (Interview 5)

> Teresa: 'Seeing advantages for pupils' goes together [with 'addressing concerns of teachers']. They both drive each other. Because your concerns would come from that or lack or something that you had seen wasn't happening in your classroom. (Interview 5)

At the workshop sessions the participants did become very interested in those activities where discussion centered on the reaction to pupil's discussion and comments. Activity 1-6 (A-12) involved the participants in watching and evaluating children's comments captured on video. This created great interest with most teachers being curious about how their own pupils would react to the same question. Seven out of the sixteen teachers noted trialling this activity without an interview prompt and three of them chose a lesson based on this activity as one of their post-*3Cs* classroom observations. With two of the activities, Dicetracks (A-7) and Double Header Ice-creams/Clue Cards (A-35), the presenter had been able to trial with her own pupils prior to the *3Cs* workshops. This meant that she was able to share her own pupil's reaction to these two activities with the *3Cs* participants. Those *3Cs* teachers that then trialled either of the activities returned to the next workshop and shared their experiences with much of the discussion centered on pupil reaction. This in turn encouraged other participants to trial the activities resulting in seven teachers trialling Dicetracks and nine trialling Double Header Ice-creams, among the highest trialling for a specific activity.

The feature pertaining to seeing advantages for pupils can probably occur at many stages within professional development. Teachers will decide that various aspects of professional development content are advantageous for their pupils as a result of judgements they make when the activity or idea is presented at a workshop, by the comments their colleagues make as a result of classroom trialling, or by the observations they make of their classroom trialling. The feature will only be effective if it reflects the intentions of the professional development but classroom trialling does not always correspond to the intended aims of the professional development (Insight 7.3). To link this feature to the relational belief for 'How children learn mathematics' is thus problematic. In the previous discussion concerning teachers' underlying justification for making use of collaborative strategies it was found that their reasons could be separated into 'instrumental-type' reasons and 'relational-type' reasons even though they all professed to value the use of collaborative strategies for enhancing the way in which children learnt mathematics. It is possible that some teachers will see advantages of professional development content for their pupils but have reasons for this that do not promote growth or change in their teaching practice. This indicates that classroom trialling and the decisions that teachers make as a result of the trialling need purposeful monitoring.

Participant reaction to workshop delivery

Some of the Chapter 7 insights deal with the way the workshop content was delivered. Insight 7.10 was the only one that was predicted based on beliefs and classroom practice.

Insight 7.7: Teachers implement workshopped activities rather than activities described in a handout

Insight 7.9: Even though the *3Cs* program was specifically about collaboration, constructing knowledge and providing opportunities for reflection for primary pupils, none of the case study teachers mentioned that the presenter modelled these same techniques to enhance the understanding of the participant.

Insight 7.10: Teachers preferred workshops that have active participation and this could be driven by their relational beliefs about how children learn mathematics even though they may not implement these beliefs in their own classroom.

Insight 7.14: Participants valued talking and listening to teachers from other schools, but preferred to undertake workshop activities with the group from their own school.

Discussion

Insights 7.7 and 7.10

In various contexts in the interviews all *3Cs* participants claimed to prefer active participation in professional development workshops. Active participation in workshops could include many aspects: using materials, working in small groups, involvement in whole group discussion, reflecting on the comments of others, and evaluating ideas presented in video format. Many of these aspects are mirrored in relational beliefs and practice concerning classroom teaching and learning.

Of the reasons given by the *3Cs* teachers for preferring active participation in workshops the following deal with enhancing understanding and reflection and are relational in nature:

- assists in making decisions about which activities will be used in your classroom;
- increases personal understanding;
- do not pick up on or remember ideas by just hearing;
- demonstrates how to undertake an activity;

- gives greater meaning to the ideas being presented;
- makes it easier to modify an activity if you have workshopped that activity.

Other reasons given were:

- prevents the workshop from becoming boring;
- need activity at the end of a long school day;
- makes the time more enjoyable.

Many of the first set of reasons above are to do with trialling classroom activities in the workshops. The relational and the experienced teachers were far more articulate in their reasons for this preference with most of them offering two or three reasons and generally mentioning the reasons to do with enhancing understanding and reflection.
This compares to the instrumental and beginning teachers who tended to only list one reason and on the whole not the enhancing understanding and reflection reasons.

One measure of the value of this teacher preference for active participation in workshops is the take-up rate of workshopped activities for classroom trialling. At each *3Cs* workshop participants were given a set of handouts. These handouts included some of the workshopped activities and also additional activities and articles related to the theme for each specific workshop. In a few instances an activity used in the pre-*3Cs* interviews were included. The trialled 'mathematics content' activities had a range of both workshopped activities and handouts. When these are analysed for extent of trialling on average the number of workshopped activities trialled were a little more than three times the handout activities trialled. The range in the difference is from equal numbers through to nine to one (workshopped to handouts). Two of the handouts activities were part of the pre-*3Cs* interviews and much of the handouts trialling was these two activities. Familiarity and recognition of the activity and having given a previous explanation of the problem may have been the factor for selection for trialling. There was an insignificant difference in the average workshopped/handout trialling ratios for the specific comparative groups in this study. What is interesting is that school groups varied on average workshopped/handout trialling ratios. It has already been noted that the extent of trialling and in particular the number of activities commonly trialled was greater at the two schools where the greatest formal and informal communication between *3Cs* participants was possible compared to the two schools where meaningful communication was problematic. The two schools with the greatest formal and informal communication have trialled more workshopped activities than handout activities when compared to the two schools were this communication was problematic. This indicates that if the school group attending professional development is drawn from an appropriate working team within the school then workshopped activities are more likely to be trialled because the shared hands-on nature of completing a task provides the stimulus for the group's discussion and classroom planning. This factor may be more significant than each individual teacher's beliefs and classroom practice.

Insight 7.14

In discussion on Insight 7.8 it was noted that most of the *3Cs* participants disliked being organized into working groups other than with the colleagues from their own school. However, all *3Cs* participants were prepared to acknowledge the value of mixing with teachers from other schools. Their justification for valuing this was based upon the notion of hearing how other teachers trialled the *3Cs* activities. Several teachers noted that this often encouraged them to trial particular activities.

In this earlier discussion the notion of 'workshop comfort zone' was raised as one possible reason for why some teachers preferred to attend professional development with their colleagues. A number of reasons related to this notion of 'workshop comfort zone' were listed. However, one other reason was also given and that was to discuss the activities and strategies with the group you will be working with on a day-to-day basis, especially if they teach at the same year level. This ties in with one of the reasons given for preferring active participation in workshops: 'assists in making decisions about which activities will be used in your classroom'. This justification is reflective in nature.

Insight 7.9

The discussion on Insights 7.7, 7.10 and 7.14 suggest that many teachers preferred to be involved in reflective practice in professional development workshops. And yet according to Insight 7.9 none of the case study teachers saw that the presentation style of the presenter was one that modelled a connection between theory and practice, that is, modelling the collaborative classroom techniques and constructivist notions under discussion at a teacher professional development level.

The idea that professional development presenters could model good classroom practice in their own presentation styles is a powerful device and is an approach used in most teacher education courses because it can bring together theory and practice in a meaningful way and often in itself provide a context for discussion. Two participants have noted that they prefer presenters who are practising teachers because they bring to the professional development relevant ideas and connections. This idea may be close to the notion of presenter modelling.

The *3Cs* participants had very definite views about the qualities of an effective presenter and they were able to articulate a broad range of presenter qualities most of them listing at least three qualities. Table D.12 (Appendix D) lists the range of presenter qualities suggested by the *3Cs* participants. The qualities have been grouped together as either instrumental, relational, either instrumental or relational, and other categories. The numbers of teachers referring to each quality are listed along with a typical comment illustrating that quality. Few distinctions can be made between the instrumental and the relational teachers – the relational teachers have favoured 'appropriate workshop management' and 'empowering participants'. The distinctions between the beginning and experience teachers are greater but not at a level considered important. The experienced teachers favoured 'being knowledgeable', 'provision of practical activities', 'appropriate workshop management', 'empowering participants', developing interaction between people' and 'giving feedback'. These differences may be explained by the fact that experienced teachers have more ideas to recall from their past professional development experiences and generally listed more qualities when responding to the interview question.

FINDINGS

The following findings need to be considered within the context of this study: a short course professional development with an agenda aimed at promoting relational beliefs and practice. A cohort of volunteer primary teachers undertook this short course that included teaching ideas for Chance and Data, strategies that encourage pupil collaboration, and consideration of constructivist notions. As well as this commitment the participating teachers were observed in their classrooms and interviewed before, during and after the delivery of the short course. Many of the features of effective professional development as listed in Chapter 2, page 43, were able to be incorporated into the organization and style of this professional development experience.

Attitudes to features / beliefs and practice

The findings from this study are:

- Teachers in general had similar attitudes to the features of effective professional development. Certain features were given either high or low priority by teachers and some were noted as of little importance. Teachers valued the outcomes of the professional development in terms of the advantages it would have for their pupils. They did not value or have a favourable attitude towards attending the professional development over an extended period of time. Some features, such as professional development being conducted in the teacher's own school setting, were seen as of little importance. On the surface there appears to be no differences in these attitudes based upon beliefs, practice and/or experience.

- Teachers valued attending professional development with colleagues and justified this with notions that mirror relational beliefs on 'pupil working mode'. However, in a practical sense the justification indicates possible instrumental and relational differences. The instrumental valuing may lead to a notion of 'workshop comfort zone'. Certain conditions also need to be in place to enhance the worth of this feature, that is, conditions where both formal and informal communication within a school are maximized.
- Attending professional development over an extended period of time was given lowest priority out of all the features by all teachers and by each teacher grouping used in this study. One explanation for this could be the external constraint of always feeling busy and lacking meaningful time. Another explanation may be the additional components of interviews and classroom observations that were imposed on the teachers. Attendance was not affected by this low priority but classroom trialling was with the beginning and instrumental groupings having the greatest decrease in trialling. The nature of classroom trialling together with the nature of the content of professional development (assuming it is to promote relational practice) is more suited to relational teachers and this may be explained by the notion that relational teachers are more prepared to be reflective and take risks.
- Classroom trialling of activities between workshop sessions was valued by all teachers but in practice may have been a more 'routine' part of everyday classroom practice for the relational teachers because they valued reflection on what they did in their teaching.
- Classroom trialling of activities, attending professional development over an extended period of time, and attending professional development with colleagues are features that appear to be more favourable to a relational classroom approach. The real benefits of these three features is only realized if the teachers have relational beliefs **<u>and</u>** implement their relational beliefs in their classroom practice. These three features are also dependent on each other – to achieve maximum benefit from any professional development all three features need to be in place in an appropriate way and their inter-connectedness needs to be noted. 'Maximum benefit' would imply meaningful reflective practice.
- Teachers who have relational classroom practice appear to value in a purposeful way many of the features of effective professional development, in fact, many of the features are aimed at promoting reflection and thus naturally

appeal more to those teachers who appreciate reflective practice as part of their own way of learning or their approach to developing new ideas. Even considering this none of the teachers made the connection between the presenters modelling and the content of the professional development.

- The individualistic nature of teacher's beliefs, classroom practice, and attitudes to professional development features and content makes any generalized recommendations problematic.

Reaction to and implementation of content / beliefs and practice

The findings from this study are:

- All teachers profess to have relational beliefs in regard to 'pupil working mode' but justify these beliefs in distinctly instrumental or relational ways. Those teachers that have relational justification did greater trialling of collaborative teaching strategies.
- Having relational beliefs on the nature of mathematics and the connected qualities of confidence and enjoyment of mathematics leads to greater classroom trialling.
- Extent of trialling can be explained in part by instrumental/relational differences in approaches to classroom planning.
- The aims of the professional development will only be realised if trialling is completed in a way that matches these aims. Teachers who have classroom practice that does not mirror the aims of the professional development find it difficult to implement activities in the way intended. Trialling leads to modification of the activities. This occurs despite the beliefs the teachers might hold.
- All teachers saw that it was important that the professional development had advantages for their pupils and this was regardless of whether their practice was instrumental or relational. However, this feature will only be purposeful if the judgements that teachers make about the advantages that they are seeing for their pupils match the intended outcomes for the professional development.
- Classroom trialling may be increased if the activities set for trialling are workshopped and if the teachers see that classroom trialling is part of their reflective process. This then suggests that relational teachers may benefit most from workshopping activities because they are more likely to appreciate reflective professional development approaches. However, a 'working team' from a school is more likely to trial workshopped activities than 'isolated'

individuals from a school and this factor may be as important as having relational beliefs.

SUMMARY

This chapter has considered the list of Insights developed in Chapters 5, 6 and 7. This consideration has involved analysis of the data from the full cohort of *3Cs* participants. Like Insights were grouped together under five themes and each theme was fully discussed. From this discussion a set of findings were established and these will inform the basis of discussion for the final chapter.

CHAPTER 9

RECOMMENDATIONS AND FUTURE DIRECTIONS

INTRODUCTION

The purpose of this study was to isolate some issues for further consideration and discussion in order to advance or improve professional development for teachers. In order to gain some insights for this the study took as its context a short course professional development: *3Cs: Chance, Constructivism & Collaboration (3Cs).* The group of primary teachers undertaking this course were observed teaching in their classrooms and were interviewed before, during and after the short course.

I raised a number of questions about the real impact of professional development in a personal reflection on involvement in teacher professional development activities in Chapter 1. The concluding question raised the notion of the individuality of teacher beliefs and practice and how this 'uniqueness' impacts on the outcomes of professional development undertaken. This study has focused on the organizational features considered necessary for effective professional development and how differing teacher beliefs and practice relate to these features.

For me, the following four points from the findings listed in Chapter 8 are the issues resulting from this study that should be given further consideration. Each participating teacher had a unique set of beliefs and these beliefs impacted on their classroom practice and attitude to professional development activity in an individual way. Many of the organizational features considered necessary for effective professional development were more suited to those teachers who implemented reflective practice in their classroom approach and in their own learning or professional development. The value of classroom trialling of activities that had been presented at the professional development sessions may have been of little value for those teachers whose beliefs and practice were not in line with the agenda set by the professional development. Attending the professional development course as a group of teachers from the one school was certainly advantageous in the extent of classroom trialling and possibly to some extent in the gains, in terms of professional growth, resulting from this trialling.

So that some recommendations can be made for consideration by professional development planners and other researchers with an interest in this field each of the points listed above will be now considered more fully. Following this future directions for the organization of professional development and research in this field will be addressed.

RECOMMENDATIONS FOR THE ORGANIZATION OF PROFESSIONAL DEVELOPMENT

Dealing with unique teacher profiles

Each participating teacher had a unique set of beliefs and these beliefs impacted on their classroom practice and attitude to professional development activity in an individual way.

It was noted in chapter 1 that there existed a gap between the theory of mathematics instruction and apparent classroom teaching (Sullivan, 1989-A) and that through the 1980's and 1990's there were calls for change in the way in which mathematics was taught (Cockcroft, 1982; NCTM, 1980; Ministry of Education, 1988; Ellerton & Clements, 1989; Skemp, 1992; Weissglass, 1994; Comiti & Ball, 1996). Calls for change and bridging the gap between theory and practice are still in place as we head into the 21st century (Goldsmith & Schifter, 1997; Lappan, 1999). In terms of the definitions developed in this study Sullivan's 'theory of mathematics instruction' would closely resemble the 'relational' practice outlined in this study and his 'apparent classroom teaching' would be mirrored by the description of 'instrumental' practice. It was clear from the analysis undertaken by Gervasoni (1995) that in Victoria the major documents and professional development in mathematics education were directing teachers towards the implementation of 'relational' classroom practice or to Sullivan's 'theory of mathematics instruction'.

These calls for change of teaching direction are aimed at shifting 'instrumental' practice to 'relational' practice. Classroom practice is shaped by the beliefs held by a teacher (Ernest, 1989; Skemp, 1976; Perry, 1996; Clarke, 1993-B) and for mathematics instruction these beliefs can be classified into three distinct although interconnected categories: beliefs concerning the nature of mathematics; beliefs about teaching approaches; and beliefs about how children best learn mathematics. Beliefs can be held with varying degrees of conviction (Thompson, 1992) and in this study the notions of 'deep-level' and 'surface-level' beliefs as defined by Raymond (1997) have been used. Raymond (1997) noted that it was the deep-level beliefs that would influence classroom practice. If a teacher's deep-level beliefs are instrumental then their practice will be likely to be instrumental; if their deep-level beliefs are relational then their classroom practice is likely to be relational. However, this study found a teacher's belief system was not as clear-cut as being either only instrumental or only relational but a unique mixture of instrumental and relational beliefs held at varying degrees of conviction.

Professional development is seen as the way in which change in classroom practice can be achieved. Professional development activity needs to challenge all teacher-held beliefs whether those beliefs are instrumental or relational. The existence of a 'gap between the theory of mathematics instruction and apparent classroom teaching' in some ways is a healthy educational environment to have as teachers should be continually questioning their practice and appraising it in terms of newly espoused theoretical ideas and the most recent innovations. Professional development activity needs to challenge and nurture beliefs in order to impact on classroom practice. Assuming that the agenda is to shift instrumental classroom practice to relational classroom practice then deep-level and surface-level instrumental beliefs need to be effectively challenged and replaced, surface-level or emerging relational beliefs also need to be challenged but nurtured in a way that they become deep-level beliefs, and deep-level relational beliefs need to be continually challenged in a way that they are strengthened. This scenario demonstrates the complex nature of teacher change. Senger (1999), in her recently reported research into the change process for three elementary teachers, confirms that teacher change is complex and unique. From her study she developed a flow chart model depicting different modes of change and the pathways that exist between each mode. The process of change for the three teachers in her study varied especially in regard to the different pathways taken to achieve change.

If the process of teacher change is unique for each individual teacher then the delivery of teacher professional development needs to respond to this for the attainment of meaningful professional growth for all. Professional development at the individual participant level could well be enhanced if professional development planners, and the individual participants, could ascertain their belief-and-practice profiles.

This notion of using an understanding of one's beliefs and how they connect to actual practice is supported by both Cooney & Shealy (1997) and Goldsmith & Schifter, (1997).

> By considering the origins and intensity with which beliefs are held, we can better understand why some beliefs tend to manifest themselves in practice whereas others do not. This kind of

> analysis can help us determine why some teachers change their instructional approach whereas others do not, despite participation in the same teacher education program and rhetoric about reform that may be strikingly similar. (Cooney & Shealy, 1997, page 97)

> [Developing a new form of mathematics practice] involves examining currently held beliefs and practices, discarding elements that no longer seem to serve the practice well, making room for new ones, and reorganizing them into a new coherent whole. (Goldsmith & Schifter, 1997, page 26)

This study found that for most teachers, especially the beginning teachers, their point of reference for mathematics and approaches to learning and teaching mathematics is their own school experiences. These were most likely of a traditional or conventional form (Bishop & Goffree, 1986; Sullivan, Bourke & Scott, 1995; – refer to Chapter 2, page 22). Their beliefs about the nature of mathematics developed at school are likely to be similar to the beliefs pertaining to the instrumentalist view described by Ernest (1989). Their past learning and teaching approach is likely to have been a 'receiving mode' approach for learning and according to Cooney & Shealy (1997) this readily translates into a 'telling mode' approach when teaching. This study also found that many of the teachers' beliefs about effective mathematics teaching and learning were influenced by their beliefs and practice pertaining to teaching and learning in other curriculum areas especially language. On the whole, for mathematics instruction, these beliefs were surface level with the outcome being that their deep-seated instrumental beliefs in the nature of mathematics had more impact on their classroom practice. This finding is supported from research by Cooney & Shealy (1997) that found that teachers' beliefs about mathematics could be held more strongly than beliefs about the teaching of mathematics.

Goldsmith & Schifter (1997) raise the same issue. Their 'new form of mathematics practice' includes beliefs about teaching and learning as well as a consideration of a new vision of what mathematics is about.

> Teachers, together with their students, create a culture of mathematical inquiry aimed at developing deep and flexible understanding of the domain. Posing questions, making and proving conjectures, exploring puzzles, solving problems, debating ideas describing and predicting patterns are all part of the new mathematics classroom. (Goldsmith & Schifter, 1997, page 20).

Schuck (1995), as a teacher educator, confirms the notion that it is difficult to alter deep-seated instrumental beliefs in order to bring about change in mathematics instruction. Her solution is the same as that being advocated here, and that is to gain an understanding of the beliefs of her students, or in this study's situation professional development participants. She wrote:

> It became obvious to me that, in order to encourage change in the way mathematics is taught in the primary school, I needed to be aware of the beliefs of students in the teacher education program in which I am involved. Some of these beliefs act as chains which make difficult the movement towards reform of school mathematics teaching. Knowing the nature of the chains also helps in the formation of new and positive links, ... The chains are encumbrances which halt the students' progress and make change extremely difficult. (Schuck, 1995, page 465)

How could a teacher or professional development planner ascertain the beliefs and practice profile of the individual participants in a particular professional development activity. In this study, analysis of teacher beliefs and practice was achieved through the use of interviews and classroom observations. Even though a large amount of interview data has been generated and it has been possible to construct a 'picture' of a teacher's unique beliefs and practice profile there are limitations on the use of interviews for obtaining reliable data of this nature. For example, interviewees may respond in a 'politically correct' way, they may give the interviewer responses that they think will support the research, and they may even develop and alter their beliefs during the course of an interview. And in regards to professional development organization it is probably not reasonable to assume that each participant could undertake interviews because of funding and time constraints. Belief profiles for individual teachers may need to be elicited in some other way, perhaps through a questionnaire or through some form of self or peer examination.

The use of self-examination could be very useful as this would give the teacher ownership over the process and allow for personal goal setting. Both the SCAN and Transcript analyses developed in Chapter 5 of this study provided useful, reliable and in-depth analysis of classroom practice. In fact following the writing of Chapter 5 I was encouraged to use both forms of analysis to explore my own teaching style. This was easy to do by taking a tape recording of one of my classroom sessions, making a transcript and applying the various techniques developed in Chapter 5. This provided many insights into the style of my own classroom practice. As well, my teacher education students have also undertaken analysis of their teaching approach as a result of discussion on questioning and explaining techniques. My teacher education classes are conducted in school venues and for part of the class time each teacher education student teaches a small group of primary pupils. It has been of interest to me that many of the student teachers have audio-taped part of one of their own teaching sessions, produced a transcript of the lesson and made some analysis of their own communication style with regard to the points raised in discussion concerning appropriate questioning and explaining style. The teacher education students have commented that this process enabled them to be more aware of their approaches to teacher-pupil discussion and to try making change if they thought this was appropriate and possible. Teachers could be readily trained to undertake a similar exercise and use SCAN or a simpler version of SCAN analysis or some other recognised technique.

There are also in existence other techniques for ascertaining teaching style. Although not ultimately used in the analysis sections of this study, each *3Cs* participant had completed a Keirsey Temperament Sorter - a simplified version of the Myers-Briggs Type Indicator (Myers, 1980). This sorter classifies respondents into sixteen different categories based on differences in such affective domains as extraversion/introversion or thinking/feeling. It was interesting to note the 'mainly instrumental' teachers tended to be grouped in one half of the sixteen categories (refer to page E-2 in Appendix E).

Achieving change in mathematics teaching involves more than just the incorporation of new instructional materials and innovative strategies but also includes the consideration of the process that is required for this complex change to take place. Ascertaining, at an individual level, a beliefs and practice profile for participants involved in professional development would be of benefit in achieving this complex change.

Recommendation

The balancing out of a teacher's deep-level and surface-level beliefs and the consequent result this has on their practice is unique. Professional development needs to encourage teachers to explore their own belief system and the impact it has on their classroom practice. It appears quite possible that deep-seated beliefs on the nature of mathematics have the most impact on classroom practice and require the most attention. Such exploration of beliefs and practice could then be used by teachers as goal setting for making change in practice. The nature of professional development programs then needs to support teachers to make this change through the use of content matter and classroom trialling that focuses on the individual nature of this change.

Learning how to learn

Many of the organizational features considered necessary for effective professional development were more suited to those teachers who implemented reflective practice in their classroom approach and in their own learning or professional development.

Cooney (1996) in discussion about teacher professionalism cites points made by Noddings (1992) that 'teachers labour in isolation' and 'lack [the] collegiality necessary for a rich professional life' (page 101). Sullivan (1989-A), in his study on the impact of pre-service teacher education, noted that because of this isolation 'teachers must know how to learn' (page 208).

The *National Statement on Mathematics for Australian Schools* (Australian Education Council, 1990) lists the following principles for effective learning in mathematics:

> Learners construct their own meanings from, and for, the ideas, objects and events which they experience.
>
> Learning happens when existing conceptions are challenged.
>
> Learning requires action and reflection on the part of the learner.
>
> Learning involves taking risks. (Australian Education Council, 1990, page 17)

These learning principles are embodied in a relational approach to classroom practice. They also seem appropriate ones for teacher learning and parallels can be readily made to teacher growth or change in practice. Existing beliefs and practice need to be challenged and this can be achieved through attending workshops or similar forums, classroom trialling and reading of appropriate articles (action) and self evaluative follow-up and discussion with colleagues, mentors or others specialized in the field (reflection). This action and reflection should allow the teacher to construct or give new meaning to their classroom practice. This process involves risk-taking for the teacher (learner).

Relational classroom practice values this process of risk-taking, action, reflection and construction of new meaning and relational teachers have classroom strategies and techniques that encourage such practice for children. This study found that teachers with relational beliefs and practice were more likely than teachers with instrumental beliefs and practice to implement this same process for effective learning for themselves. These teachers are then more likely to appreciate many of the features of effective professional development such as researching new ideas in their classroom and reflecting upon the responses, collegial communication, and having extended time to consider and consolidate new ideas. It is possible that instrumental teachers do not appreciate this approach to effective learning and do not put it into practice as a personal learning strategy. It is possible that there are also other constraints that make change more difficult for instrumental teachers. This study found that one such constraint for instrumental teachers could well be the inability to take risks in classroom practice because of a low self-perception in mathematics confidence or lack of appropriate understanding of the mathematics involved.

Cooney (1996) confirms that there is a connection between learning approaches and the ability to adopt and put into practice classroom innovations. He describes a number of teachers that display varying qualities for personal learning. He could not see that the teacher whose thinking was isolated from the thoughts of others could ever become a reflective learner. Whereas other teachers connected their thoughts about their practice to the context in which it took place even though they may not have resolved the conflicts that resulted with their current beliefs on the nature of mathematics teaching or beliefs on mathematics. Cooney (1996) refers to this as 'naïve connectionism' reserving the term 'reflective connectionism' for the teacher who could make connections and was 'able to take various positions and weave them into a coherent set of beliefs' (page 111).

Do teachers see that most experiences are situations for learning and reflection? During the final interview I asked the following question:

> When I planned this study I only saw *3Cs* as your involvement in professional development. I have come to wonder if the classroom observations and interviews have played any role in your professional growth. What is your opinion?

I had predicted that responses would be mostly 'politically-correct' and be in the affirmative. To my surprise about two-thirds of the participants gave a response where they either mentioned that it made them accountable for what they were doing or that they were only supplying me with the research data that I needed. The following example response exemplifies this: 'I am really giving you what I think so I am not really learning anything here' (from an interview 5). Only four of the participants said that the observations and interviews had encouraged them to think more closely about their classroom practice and beliefs. Three of these four teachers were 'mainly relational'. Instilling the 'process of risk-taking, action, reflection and construction of new meaning' as a normal routine part of any personal experience provides a great challenge to professional development planners and presenters.

One of the features for effective professional development is that teachers like to see that the professional development has advantages for their pupils. In this study this feature was considered by the participants to be of the greatest importance for successful professional development. If teachers can appropriately implement effective learning principles in their classrooms and judge these as appropriate then the professional development planner needs to build in a component into the professional development content or workshop an activity that encourages the participant to realize that these learning approaches are also effective for their own learning. All teachers need to come to understand that action, reflection, risk taking and construction of new meaning are part of their own approach to learning. This study found that all teachers did implement some classroom trialling of the

3Cs activities and were thus capable of taking action that for some also involved risk-taking. But this study has demonstrated that a distinction could be made between the teachers on the way they may have modified the activity as well as the direction their reflection took following the trialling. Teachers need to be encouraged to adopt appropriate reflective processes. Without the ability to meaningfully reflect on experiences new meaning cannot be purposefully constructed in order to result in change in classroom practice.

Cooney & Shealy (1997) support this notion that reflection is pivotal to producing teacher change. They claim that 'the act of reflection is central to any reform process that values teachers as adaptive agents' (page 100). And Goldsmith & Schifter (1997) list the following questions for future research that place the notion of teacher reflection as critical for understanding the process of professional development.

> How do teachers reflect on their classroom experiences in order to make changes? What kinds of resources can influence teachers' process of reflection and subsequent action? (Goldsmith & Schifter, 1997, page 44)

Schon (1987), in his discussion on problems in professional education, shared two personal communications that for me encapsulated the difficulty of achieving appropriate change in classroom practice:

> We know how to teach people how to build ships but not how to figure out what ships to build

and

> We need most to teach students how to make decisions under conditions of uncertainity, but this is just what we don't know how to teach. (Schon, 1987, page 11)

Schon (1987) refers to the notion of 'indeterminate zones of practice' in which outstanding teachers would be said to have more than just professional knowledge but intuition or wisdom in order to deal with classroom situations in an appropriate way (and for this study and mathematics instruction read 'appropriate way' as relational approaches). Schon refers to this as the 'art of teaching' and one of his recommendations is to carefully study the 'performance of unusually competent performers'. Mathematics education research is already on track with this recommendation (Wood, Cobb & Yackel, 1991; Britt, Irwin Ellis & Ritchie, 1993; Sullivan & Mousley, 1993; Jaworski, 1994). Schon's next recommendation is to investigate how people actually acquire 'professional artistry'. One of the key factors for acquiring 'professional artistry' would be the personal use of effective learning approaches. So teachers need to be encouraged to adopt reflective practices. Relational teachers already do this or have personal learning approaches that are close to being reflective. Instrumental teachers, the teachers that provide professional development planners with the greatest challenge, may need assistance or encouragement to become effective 'reflective teachers'. There are possibly many ways in which to achieve this.

Presenters could take on a role that could assist teachers to adopt reflective practice. Workshop discussion following hands-on activities needs to be appropriately probing in order to extend the ideas under discussion. Presenters could facilitate an approach for evaluating classroom trialling that supported the agenda of the professional development.

A professional development presenter could model reflective practice as part of their presentation mode. This could involve giving explanation for their own actions and justifying the organizational features underpinning the structuring of the professional development. The features of effective professional development discussed in this study relate to the organization of professional development but underpinning the reasons for these features being seen as effective and consequently being recommended for appropriate professional growth are effective learning principles. For example, classroom trialling is seen as an effective professional development feature because 'learners construct their own meanings from, and for, the ideas, objects and events which they experience' (Australian Education Council, 1990, page 17). Loughran (1994), in his research into the way in which teachers think about their practice, modelled reflective practice in his undergraduate teaching course. He found that this modelling process enhanced the student teacher's own learning situation.

The teachers in this study had very definite attitudes towards some of the features of effective professional development, either as positive or negative reactions. For example, making connection from the outcomes of the professional development to the advantages it had for pupils was a positive for the participants in this study whereas conducting the professional development over an extended period of time was problematic for most of the teachers. Even though these reactions need to be considered in the context of *3Cs* and the associated research commitments there are several important ideas for professional development planners to consider. Features that are seen as positives by teachers should be strengthened or enhanced at the planning stage. Features that are known to be problematic for teachers need to be purposefully included at the planning stage and appropriately justified to participants. All of the effective features considered in this study have at some stage been found to benefit professional growth. The findings from this study should merely alert professional development planners and presenters to the fact that not all teachers necessarily understand or appreciate the purpose of the underlying organizational structure put in place.

Presenters should discuss with their participants the value of attending professional development as a group, the advantages that can be gained by undertaking the professional development over an extended period of time, and outline the reasons for why classroom trialling of activities is included as part of the professional development. Presenters should connect such discussion with effective learning principles for students as well as promote the notions of 'risk-taking, action, reflection and construction of new meaning' as valuable facets of the teachers' own learning process.

Recommendation

Professional development planners need to build in components or activities that encourage participants to value and make use of effective learning principles as appropriate approaches for their professional growth. Along with presenters, planners need to ensure that the participants have an understanding of the organizational features utilized and that they come to understand the links between effective learning principles and the features for effective professional development.

The need for mentors

The value of classroom trialling of activities that had been presented at the professional development sessions may have been of little value for those teachers whose beliefs and practice were not in line with the agenda set by the professional development.

This study found that some teachers did not undertake classroom trialling according to the agenda set for *3Cs*. Other researchers and writers support this finding: teachers tackling new and innovative practice tend to '*adapt* or *interpret* the proposed innovation to *suit* their practice' (Richards & Clarke, 1996, page 484); 'those conceptions that underlie existing practice can lead to a re-shaping of an innovative program into a form that aligns more comfortably with the status quo and can inadvertently sabotage teacher change' (Herrera, 1996, page 80); and [new materials or strategies are] modified or used by the teacher in ways that preserve little of the intent of those who originally designed the materials or techniques. (Goldsmith & Schifter, 1997, page 26)

It then appears essential that classroom trialling requires some form of mentoring and appropriate follow-up. As well as the need for classroom trialling to match the agenda set for the professional development it is also necessary to monitor the participant's reaction to the trialling and allow for meaningful or appropriate evaluation of the trialling. Mentors could be drawn from a number of people: an in-school colleague, a critical friend from outside the school, or the professional development presenter.

The idea of using mentors in teacher professional development is not new. Of the examples of professional development conducted in Victoria and outlined in Chapter 1, mentors were included in the organizational structure of their respective professional development in different ways. In *Key Group* each group of teachers was provided with a mathematics consultant, included in the *EMIC* presenter's role were school visits in order to assist in some way in participants' classrooms, and the *MIS* facilitator met with staff for planning purposes. A further example of mentoring in the form of coaching (Showers, 1985) is referred to in Chapter 2. One of the most recent examples of professional development in mathematics teaching in Victoria is the professional development aspect of the *Early Numeracy Research Project* (Clarke, 2001). Much of the content and motivation for the teacher meetings and sharing in this project arise from the research into the early numeracy understanding of pupils that is undertaken by the researchers and the participating teachers. The project team point out that from the start a collaborative approach was taken where the participating teachers and researchers struggled together to make sense of the research findings and to develop innovative ideas for teaching. Clarke (2001) reports that:

> This process has proved very powerful in teachers' own professional development. They have increased their knowledge of how children learn mathematics in general, they have a much clearer picture of their own children's understanding, and they have a repertoire of teaching approaches to enhance this understanding. The role of the co-researcher has therefore been a powerful professional development tool. (Clarke, 2001, page 23)

The role of the co-researcher in the *Early Numeracy Research Project* is obviously a very empowering form of mentorship.

From my experiences as an *EMIC* tutor and an *MIS* facilitator 'mentoring assistance' was given at the same level or extent to all participants. The results of this study suggest that some teachers need more assistance in making change. In particular the teachers that have instrumental classroom practice are those most likely to need most assistance and should be given more time with a mentor. This would partly accommodate the first recommendation which notes that teachers need to be treated in an individual way. The extent or level of mentor assistance could be gauged by obtaining a teacher's beliefs and practice profile.

Mentoring assistance could include many facets. Part of the role would be monitoring classroom trialling and assisting the teacher with evaluation of the trialling. Another part of the role would be assisting the teacher to value and adopt personal effective learning principles such as risk-taking and meaningful reflective practice.

Recommendation

Classroom trialling and its interpretation needs to be monitored in some way. This is especially so for those teachers who have beliefs and classroom practice that run counter to the agenda for the professional development. Mentors could be an appropriate solution. Mentors could also assist with encouraging participants to value and make use of effective learning principles as appropriate approaches for their professional growth.

Ensuring that classroom trialling takes place in an appropriate way

Attending the professional development course as a group of teachers from the one school was certainly advantageous in the extent of classroom trialling and possibly to some extent in the gains, in terms of professional growth, resulting from this trialling.

In this study classroom trialling of the *3Cs* activities and ideas did create rich experiences. When trialling did occur it certainly encouraged collegial discussion at the school level in both formal and informal situations. The experiences of trialling were also shared at the *3Cs* workshops which in some cases led to further trialling by other participants. In some instances the *3Cs* presenter had trialling experiences to share with the participants and this certainly enriched the presentation and made her more credible in the eyes of the participants.

Cooney & Shealy (1997) noted that new knowledge is constructed from the evidence resulting from actual experiences and Schon (1987) discusses the need for a 'reflective practicum.

> Perhaps learning *all* forms of professional artistry depends [on the] ..... freedom to learn by doing in a setting relatively low in risk, with access to coaches who initiate students into "traditions of the calling" and help them, by "the right kind of telling", to see on their own behalf and in their own way what they need most to see. We ought, then, to study the experience of learning by doing and the artistry of good coaching. (Schon, 1987, page 17)

The 'actual experiences' noted by Cooney & Shealy could be achieved through the workshopping of classroom activities and by classroom trialling. Schon's comment suggests that the richest experience will probably occur in the classroom and be enhanced with the use of mentors. Using mentors has already been discussed in the previous section.

Recommendation

Classroom trialling is a crucial component for teacher growth and should be included in a meaningful way in professional development. Classroom trialling can be enriched if a group of colleagues undertakes the professional development.

FURTHER PERSONAL REFLECTIONS AND FUTURE DIRECTIONS FOR FURTHER RESEARCH

The professional development context for this study was based on the short course model (Owen, Johnson, Clarke, Lovitt & Morony, 1988) because of the recommendation made by SCTP (1996), the possibility of including many of the features considered as effective for professional development, the familiarity that primary teachers in Victoria would have with this model, and the time that the author and the professional development presenter could allocate to the study. The choice of the short course model places a limitation on the findings for this study by focusing my attention and possibly that of the participants on to specific features of effective professional development. As well, except for one school group the *3Cs: Chance, Constructivism & Collaboration (3Cs)* participants self-selected themselves to undertake the program and the implication from this is that they were already interested in mathematics teaching and felt reasonably confident in their mathematics ability. This places a further limitation on the outcomes from this study.

It would be of interest to test out the ideas and findings in other professional development situations: different professional development models and/or with participants that are not self-selected. For example, as mentioned in Chapter 1 I have been involved in various professional development formats or models. *Maths in Schools (MIS)* (refer to Chapter 1, page 5 for a brief description of this professional development program) for me, was the more empowering for its participants. What was it about *MIS* that made it empowering? How did *MIS* and *3Cs* differ in their use of features of effective professional development? *MIS* had many of the same organizational features as *3Cs* – a group of teachers from a school, conducted over an extended period of time (in fact a full year), and in most cases classroom trialling of activities. What was the difference? One of the major differences was that the teachers involved in *MIS* had ownership over the direction that the professional development took and they were spending time on a task that was an issue for them. How could the notion of teacher ownership be made more a part the short course model of professional development activity? And if this could be achieved would it change the situation for the participants? Would the teachers be more likely to maintain a high level of classroom trialling throughout the length of the course? Would they find the extended time as problematic?

The notion of teacher ownership must have also been an issue for Clarke (2001) with the *Early Numeracy Research Project* as he states:

> In considering the various features of the ENRP, we believe that all these key features have been met [features refers to the listing by (Clarke, 1994) in Chapter 2, page 42]. Although the project teachers were not part of the design process originally, every endeavour has been made to accommodate their input along the way. (Clarke, 2001, page 23)

Self- selection or choosing to undertake something to a certain extent generates a feeling of ownership. The one school group where it appeared that the school principal had applied pressure for the teachers to be involved was the school group that did the least classroom trialling and where the participants found the extended time most problematic. How can a school principal appropriately encourage their teachers to be involved in professional development activity without it being viewed as an imposition? How can short course planners and presenters build in techniques that ensure that participants genuinely feel a real sense of ownership of the content and the direction of the professional development?

Another major difference between *MIS* and *3Cs* was that *MIS* was generally conducted with a whole school staff. Did this encourage increased collegial support and sharing? Was the quality of the support and sharing of a higher order? Were some teachers acting as mentors to other teachers? Were relational teachers confirming the practice of other relational teachers? Were instrumental teachers challenging the practice of relational teachers and vice-versa? Did collegial support, sharing, and having practice confirmed or challenged by a critical friend lead to increased reflective practice?

A further major difference between *MIS* and *3Cs* was that 'the expert' was part of the organizing team (facilitator) and not the presenter. Does the use of a presenter give continued credence to practice based on 'receiving' and 'telling'? Is the use of a 'facilitator' more empowering to the teachers involved by allowing freedom for their own decision-making, risk-taking and reflection? Would the decision-making process involved with greater teacher ownership and decision-making over the direction of the professional development activity allow the participants to have a greater appreciation of the organizational features put in place and value the reasons supporting these features as effective learning principles?

Would the answers to the above questions go some way to considering the motivational factors referred to by Goldsmith & Schifter (1997). They see motivational factors on learning as an often over-looked aspect of promoting change in practice. They claim that initial motivation is highly important and that professional development providers need 'to know how to encourage teachers to find a compelling reason to undertake the task of transforming their practice' and to understand 'what keeps teachers motivated to work on their teaching' particularly through those frustrating and uncomfortable periods of change (Goldsmith & Schifter, 1997, page 46). The empowerment or motivation resulting from *MIS* could well relate to features of teacher ownership, working on a task made relevant and very real to the teachers, effective teacher collaboration and/or 'the expert' being part of the team. Features such as these are only structural or organizational. Professional development planners and researchers in the field need to look beyond structure and organization and investigate the principles of effective learning that underpin these organizational features in order to gain a greater understanding of the connections between structural features, effective principles of learning, and such personal traits as motivation and empowerment.

This study has involved a large number of participants even though only four teachers were studied in depth. It would now be appropriate using the knowledge gained from this study to select a particular teacher type and undertake a longitudinal study of how they were able to manage change in their classroom. Goldsmith & Schifter (1997) lend support to such a longitudinal approach by noting that:

> Research directed toward mapping the issues teachers confront as they enact their new beliefs and understandings in the classroom will help to create a fuller picture of how teachers move through the terrain of creating a reformed mathematics practice. (Goldsmith & Schifter, 1997, page 38)

Useful insights could be gained from research into both a 'mainly relational' and 'mainly instrumental' teacher. In-depth study of a relational teacher would give information on Schon's notion of acquiring 'professional artistry' whereas in-depth study of an instrumental teacher would provide valuable information on the constraints impeding change and the taking up of innovative ideas.

This study has resulted in a number of worthwhile outcomes and raised further issues for consideration. Research into teacher professional development needs to continue to explore teacher beliefs and what is needed for teachers to change their beliefs. Continuing research into how the features of effective professional development connect with how meaningful reflection can be acquired is critical in the quest for understanding the process of teacher change.

THE TEACHERS HAVE THE FINAL SAY

The *3Cs* participants have made comments that support the recommendations made in this chapter. Their comments indicate that their approach to professional development and the resulting outcomes are quite individual. Their comments support the notion of the significance of attending professional development with close colleagues and of trialling activities in their classrooms. Their comments support the notions that professional development is a process in which the teacher participant needs to be reflective.

> I think that it is important that you have more than one teacher from a school because you then have that day-to-day, "How did it go", rather than wait for the next session. And I think it is doing the activity between sessions and coming back with questions. "OK, this works well." "Why didn't it work with my kids?" Things like that. (Karen, Interview 5)

> Doing activities [in the workshops] that the kids are going to do. We are actually experiencing so we are putting ourselves in place of the pupils and we actually seeing how they are going to react to the different situations. (Gerry, Interview 5)

> Well (after having completed *3Cs*) I feel that I am more equipped to teach Chance and Data and I probably know more of what to look for when ..... I'm not just giving an activity I am looking at the way [the children] are doing the activity, whereas I don't think I was doing that before. (Olivia, Interview 5)

> If you try to ask a question and [the PD presenter] says we've talked about that or ..... that sort of approach where they are not interested in what you have to say but only what they have to get across. Being attuned to the audience's needs. (Helen, Interview 5)

> [The purpose of PD is] to introduce us to new things, to trial them and give us confidence to give it a go, but also a reflection time. Sometimes it just reaffirms what you are already doing. It is just even interesting to listen to what teachers from other schools are doing and sometimes I think, "That is a good idea, oh I hadn't thought of that, I could try that". (Neva, Interview 5)

> [The *3Cs* presenter] always asked you what you thought rather than giving you the answer. It was always sort of go back and question you own thinking. (Teresa, Interview 5)

> [A PD presenter] needs to be a good communicator, evaluate the participants, gain their opinions. That's a hard question. I don't know. It is very individual. (Megan, interview 5)

> I probably didn't focus on what [the pupils] were getting out of it than what I probably am now. ..... Those things might have happened before but I don't think I was equipped to focus on it as much as what I am now. I think that is where the PD has helped a lot. (Malcolm, Interview 4)

And the final word:

> Just one. What! They're all important. (Nora, Interview 5, her response when asked to select the most important feature for professional development from the list of eight features presented to her)

References

Ahlstrand, E. (1994). Professional isolation and imposed collaboration in teachers' work. In I. Carlgren, G. Handel, & S. Vaage (Eds.), *Teachers' minds and actions: Research on teachers' thinking and practice* (pp. 260-271). London: The Falmer Press.

Alexopoulos, N. (1986). The key group project. In N. F. Ellerton (Ed.), *Mathematics: Who needs what?* (Proceedings of the 23rd annual conference of the Mathematics Association of Victoria, pp. 94-96). Melbourne: MAV.

Aronson, E., Blaney, N. Stephan, C. Sikes, J., & Snapp, M. (1978). *The jigsaw classroom*. Beverley Hills, California: Sage.

Australian Education Council (1990). *A national statement on mathematics for Australian schools.* Carlton, Victoria: Curriculum Corporation.

Azcerate, P., & Cardefioso, J. M. (1994). *The notion of randomness in future primary school teachers.* Paper presented at the Fourth International Conference on Teaching Statistics (ICOTS 4), Marrakech, Morocco.

Baird, J. R. (1991). Individual and group reflection as a basis for teacher development. In P. Hughes (Ed.), *Teachers' Professional Development* (pp. 95-113). Melbourne: Australian Council for Educational Research.

Baroody, A. (1987). *Children's mathematical thinking.* New York: Teachers College Press.

Beeby, T., Burkhardt, H., & Fraser, R. (1980). *Systematic classroom analysis notation.* University of Nottingham: Shell Centre for Mathematical Education.

Behounek, K. J., Rosenbaum, L.J., Brown, L., & Burcalow, J.V. (1988). Our class has twenty-five teachers. *Arithmetic Teacher, 36*(4), 10-13.

Bellingham, J. (1994). Problem solving for preps, grade one and two: A focus on co-operative groups. In C. Beesey, & D. Rasmussen (Eds.), *Mathematics without limits* (Proceedings of the 31st annual conference of the Mathematical Association of Victoria, pp. 389-393). Melbourne: MAV.

Bishop, A. J., & Goffree, F. (1986). Classroom organisation and dynamics. In B. Christiansen, A.G. Howson, & M. Otte (Eds.), *Perspectives on mathematics education* (pp. 309-365). Dortrect, Netherlands: D. Reidel Publishing Company.

Board of Studies (1995). *Curriculum and standards framework: Mathematics.* Carlton, Victoria: Board of Studies.

Borovcnik, M., & Peard, R. (1996). Probability. In A. J. Bishop, K. Clements, C. Keitel, J. Kilpatrick, & C. Laborde (Eds.), *International Handbook of Mathematics Education* (pp. 239-287). Netherlands: Kluwer Academic Publishers.

Britt, M. S., Irwin, K.C., Ellis, J.A., & Ritchie, G. (1993). Changing mathematics teaching: The case of Christine Brown. In B. Atweh, C. Kanes, M. Carss, & G. Booker (Eds.), *Contexts in mathematics education* (Proceedings of the 16th Annual Conference of the Mathematics Education Research Group of Australasia, pp. 135-139). Brisbane: MERGA.

Burns, M. (1990). The maths solution: Using groups of four. In N. Davidson (Ed.), *Cooperative learning in mathematics: A handbook for teachers* (pp. 21-46). Menlo Park, California: Addison Wesley.

Callingham, R. A., Watson, J. M., Collis, K. F., & Moritz, J. B. (1995). Teacher attitudes towards chance and data. In B. Atweh, & S. Flavel (Eds.), *Galtha* (Proceedings of the 18th annual conference of the Mathematics Education Research Group of Australasia, pp. 143-150). Darwin: MERGA.

Chambers, D. L. Hankes, J. E. (1994). Using knowledge of children's thinking to change teaching. In D. B. Aichele (Ed.), *Professional development for teachers of mathematics* (286-295). Reston, Virginia: National Council of Teachers of Mathematics.

Clarke, B. A. (1995-A). *Expecting the unexpected: Critical incidents in the mathematics classroom.* Unpublished doctoral thesis, University of Wisconsin, Madison.

Clarke, D. M. (1993-A). *Influences on the changing role of the mathematics teacher.* Unpublished Ph.D thesis, University of Wisconsin, Madison.

Clarke, D. (1993-B). Influences on the changing role of the mathematics teacher. In B. Arweh, C. Kanes, M. Carss, & G. Booker (Eds), *Contexts in mathematics education.* (Proceedings of the 16th annual conference of the Mathematics Education Research Group of Australasia, pp. 183-189). Brisbane: MERGA.

Clarke, D. (1994). Ten key principles from research for the professional development of mathematics teachers. In D. B. Aichele (Ed.), *Professional development for teachers of mathematics: 1994 yearbook* (pp. 37-48). Reston, Virginia: National Council of Teachers of Mathematics.

Clarke, D. (1995-B). Changing teacher roles: A case study. In B. Atweh, & S. Flavel (Eds,), *Galtha* (Proceedings of the 18th annual conference of the Mathematics Education Research Group of Australasia, pp. 178-183). Darwin: MERGA.

Clarke, D. (2001). Understanding, assessing and developing young children's mathematical thinking: Research as a powerful tool for professional growth. In J. Bobis, B. Perry, & M. Mitchelmore (Eds.), *Numeracy and beyond* (Proceedings of the 24th annual conference of the Mathematics Education Research Group of Australasia, Volume 1, pp. 9-26). Sydney: MERGA.

Coats, J., Ogilvie, P. & Stickland, R. (1989). *I'm not alone: Cooperative learning and ESL students in the mainstream classroom.* Melbourne, Victoria: Ministry of Education.

Cobb, P. (1986). Making mathematics: Children's learning and the constructivist tradition. *Harvard Educational Review, 56*(3), 301-306.

Cobb, P. (1994). A summary of four case studies of mathematical learning and small-group interaction. In J. P. da Porte, & J. F. Matos, (Eds.), *Proceedings of the 18th Conference of the International Group for the Psychology of Mathematics Education (Vol. 2)* (pp. 201-208). University of Lisbon, Portugal: International Group for the Psychology of Mathematics Education.

Cobb, P., Wood, T., & Yackel, E. (1991). A constructivist approach to second grade mathematics. In E. von Glasersfeld (Ed.), *Radical constructivism in mathematics education* (pp. 157-176). Dordrecht, Netherlands: Kluwer Academic Publishers.

Cockcroft, W. H. (1982). *Mathematics counts.* London: Her Majesty's Stationery Office.

Comiti, C., & Ball, D. L. (1996). Preparing teachers to teach mathematics: A comparative perspective. In A. J. Bishop, K. Clements, C. Keitel, J. Kilpatrick, & C. Laborde (Eds.), *International handbook on mathematics education, Volume 2* (pp. 1123-1153). Dordrecht: Kluwer Academic Publishers.

Conners, B. (1991). Teacher development and the teacher. In P. Hughes (Ed.), *Teachers' professional development* (pp. 53-81). Melbourne: Australian Council for Educational Research.

Consultancy Development Unit (1995). *Maths making links.* Melbourne: Deakin University.

Cooney, T. J. (1996). Conceptualizing the professional development of teachers. In C. Alsina, J.M. Alvarez, B. Hodgson, C. Laborde, & A. Perez (Eds.), *8th International Congress on Mathematical Education: Selected lectures* (pp. 101-117). Sevillia, Spain: S.A.E.M. 'Thales'.

Cooney, T. J., & Shealy, B.E. (1997). On understanding the structure of teachers' beliefs and their relationship to change. In E. Fennema, & B. S. Nelson (Eds.), *Mathematics teachers in transition* (pp. 87-109). New Jersey: Lawerence Erlbaum Associates.

Costello, R. (1991). Government policy for the future development of teachers. In P. Hughes (Ed.), *Teachers' professional development* (pp. 129-146). Melbourne: Australian Council for Educational Research.

Dalton, J. (1985). *Adventures in thinking: Creative thinking and cooperative talk in small groups.* Melbourne: Nelson.

Davidson, N. (1990-A). Small-group cooperative learning in mathematics. In T. J. Cooney, & C. R. Hirsch (Eds.), *Teaching and learning mathematics in the 1990's* (pp. 52-61). Reston Virginia: NCTM.

Davidson, N. (1990-B). Introduction and overview. In N. Davidson. (Ed.), *Cooperative learning in mathematics: A handbook for teachers* (pp. 1-20). Menlo Park, California: Addison Wesley.

Davidson, N., & Kroll, D.L. (1991). An overview of research on cooperative learning related to mathematics. *Journal for Research in Mathematics Education, 22*(5), 362-365.

Davis, R. B., Maher, C.A., & Noddings, N. (1990). Suggestions for the improvement of mathematics education. In R. B. Davis, C. Maher, & N. Noddings (Eds.), *Constructivist views on the teaching and learning of mathematics* (pp. 187-191). Reston, Virginia: NCTM.

Dees, R. L. (1991). The role of cooperative learning in increasing problem-solving ability in a college-remedial course. *Journal for Research in Mathematics Education, 22*(5), 409-421.

Directorate of School Education (1995). *Mathematics Course Advice levels 1-4.* Melbourne: DSE

Directorate of School Education (1995). *Teacher personal professional development planning: Implementation guide.* Melbourne: DSE.

Doyle, W., & Ponder, G.A. (1977-78). The practicality ethic in teacher decision-making. *Interchange, 8*(3), 1-12.

Edwards, R. (1996). Teaching statistics: Teacher knowledge and confidence. In P. C. Clarkson (Ed.), *Technology in education* (Proceedings of the 19th annual conference of the Mathematics Education Research Group of Australasia, pp. 178-185). Melbourne: MERGA.

Ellerton, N. F., & Clements, M. A. (1989). Foreword. In N. F. Ellerton, & M. A. Clements (Ed.), *School mathematics: The challenge to change* (pp. vii-viii). Geelong, Victoria: Deakin University.

Erickson, F. (1986). Qualitative methods in research on teaching. In M. C. Wittrock (Ed.), *The third handbook of research on teaching* (pp. 119-161). New York: Macmillan.

Erickson, T. (1989). *Get it together: Math problems for groups, grades 4-12.* California: EQUALS.

Ernest, P. (1989). The impact of beliefs on the teaching of mathematics. In P. Ernest (Ed.), *Mathematics teaching: The state of the art.* (pp. 249-254). London: Falmer Press.

Etchberger, M. L., & Shaw K.L. (1992). Teacher change as a progression of transitional images: A chronology of a developing constructivist teacher. *School Science and Mathematics, 92*(8), 411-417.

Even, E., Tirosh, D., & Markovits, Z. (1996). Teacher subject matter knowledge and pedagogical content knowledge: Research and development. In L. Puig, & A. Gutierrez (Eds.). *Proceedings of the 20th Conference of the International Group for the Psychology of Mathematics Education (Volume 1)* (pp. 119-134). Valencia, Spain: International Group for the Psychology of Mathematics Education.

Fennema, E., & Franke, M. L. (1992). Teachers' knowledge and its impact. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning.* (pp. 147-164). New York: MacMillan.

Ferguson, S., & Montgomery, P. (1994). Maths in schools. In C. Beesey, & D. Rasmussen (Eds.), *Mathematics without limits* (Proceedings of the 31st annual conference of the Mathematical Association of Victoria, pp. 41-44). Melbourne: MAV.

Fullan, M. G. (1995). The limits and the potential of professional development. In T. R. Guskey, & M. Huberman (Eds.) *Professional development in education: New paradigms and practices* (pp. 253-267). New York: Teachers College Press.

Gervasoni, A. (1995). *Student and teacher beliefs about helpful teaching practices in mathematics instruction.* Paper presented at the 18th annual conference of the Mathematics Education Research Group of Australasia, Northern Territory University, Darwin.

Goldsmith, L. T., & Schifter, D. (1997). Understanding teachers in transition: Characteristics of a model for the development on mathematics teaching. In E. Fennema, & B. S. Nelson (Eds.), *Mathematics teachers in transition* (pp. 19-54). New Jersey: Lawerence Erlbaum Associates.

Good, T. (1990). *Small-group instruction in mathematics: Naturalistic research in teaching and learning.* (Technical Report #493). Columbia: Centre for Research in Social Behaviour, University of Missouri.

Good, T. L., Grouws, D.A., & Mason, D.A. (1990). Teachers' beliefs about small-group instruction in elementary school mathematics. *Journal for Research in Mathematics Education, 21*(1), 2-15.

Good, T. L., McCaslin, M.M., & Reys, B.J. (1992). Investigating work groups to promote problem solving in mathematics. In J. Brophy (Ed.), *Advances in research on teaching* (pp. 115-160.). Greenwich, CT: JAI Press.

Gooding, A., & Stacey, K. (1993). Characteristics of small group discussion reducing misconceptions. *Mathematics Education Research Journal, 96*(1), 60-73.

Gould, P. (1993). *Cooperative problem solving in mathematics: Grades 5-8.* Sydney: Mathematical Association of New South Wales.

Graham, J. (1995-A). School change management strategies. *The AEU News, 1*(2), page 12.

Graham, J. (1995-B). Teacher appraisal: Lessons from the field. *The AEU News, 1*(3), page 5.

Green, T. (1971). *The activities of teaching.* New York: McGraw-Hill.

Greer, B., & Ritson, R. (1994). *Readiness of teachers in Northern Ireland to teach data handling.* Paper presented at the Fourth International Conference on Teaching Statistics (ICOTS 4), Marrakech, Morocco.

Guskey, T. R. (1985). Staff development and teacher change. *Educational Leadership 42*(7), 57-60.

Guskey, T. R. (1986). Staff development and the process of teacher change. *Educational Researcher 15*(5), 5-13.

Guskey, T. R. (1995). Professional development in education: In search of the optimal mix. In T. R. Guskey, & M. Huberman (Eds.), *Professional development in education: New paradigms and practices* (pp. 114-131). New York: Teachers College Press.

Herrera, T. A. (1996). The role of the prior conceptions in teachers' responses to staff development: A synopsis of case studies of three middle school mathematics teachers. In L. Puig, & A. Gutierrez (Eds.), *Proceedings of the 20th conference of the International Group for the Psychology of Mathematics Education (Volume 3)* (pp. 75-80). Valencia, Spain: International Group for the Psychology of Mathematics Education.

Herrington, T., Sparrow, L., & Swan, P. (1995). Professional development: Whose problem is it anyway? In B. Atweh, & S. Flavel (Eds.), *Galtha* (Proceedings of the 18th Annual Conference of the Mathematics Education Research Group of Australasia, pp. 338-344). Darwin: MERGA.

Hill, L. M. (1994). *Promoting self-control of learning of pre-service primary teachers.* Unpublished doctoral thesis, Monash University, Melbourne, Victoria.

Hollingsworth, H. (1996). Change trajectories in teacher professional growth. In P. C. Clarkson (Ed.), *Technology in Mathematics Education* (Proceedings of the 19th annual conference of the Mathematics Education Research Group of Australasia, pp. 290-297). Melbourne: MERGA.

Jaworski, B. (1989). Mathematics teaching: Belief and practice. In P. Ernest (Ed.), *Mathematics teaching: The state of the art* (pp. 167-174). London: Falmer Press.

Jaworski, B. (1994). Investigating mathematics teaching: A constructivist enquiry. London: The Falmer Press.

Johnson, D. W., & Johnson, R.T. (1987). Research shows the benefit of adult cooperation. *Educational Leadership, 45*(3), 27-30.

Johnson, D. W., & Johnson, R.T. (1989). Cooperative learning in mathematics education. In P. R. Trafton, & A. P. Shulte (Eds.), *New directions for elementary school mathematics* (pp. 234-245). Reston, Virginia: NCTM.

Johnson, D. W., & Johnson, R.T. (1989-90). Social skills for successful group work. *Educational Leadership, 47*(4), 29-33.

Johnson, D. W., & Johnson, R.T. (1990). Using cooperative learning in math. In N. Davidson (Ed.), *Cooperative learning in mathematics: A handbook for teachers* (pp. 103-125). Menlo Park, California: Addison Wesley.

Jones, G. A., Langril, C. W., Thorton, C. A., & Mogill, A. T. (1997). A framework for assessing and nurturing young children's thinking in probability. *Educational Studies in Mathematics, 32*, 101-125.

Joyce, B., & McKibbin, M. (1982). Teacher growth states and school environments. *Educational Leadership, 40*(2), 36-41.

Kahneman, D. T., & Tversky,A. (1972). Subjective probability: A judgement of representativeness. *Cognitive Psychology, 3*, 430-454.

Kahneman, D. T.,& Tversky, A. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive Psychology, 5*, 207-232.

Konold, C. (1991). Understanding students' beliefs about probability. In E. von Glasersfeld (Ed.), *Radical constructivism in mathematics education* (pp. 139-156). Netherlands: Kluwer Academic Publishers.

Labinowicz, E. (1985). *Learning from children: New beginnings for teaching numerical thinking*. Menlo Park, California: Addison-Wesley Publishing Company.

Lappan, G. (1999). Looking back and looking forward: What have we learned and where are we going? In K. Baldwin, & J. Roberts (Eds.), *Mathematics: The next millennium* (Proceedings of the 17th biennial conference of the Australian Association of Mathematics Teachers, pp. 4-16). Adelaide: AAMT.

Lappan, G., & Theule-Lubienski, S. (1992). Training teachers or educating professionals? What are the issues and how are they being resolved? In D. F. Robitaille, D.H. Wheeler, & C. Kieran (Eds.), *Selected lectures from the 7th International Congress on Mathematics Education* (pp. 249-261). Quebec: International Congress on Mathematical Education.

Leder, G. (1989). Teachers as agents of change in mathematics education: Introduction. In N. F. Ellerton, & M.A. Clements (Eds.), *School mathematics: The challenge to change* (pp. 217-219). Geelong: Deakin University.

Leithwood, K., & Montgomery, D. (1982). The role of the elementary school principal in program improvement. *Review of Educational Research, 52*, 309-339.

Lerman, S. (1983). Problem-solving or knowledge-centred: the influence of philosophy on mathematics teaching. *International Journal of Mathematical Education in Science and Technology, 14*(1), 59-66.

Lieberman, A. (1986). Collaborative work. *Educational Leadership, 43*(5), 4-8.

Loughran, J. J. (1994). *Developing reflection in pre-service education students: Learning through modelling of teaching and learning.* Unpublished doctoral thesis, Monash University, Melbourne.

Lovitt, C., & Clarke, D. (1988). *MCTP professional development package: Activity bank.* Canberra: Curriculum Development Centre.

Malone, J., & Ireland, D. (1996). Constructivist research on teaching and learning mathematics. In B. Atweh, K. Owens, & P. Sullivan (Eds.), *Research in mathematics education in Australasia 1992-1995* (pp. 119-134). Sydney: Mathematics Education Research Group of Australasia.

Mason, D. A., Reys, B. J., & Good, T. L. (1990). *Three models of active teaching and learning in mathematics using work groups* (Technical Report #490). Columbia: University of Missouri.

Merriam, S. B. (1988). *Case study research in education: A qualitative approach.* San Francisco, CA: Jossey-Bass.

Ministry of Education, Victoria (1988). *The mathematics framework P-10: A forward look.* Melbourne: Ministry of Education, Victoria.

Ministry of Education, Victoria (1989). *Exploring mathematics in classrooms - Tutor's manual.* Melbourne: Ministry of Education, Victoria.

Montgomery, P. (1995-A). *Maths in schools: A journey in professional development - Volume 1 - Resource manual.* Melbourne: Mathematical Association of Victoria.

Montgomery, P. (1995-B). *Maths in schools: A journey in professional development - Volume 2 - Case studies.* Melbourne: Mathematical Association of Victoria.

Munday, C., Hoey, G., Gringhuis, H., Sullivan, J., & Smith, R. (1995). Yawarra Primary. In P. Montgomery (Ed.), *Maths in Schools: A journey in professional development Volume 2 Case Studies* (pp. 44-51). Melbourne: Mathematical Association of Victoria.

Myers, I. B. (1980). *Introduction to type*. Palo Alto, CA: Consulting Psychologists Press Inc.

NCTM (1980). *An agenda for action*. Reston, VA: National Council of Teachers of Mathematics.

Owen, J., Johnson, N., Clarke, D., Lovitt, C., & Morony, W. (1988). *The mathematics curriculum and teaching program: Guidelines for consultants and curriculum leaders*. Canberra: Curriculum Development Centre.

Perry, B., Howard P., & Conroy, J. (1996). K-6 teacher beliefs about the learning and teaching of mathematics. In P. C. Clarkson (Ed.), *Technology in mathematics education* (Proceedings of the 19th annual conference of the Mathematics Education Research Group of Australasia, pp. 453-460). Melbourne: MERGA.

Peter, A. (1995). Teacher professional growth processes and some of their influencing factors, in L. Meira, & D. Carraher (Eds.), *Proceedings of the 19th conference of the International Group of the Psychology of Mathematics Education, Volume 3*, pp. 320-327). Recife, Brazil: International Group of the Psychology of Mathematics Education.

Peterson, S. (1995-A). You have to think your way through: Speaking from school. *Prime Number, 10*(2), 9-10.

Peterson, S. (1995-B). If the in is separate from the out then it's a tunnel: Speaking from school. *Prime Number, 10*(1), 10-12.

Philipp, R., Sowder, J., & Flores, A. (1992). The act of teaching mathematics: A case study. In W. Geeslin, & K. Graham (Eds.), *Proceedings of the 16th Psychology of Mathematics Education Conference (Volume 3)*, pp. 27-34). University of New Hampshire, Durham, USA: International Group for the Psychology of Mathematics Education.

Prawat, R. S. (1992). Teachers' beliefs about teaching and learning: A constructivist perspective. *American Journal of Education, May*, 354-395.

Qualitative Solutions & Research (1995). *Workshop manual for Q.S.R. NUD•IST qualitative data analysis software.* Melbourne: QSR Pty Ltd.

Raymond, A. M. (1997). Inconsistency between a beginning elementary school teacher's mathematics beliefs and teaching practice. *Journal for Research in Mathematics Education, 28*(5), 550-576.

Reid, J., Forrestal, P., & Cook, J. (1989). *Small group learning in the classroom.* Scarborough, W.A: Primary English Teaching Association.

Rice, M. (1991). *Key group: A case study in the professional development of primary mathematics teachers.* Paper presented at the Annual Conference of the Australian Association for Research in Education, Gold Coast, Queensland.

Richards, M., & Clarke, D. (1996). Goal transformation in professional development programs. In P. C. Clarkson (Ed.), *Technology in mathematics education* (Proceedings of the 19th annual conference of the Mathematics Education Research Group of Australasia, pp. 477-485). Melbourne: MERGA.

Robinson, I. (1987). Exploring mathematics in classrooms (EMIC). In W. B. Caughey (Ed.), *From Now to the Future* (Proceedings of the 24th annual conference of the Mathematical Association of Victoria, pp. 13-19). Melbourne: MAV.

Schon, D. A. (1987). *Educating the reflective practioner: Toward a new design for teaching and learning in the professions.* San Francisco, California: Jossey-Bass Inc.

Schuck, S. (1995). Forging links and breaking chains in primary teacher education: Negotiating powerful ideas. In B. Atweh, S. Flavel (Eds.), *Galtha* (Proceedings of the 18th annual conference of the Mathematics Education Research Group of Australasia, pp. 465-470). Darwin: MERGA.

SCTP (1996). *Teacher professional development.* Melbourne: Standards Council of the Teaching Profession, Victoria.

Senger, E. S. (1999). Reflective reform in mathematics: The recursive nature of teacher change. *Educational Studies in Mathematics, 37*, 199-221.

Shaughnessy, M. (1992). Research in probability and statistics: Reflections and directions. In D. A. Grouws (Ed.), *Handbook of research on teaching and learning mathematics* (pp. 465-494). Reston: NCTM.

Shaughnessy, J. M. (1996). Emerging research issues in the teaching and learning of probability and statistics. In B. Phillips (Ed.), *Papers on statistical education presented at ICME-8* (pp. 39-48). Melbourne: International Association for Statistical Education.

Showers, B. (1984). *Peer coaching: A strategy for facilitating transfer of training.* Oregon: University of Oregon.

Showers, B. (1985). Teachers coaching teachers. *Educational Leadership, 42*(7), 43-48.

Skemp, R. R. (1976). Relational understanding and instrumental understanding. *Mathematics Teaching, 77*(Dec), 20-26.

Skemp, R. R. (1992). Bringing theory into the classroom: The school as a learning environment for teachers. In B. Southwell, B. Perry, & K. Owens (Eds.), *Space - The first and final frontier* (Proceedings of the 15th annual conference of the Mathematics Education Research Group of Australasia, pp. 44-54). Sydney: MERGA.

Slavin, E. (1982). *Cooperative learning: Student teams.* Washington, D.C.: National Education Association of the United States.

Slavin, E. (1990). Research on cooperative learning: Consensus and controversy. *Educational Leadership, 47*(4), 52-54.

Smith, R. (1990). *Mathematics and role play.* Unpublished Masters project, Monash University, Clayton, Victoria.

Smith, R. (1994). Encouraging working and talking together: Giving clues. In C. Beesey, & D. Rasmussen (Eds.), *Mathematics without limits* (Proceedings of the 31st annual conference of the Mathematical Association of Victoria, pp. 438-441). Melbourne: MAV.

Smith, R. (1995). Promoting mathematics interaction. In A. Richards (Ed.), *FLAIR: Forging links and integrating resources* (Proceedings of the 15th biennial conference of the Australian Association of Mathematics Teachers, pp. 330-336). Darwin: AAMT.

Smith, R. (1997). Classroom research: Reporting teachers' stories. In V. Zack, J. Mousley, & C. Breen (Eds.), *Developing pratice: Teachers' inquiry and educational change*, pp. 63-73). Geelong, Victoria:, Centre for Studies in Mathematics, Science and Environmental Education, Deakin University.

Smith, R. (1998). *Using a classroom observation schedule: A researcher's story.* Paper presented at the Contemporary Approaches to Research in Mathematics, Science and Environmental Education Symposium, November, Deakin University, Burwood, Victoria.

Smith, R. (2000-A). *The impact of attending professional development as a group of teachers.* Paper presented at the 24th Conference of the International Group for the Psychology of Mathematics Education, Hiroshima, Japan.

Smith, R. (2000-B). *Catering for individual differences: Teacher professional development.* Paper presented at the 9th International Congress for Mathematics Education, Tokyo, Japan.

Smith, R. (2000-C). *Connecting teacher beliefs and features of effective professional development: Reactions to professional development conducted over an extended period of time.* Paper presented at the 9th International Congress for Mathematics Education, Tokyo, Japan.

Smith, R., & Beeby, T. (1992/93). *Report: Professional development program for improving primary teachers' competence with mathematics, science and technology teaching* (Unpublished). Melbourne: Deakin University.

Southwell, B. (1995). Towards a theoretical framework for research in beliefs and values in mathematics education. In B. Atweh, & S. Flavel (Eds.), *Galtha* (Proceedings of the 18th Annual Conference of the Mathematics Education Research Group of Australasia, pp. 477-483). Darwin: MERGA.

Sparks, D., & Loucks-Horsley, S. (1989). Five models of staff development for teachers. *Journal of Staff Development, 10*(4), 40-57.

Sparks, D., & Loucks-Horsley, S. (1990). Models of staff development. In W. R. Houston (Ed.), *Handbook of research on teacher education* (pp. 234-250). New York: Macmillan & the Association of Teacher Educators.

Stenhouse, L. (1981). *Case study in educational research and evaluation.* Paper presented at the Fallstudien in der Padagogik, Bielefeld, West Germany.

Sullivan, P. A. (1989-A). *An investigation of the impact of pre-service teacher education and other professional support on classroom practices of primary teachers.* Unpublished Ph.D. thesis, Monash University, Melbourne, Victoria.

Sullivan, P. (1989-B). Factors inhibiting change – A case study of a beginning primary teacher. *Mathematics Education Research Journal, 1*(2), 1-16.

Sullivan, P., & Mousley, J. (1993). Describing teaching: Categories from teacher educators' descriptions of quality practice. In B. Atweh, C. Kanes, M. Carss, & G. Booker (Eds.), *Contexts in mathematics education* (Proceedings of the 16th Annual Conference of the Mathematics Education Research Group of Australasia, pp. 523-529). Brisbane: MERGA.

Sullivan, P., Bourke, D., & Scott, A. (1995). Open-ended tasks as stimuli for learning mathematics. In B. Atweh, & S. Flavel (Eds.), *Galtha* (Proceedings of the 18th Annual Conference of the Mathematics Education Research Group of Australasia, pp. 484-492). Darwin: MERGA.

Taylor, R. (1989). The potential of small-group mathematics instruction in grades four through six. *Elementary School Journal, 89*(5), 633-642.

Thompson, A. G. (1984). The relationship of teachers' conceptions of mathematics and mathematics teaching to instructional practice. *Educational Studies in Mathematics, 15*(2), 105-127.

Thompson, A. G. (1992). Teachers' beliefs and conceptions: A synthesis of the research. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 127-146). New York: MacMillan.

Thorton, C. A. (1991). Think, tell, share - Success for students. *Arithmetic Teacher, 38*(6), 22-23.

Truran, K. (1994). *Children's perceptions of their control over the behaviour of random generators.* Paper presented at the Contemporary Approaches to Research in Mathematics, Science and Environmental Education Symposium, Deakin University, November, Burwood Campus, Melbourne.

Tytler, R. (1998). The nature of students' informal science conceptions. *International Journal of Science Education, 20*(8), 901-927.

Tytler, R., Smith, R., Grover, P. & Brown, S. (1996). *A comparison of professional development models for teachers of primary mathematics and science.* Paper presented at the Australian Science Education Research Association Conference, July, Canberra.

von Glasersfeld, E. (1996). Aspects of radical constructivism and its educational recommendations. In L. Steffe, & P. Nesher (Eds.), *Theories of mathematical learning* (pp. 307-314). Mahwah, NJ.: Lawrence Erlbaum.

Weissglass, J. (1994). Changing mathematics teaching means changing ourselves: Implications for professional development. In D. B. Aichele, & A.E. Coxford (Eds.), *Professional development for teachers of mathematics* (pp. 67-78). Reston, VA: NCTM.

Whitford, J. (1988). EMIC and other maths projects. In D. Firth (Ed.), *Maths counts - Who cares* (Proceedings of the 25th annual conference of the Mathematical Association of Victoria, pp. 182-185). Melbourne: MAV.

Wood, T., Cobb, P., & Yackel, E. (1991). Change in teaching mathematics: A case study. *American Educational Research Journal, 28*(3), 587-616.

Yaxley, B. (1991). Teaching, teacher thinking and teacher development. In P. Hughes (Ed.), *Teachers' professional development* (pp. 82-94). Melbourne: Australian Council for Educational Research.

APPENDIX A

3CS: CHANCE, CONSTRUCTIVISM & COLLABORATION

Workshop Leader's Notes

Contents:

SESSION 1

LANGUAGE, COLOURED DICE

AND SIMPLE CHANCE EXPERIMENTS

Activity Number	Page reference	Activity Handout	Workshopped activity (W) and/or Handout (H)	Major focus M/T/C M*
1-1	A-3	Introductions		
1-2	A-4 to 6	Chance language		
	& 14	• Ordering	W/H	M
		• Four words and everyday statements	W	M
		• Four words & a biased die	W	M
		• Acey-Duecy	W/H	M/C
1-3	A-7 to 9	Dice Tracks		
	& 14	• Playing the game	W/H	M
		• Discussion	W	C
		• Mathematics CSF Chance	W/H	M/C
1-4	A-10	Applying number to the continuum	W	M
1-5	A-11,	Think-pair-share - Rolling two yellows	W/H	M*/T
	14-15	(Continued in Session 2)		
1-6	A-12	Lucky die (video)	W/H	M/C
1-7	A-13	Administration		
	A-14	Suggested activities for using coloured dice	H	M

(M-mathematics content; T-teaching strategies content; C-constructivist notions content; M*-mathematics content aimed at extending participant's knowledge)

ACTIVITY 1-1

Introductions

Approximate time: 15 minutes

Materials needed: Overhead transparency for outline of 3C's program (O/H 1.1)

Overhead transparency for session outline (O/H 1.1)

Step One

Teachers and facilitator and researcher introduce each other.

Step Two

Teachers talk about why they have chosen to do this professional development.

Step Three

Facilitator gives overview and intent of professional development. (O/H 1.1) Takes suggestions for other items of 'concern to teachers'.

Step Four

Facilitator outlines session 1 (O/H 1.2)

THREE C's:
CHANCE,
CONSTRUCTIVISM and
COLLABORATION

Over the six sessions:

- Participate in and trial classroom activities in the topic of chance
- Explore children's understanding of chance concepts
- Develop personal chance understanding
- Participate in and trial teaching strategies aimed at promoting pupil discussion and classroom collaboration
- Consider and discuss constructivist approaches to learning

O/H 1.1

SESSION 1:
Language, Coloured Dice and Simple Chance Experiments

- Introductions
- Starting point - working from and developing the children's chance language
- Activities using biased dice
- Using a 'conflict situation' to promote thinking
- Linking number to the language of chance
- Think-pair-share as a strategy to promote collaboration
- Children's thinking on random generators

O/H 1.2

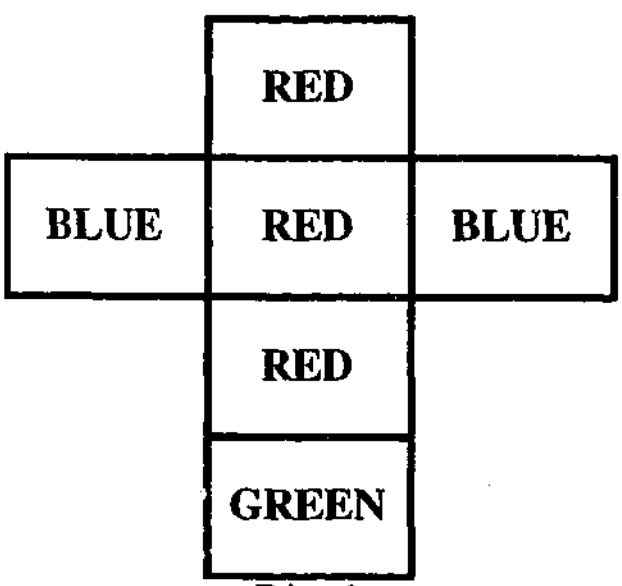
ACTIVITY 1-2

Chance Language

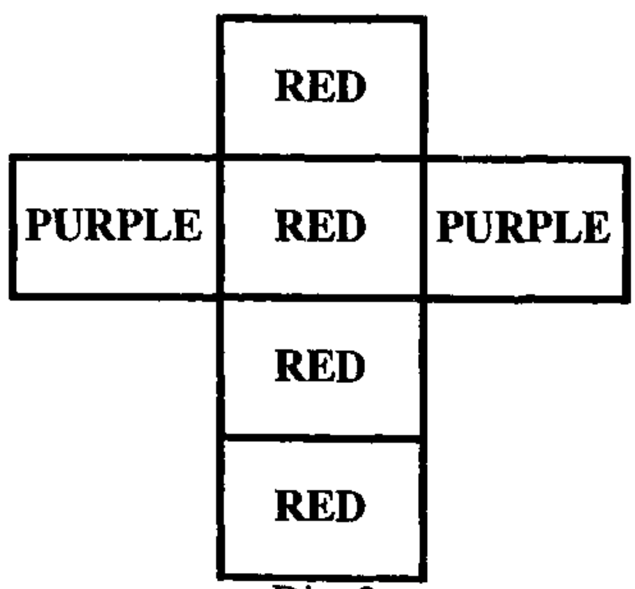
Approximate time: 15 minutes

Materials needed: Flashcards of chance language (refer to list below)
Biased die - 3 yellow sides, 2 red, 1 black (see Die 1)
Overhead transparency of Acey-Deucy Game for Helen to use (O/H 1.3)

Certain	Buckleys
Never	Probably
Impossible	Most likely
Unlikely	Dead certain
Pigs might fly!	Could
One in a million	Definitely
Once in a blue moon	Doubtful
Perhaps	No way
Maybe	Fifty-fifty
In the box seat	Fat chance



Die 1



Die 2

Step One: Ordering chance words

Give out one flashcard to each participant and ask them to come to a large space in the room (probably the front of the room)

Suggest that the activity is for sorting and ordering and firstly ask them to arrange themselves in:

- alphabetical order

then

- by the number of letters in their expression

then

- from least certain to most certain.

(NOTE: this final ordering can become very time consuming and may have to be drawn to a close before all participants are satisfied of the order)

Select four words from the ordering - the two extremities (usually never/impossible and certain/dead certain) - plus two representing the 'middle' of the continuum - suggest 'maybe' and 'likely'.

Write the four words on the blackboard modelling the continuum i.e.

NEVER ______ MAYBE ______ LIKELY ______ CERTAIN

Collect flashcards and participants return to seats.

Step Two: Four words and everyday statements

Ask each table group to write one everyday statement for each chance word.
Statements to be shared with the whole group.

Examples:

NEVER:	You will never find pineapples growing at the South Pole.
MAYBE:	Maybe there are two people in this room that share the same birthday.
LIKELY:	It is likely that it will rain this afternoon even though it is sunny now.
CERTAIN:	You could be certain that Hawthorn will win the Grand Final this year!

Step Three: Four words and a biased die

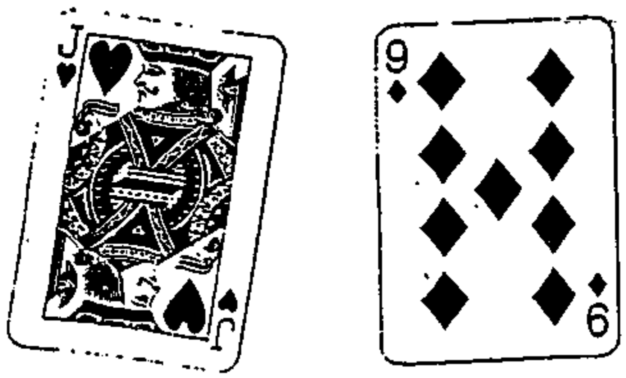
Give each table group biased die 1 - 3 yellow sides, 2 red sides, 1 black side.
Explain that these dice are easy to make using a milk carton - the children could make their own as part of a measurement / spatial relations session or buddies / year 6 could make them for a lower grade.
Ask each table group to write a statement for the die to match each of the four words.
Share these statements.

Examples:

NEVER:	You will never roll green.
MAYBE:	Maybe you will roll black.
LIKELY:	You are more likely to roll yellow than red.
CERTAIN:	You could be certain that you will roll either red, yellow or black.

Step Four: Acey-Deucy

Have Helen (one of the participants) explain to the group how she had her year 5 class list and sort a selection of chance words. Then Helen could describe how she had her class play the game of Acey-Deucy and link their thinking to the sorted list of chance words. Helen to use O/H1.3



close to impossible

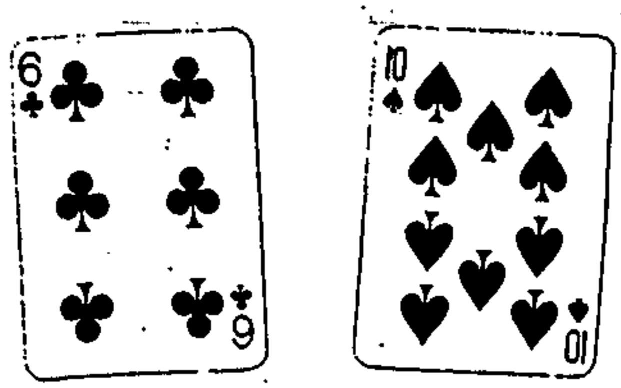
100 to 1

improbable

doubtful

no way

O/H 1.3



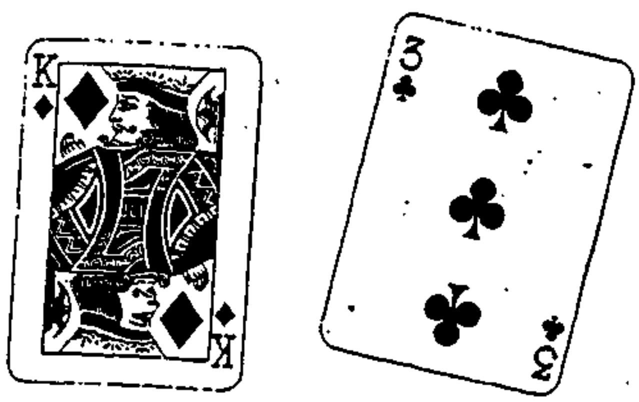
50 50

maybe

could

half a chance

O/H 1.3



very good chance

highly likely

probably

possibly

not definitely but close

O/H 1.3

ACTIVITY 1-3

Dice Tracks

Approximate time: 15 minutes

Materials needed: Gameboards, counters, biased die from Activity 2

Overhead transparencies of C&SF levels 1 -4 (O/H 1.4)

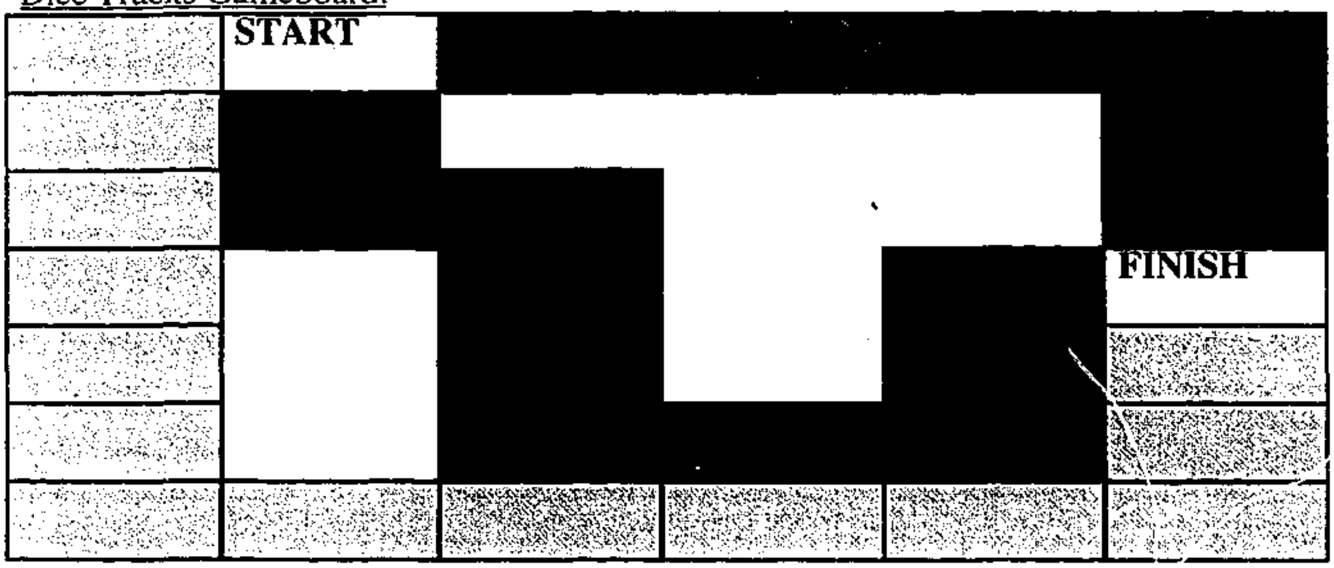
Step One

Use the biased die to play Dice Tracks.

Rules:

Three players plus a 'die-roller'. Players choose which track they would prefer to play on - yellow, red or black. Their coloured counters are placed on the 'START'. Die-roller rolls the die and as each colour comes up the player with that colour can move their counter on one space each time. The first player to reach 'Finish' is the winner.

Dice Tracks Gameboard:



Play the game several times so that everyone gets a chance at being the die-roller and going first at selecting which colour track they want to play on.

Discussion:

For what year levels would this game be most appropriate?
What sorts of decisions would young children be making when they play this game?
What would be the learning outcomes of this activity for Prep/Year 1/Year 2?
List these on overhead as they are suggested.
For example:

- realising that some events involve chance
- using chance language such as 'luck', 'fair', 'impossible', 'likely', etc
- realising when the game is repeated that a different scenario is played out

Use O/H 1.4 to locate similar outcomes listed for levels 1 and 2.

**Note the conflict situation that arises, i.e. the 'obvious' track to take is not necessarily the best track to chose. When trialling this game children naturally chose the shortest track to play on. It takes a number of games before they realise that the dice is biased.

THE MATHEMATICS C&SF

STRAND: **Chance and data**
SUB-STRAND: **Chance**

	Curriculum Focus	Learning Outcomes
Level 1	Recognising elements of chance in familiar situations	Recognise that some events involve chance Use language asscciated with uncertainity such as 'will', won't' and 'might' Recognise that different results . are possible when some actions are repeated

O/H 1.4

Level 2	Classifying events as certain, possible or impossible Comparing possible events	Identify certain, possible and impossible events in familiar situations and simple chance experiments Distinguish impossible from unlikely events Compare two possible events in a familiar situation as more or less likely to happen

O/H 1.4

Level 3	Determining outcomes from simple experiments Making random selections Ordering more or less likely situations	Record and identify all possible outcomes arising from simple chance experiments Identify some outcomes as being equally likely Use simple techniques for random selection Order a few easily understood events from least likely to most likely, justifying their choice by referring to experience or other information

O/H 1.4

Level 4	Ordering the likelihood of everyday situations involving chance Using a numerical scale for chance events Using the common (everyday) language of chance	Order events from least likely to most likely using available data (for example, use weather data to order capital cities on chance of rain in January) Analyse outcomes from simple experiments with dice and spinners and order them from least likely to most likely Design a simple random device (such as a die, spinner or bag of coloured counters) to produce a specified order of probability

O/H 1.4

		Make simple predictive statements about everyday events using the appropriate language of chance Place informal expressions about chance on a numerical scale from 0 to 1 Interpret numerical and non-numerical probability statements commonly used (for example, even chance, same chance, 50%, fifty-fifty, one-in-three, $^1/_4$, odds on, ...)

O/H 1.4

ACTIVITY 1-4

Applying Number to the Continuum

Approximate time: 15 minutes

Materials needed: Biased die already used (3yellow, 2 red, 1 black) - DIE 1 (From Activity 2)

Step One: Establishing the continuum

Put a continuum on board as below. Remind the group of their biased die statements as you put it on the board.

NEVER	MAYBE	LIKELY	CERTAIN

Step Two: Considering number

Discuss possible number arrangements that could be placed on this continuum.
For example:

0		5		10
0%		**50%**		**100%**
0		$^1/_2$		1
		50-50		
NEVER	MAYBE		LIKELY	CERTAIN

Suggest that we will use percentage for the following activity, and that many children (Year 4 on) can relate to the concept of percentage.

Step Four: Plotting Die 1

Show DIE 1.
Have the participants state the possible outcomes / events from one roll of DIE 1.
Have the participants suggest the order that they would expect them to occur.

Match the outcome statements to a position on the continuum and ask for numerical values to correspond to each statement.
The end result should be:

0%			**50%**		**100%**
NEVER		MAYBE		LIKELY	CERTAIN
Rolling a black	Rolling a red		Rolling a yellow		
$^1/_6$	$^1/_3$		$^1/_2$		
17%	33%		50%		

Mention how this could be checked in the classroom by trialling many rolls.

ACTIVITY 1-5

Think-pair-share Strategy - Rolling Two Yellows

Approximate time: 15 minutes

Materials needed: Die 1 (3 yellow, 2 red, 1 black)
(From Activity 2)

Die 2 (4 yellow, 2 purple)
(From Activity 2)

Step One: Using Think-pair-share

Show the participants Dice 1 and 2.
Participants individually draw a continuum N________________________C

Explain the teaching strategy:

- Work Individually - a few minutes
- Share ideas / solutions with a partner. If possible come to some consensus.
- Pairs share with each other. If possible come to some consensus.

Set the problem:
What is the chance of rolling two yellows? Mark your prediction on the NEVER-CERTAIN continuum. Include an approximate percentage.

(Because of lack of time the further development of this activity was transferred to Session 2 - refer to Activity 2-2)

ACTIVITY 1-6

Lucky Die

Approximate time: 15 minutes

Materials needed: Video

Step One: Show video and discussion

Show the video snippet which asks children of varying ages whether they think that one number is harder to roll than any other when rolling a normal six-sided die.

<u>Discussion:</u>
Are these the sort of responses you would expect?
At what age would these biases disappear?
Would adults think like these children?

<u>Summary of video:</u>
The video shows children representative of prep to year 6 discussing with the researcher whether they can engineer the tossing of a coin or the rolling of a die to achieve a desired result (based on the research by Truran, 1994). The comments obtained are similar to Truran's and examples include:

- If you've got heads on top it lands tails (John)
- Number six [is the hardest to roll] because its the highest number and you're not very fortunate withit. (Martha)
- Six (is the hardest to roll). I just cross my fingers and say 'please get a six'" (Angie)
- I get every number the same because I roll [the die] fast. (Thomas)

ACTIVITY 1-7

Administration

Approximate time: 5 minutes

Materials needed: Handouts: Session 1 evaluation sheet & Session Handouts (refer to page A-14)

Step One: Explanation of between sessions trialling

- The first activity is to plan and trial a chance activity that makes use of the think-pair-share strategy and to reflect upon its value for encouraging pupils to talk about the mathematics involved in the activity.

- The second activity is to ask several children if they think there is a number on a normal six-sided die that is more difficult to roll than any other, why, and if they do anything to influence the roll of a die. Can they classify their responses using Truran's classification? Consider the implications for teaching chance.
  Note that the following reading was distributed prior to session 1:
  Truran, K. (1994). *Children's Perceptions of Their Control Over the Behaviour of Random Generators.* A paper presented at the Contemporary Approaches to Research in Mathematics, Science and Environmental Education Seminar, Deakin University, Dec. 1994.

Step Two: Complete Session 1 evaluation sheet

<u>End of Session 1:</u>

Today's session has focussed on a number of activities / discussion. Some of these are listed below. Number those listed from one to five in the order of usefulness to you.

- **Developing children's chance language**
- **Activities using biased dice**
- **Think-pair-share as a strategy to promote collaboration**
- **Discussion about children's thinking on random generators**
- **Using a 'conflict situation' to promote thinking**

Give reasons for your number one choice:

____

____

____

Give reasons for your number five choice:

____

____

____

Other comments on today's session are:

List of handouts

- Cover page
- The Mathematics C&SF: Chance (copy of O/H 1.4.- refer pages A-8 & A9)
- List of chance words used in Activity 2 (Refer page A-4)
- Journal article; Thorton, C.A. (1991), Think, Tell, Share - Success for students, *Arithmetic Teacher, February,* pp22-23.
- Page of suggested activities to use with the Think-pair-share strategy (sample only given on page A-14)
- Page of suggested activities for using coloured dice (sample only given on page A-14)
- Between sessions classroom trialling sheet (refer to page A-15)
- Between sessions teacher research sheet (refer to page A-15)

Problems to use with Think-pair-share.
The language used by the children will depend on their year level and the amount of work previously done on chance. However, all children should be able to tackle these problems working from their existing knowledge. Answers such as 'highly likely', 'maybe' and 'never' are just as acceptable as approximate percentages.
In all of these examples pupils should individually develop their own thoughts first, then share their ideas with a partner and reach consensus where possible. Pairs should then share their 'consensus ideas' and refine their thoughts where appropriate. Following some classroom sharing the problem should be investigated in a hands-on way.

- **Names in a hat**
  Write all of the class' names on flashcards and put them in a hat. PROBLEM: What is the chance of picking out a pair of names and finding them to be both girls' names?
- **Smarties**
  Empty a packet of Smarties into a jar and show them to the class.
  What is the chance that if we all take two at random out of the jar that at least one person in the grade will have two of the same colour? What colour do you expect this to be?
- **Playing cards**
  What is the chance of taking at random two cards from a pack and finding them to be both black?

Classroom activities using coloured dice

How many rolls?
Use two different biased dice. Students to estimate how many turns it will take until double 'green' has been rolled. A leader or dice-roller rolls the dice and a tally of turns is kept until a double green is rolled. The winner will be the student with the closest estimate. At the conclusion of a number of games discussion should be held on whether there is any pattern apparent for the totals of each game.

Invent a fair game
Use one or two biased dice to invent a fair game. Ideally pupils would work in pairs, brainstorm ideas, design the board and rules for the game, trial the game, then refine the board and rules. The game should be given to another pair for trying out and this pair should write comments on how easy it was to understand the rules, whether they thought the game was fair, and comment on possible improvements.

Counters Game
Use a biased die and a container of matching coloured counters. The teacher or die-roller rolls the die and any pupil having a counter matching the colour rolled can replace this counter in the container. The winner is the first person to replace all of their counters.

CLASSROOM TRIALLING:

BETWEEN SESSIONS 1 AND 2:

Plan and tria' a session for the topic of chance that uses the 'Think-pair-share' strategy. The following headings may assist your planning and evaluation.

Problem:

Summary plan:

Resources needed:

Intended learning outcomes:

Pupil reaction:

- **to the chance content**
- **to the 'think-pair-share' strategy**

How could it be improved the next time:

TEACHER RESEARCH:

BETWEEN SESSIONS 1 AND 2:

Ask a few children from varying year levels Kath Truran's question on dice rolling: "When I toss this die is there any number or numbers that are harder to get than others?" Follow-up their responses with "Why?" and "Do you have any special ways of rolling the die to get your 'hard' number?"
Make brief notes of children's responses and age/year level.

SESSION 2

RANDOM GENERATORS AND JIGSAW

Activity Number	Page reference	Activity Handout	Workshopped activity (W) and/or Handout (H)	Major focus M/T/C M*
2-1	A-17 to 18 & 29	Game - 'Your Choice'	W/H	M
2-2	A-19 to 20	Rolling Two Yellows (continued from activity 1-5)		
		• Dealing with the problem	W	M*
		• Discussion	W	M/C
2-3	A-21	Between Sessions Sharing - Think-pair-share Trialling	W	M/T/C
2-4	A-22 to 23	Between Sessions Sharing - Children's beliefs about random generators	W/H	M/C
2-5	A-24 to 26 & 29	Jigsaw - Making a random generator	W/H	M/T
2-6	A-27 & 29	Game - 'Toss of Luck'	W/H	M/C
2-7	A-28	Administration		
	A-29	Notes on quick games	H	M
	A-30	Suggested activities for Jigsaw	H	M/T
	A-30	Tennis clothing problem	H	M
	A-29	Mystery Balloons	H	M
	A-29	Pages from Bellingham, J. (1995)	H	M/T

(M-mathematics content; T-teaching strategies content; C-constructivist notions content; M*-mathematics content aimed at extending participant's knowledge)

ACTIVITY 2-1

A Quick Game of 'Your Choice'

Approximate time: 10 minutes

Materials needed: Overhead transparency of session outline (O/H2.1)
Biased die - 3 yellow /2 red /1 black (refer session 1)
Set of colour slips (red, yellow, black) for each participant.

Step One: Session overview

Use O/H 2.1 to outline the expected content of this session.

SESSION 2:
Random Generators and Jigsaw

- A quick game - Your Choice
- Complete the task - Chance of rolling two yellows.
- Between sessions sharing - Think-pair-share
- Between sessions sharing - Children's beliefs on random generators
- JIGSAW - constructing a random generator
- Another quick game - Toss of Luck

O/H 2.1

Step Two: Explain the rules of 'Your Choice'

Explain the rules for 'Your Choice'.

<u>Rules: YOUR CHOICE</u>
All participants stand and each participant holds up a colour slip for which colour they think will be rolled.
Leader rolls the biased die. Those participants that had the colour rolled can remain standing. The others sit down.
The leader continues to roll the die and the participants choose a colour slip each time.
The game is continued until only one person is left - this person becomes the winner.

Step Three: Play the game

Have participants play the game of 'Your Choice'.

Step Four: Brief discussion

Use the following points for brief discussion:

- What decisions were participants making?
- What are possible learning outcomes?
- Which year levels is it best suited to?
- Someone may have tried a similar game with their class and wish to comment further re learning outcomes or organization for example, Greedy Pig, Heads and Tails.

ACTIVITY 2-2

Rolling two yellows (continued from session 1)

Approximate time: 20 minutes

Materials needed: Biased die already used (3 yellow, 2 red, 1 black) - DIE 1
Second biased die (4 yellow, 2 purple) - DIE 2
Overheads of tables (O/H2.2 & 2.3)

Step One: Revisit the problem of 'Rolling two yellows'

Remind the group of what they started in the last session:
Show Dice 1 and 2.
Participants <u>individually</u> drew a continuum N________________________C

This was the problem:
What is the chance of rolling two yellows? Mark on the NEVER-CERTAIN continuum where you think the chance is of this occurring. Include an approximate percentage.

<u>Discussion:</u>
Firstly there was <u>individual thinking</u>:
What were some of the suggestions at this point?
Then there was <u>sharing in pairs</u>:
Who changed their estimates because of the persuasive arguments of their partner? Explain.
Who compromised the two results and went for middle ground?
Then <u>table groups shared</u>:
What discussion happened at that point?

How can we find a reasonable answer for this problem?

Step Two: Modelling the problem

One way will be to test it out - try this method.
Do 6 rolls as a model.

Use the following chart:

DICE ROLL	SUCCESS	RUNNING %
y / y	√	100
y / y	√	100
r / p	x	67
b / y	x	50
r / y	x	40
y / y	√	50

Run simple experiment. Each pair roll the two dice 10 times, each pair records the results as in the above model. Compare the result with the original consensus decisions. General discussion.

Step Three: A mathematical solution

Can the groups of 4 come up with a more mathematical way of showing what is happening.
Allow participants to explain their methods.

Hopefully someone will have devised a two-way chart as follows:

	Yellow	Yellow	Yellow	Yellow	Purple	Purple
Yellow	Y / Y	Y / Y	Y / Y	Y / Y	Y / P	Y / P
Yellow	Y / Y	Y / Y	Y / Y	Y / Y	Y / P	Y / P
Yellow	Y / Y	Y / Y	Y / Y	Y / Y	Y / P	Y / P
Red	R / Y	R / Y	R / Y	R / Y	R / P	R / P
Red	R / Y	R / Y	R / Y	R / Y	R / P	R / P
Black	B / Y	B / Y	B / Y	B / Y	B / P	B / P

It can be seen from the 2-way table that there are 36 ways (combinations) of rolling the two dice. Of these 12 are yellow-yellow. The chance of rolling two yellows is $^{12}/_{36}$, or $^{1}/_{3}$ or 33%.

This is a surprising result to most people who expect that two yellows would come up far more often because in total yellow is represented more than any other colour i.e. $^{7}/_{12}$.

<u>Discussion point:</u>
This surprising result is another example of presenting a 'conflict situation'.
The trialling that occurs should begin to question the initial thinking and create a climate for wanting to discover the real truth behind the problem.

	Y	Y	Y	Y	P	P
Y						
Y						
Y						
R						
R						
B						

O/H2.2

	Y	Y	Y	Y	P	P
Y	Y / Y	Y / Y	Y / Y	Y / Y	Y / P	Y / P
Y	Y / Y	Y / Y	Y / Y	Y / Y	Y / P	Y / P
Y	Y / Y	Y / Y	Y / Y	Y / Y	Y / P	Y / P
R	R / Y	R / Y	R / Y	R / Y	P / R	P / R
R	R / Y	R / Y	R / Y	R / Y	P / R	P / R
B	B / Y	B / Y	B / Y	B / Y	B / P	B / P

O/H2.3

ACTIVITY 2-3

Between Sessions Sharing - Think-pair-share Trialling

Approximate time: 15 minutes

Materials needed: Random generator: 4 different colours in a bag (4 of 2 colours and 5 of two colours)

Step One: Sorting out the groups

Use the 'random generator' to group participants on to new tables just for this activity.

Step Two: Sharing of between sessions trialling

Each participant to share with their group the activity that they trialled.
Each table group to come up with a list of the strengths / weaknesses of Think-tell-share as a teaching strategy.

Step Three: Whole group discussion

PART A: Sharing of highlights of other participant's trialling.

PART B: Discussion on strengths / weaknesses of Think-tell-share.

<u>Discussion points:</u>
ADVANTAGES / STRENGTHS

- Individuals gather their own ideas before coming into a grouping and hence may not rely on the dominant pupils if they had all started off as a group.
- When they are in pairs they are rehearsing what they may say to a larger group, this may help to take the pressure off them.
- Reinforcing children's use of mathematical language, and language at their level.
- May consolidate and extend their own understanding by having to verbalise.
- By having to come to some consensus they may need to re-shape their thinking.

All of these fit nicely into a CONSTRUCTIVIST APPROACH.

DISADVANTAGES / WEAKNESSES

- Time-consuming.
- May reinforce misconceptions, especially if one of the children is very dominant.

Step Five: Return to own tables

ACTIVITY 2-4

Between Sessions Sharing - Children's Beliefs about Random Generators

Approximate time: 10 minutes

Materials needed: Overhead transparencies summarising Truran's research (O/H2.4 - one sample included)

Overhead transparency of blank table (O/H 2.5)

Step One: Whole group discussion

General whole group discussion resulting from:

- Reading of Truran's article
- Video snippets
- Personal classroom research.

Discussion points:

Share observations from their own questioning.

Do these observations match what Kath Truran found?

Are they like the ones on the video snippett?

At what year levels do beliefs begin to change about the behaviour of random generators?

What are the implications for teaching?

A possible table:
Participants could share with group the results for each year level.
Data could be collected by tallying on O/H 2.5 - then totalled when all data is entered and note any generalisations if they occur.

Animism

An intervening force effects the outcome of the random result.

Interview

Kath: When I toss this 12-sided die is there any number or numbers that are harder to get than others?

John: Yes, nine is.

Kath: Why nine?

John: Because it's unlucky.

Kath: Well lets roll the dice and see what happens.

(Result from three rolls: 9, 9, 3)

That's interesting - two nine's and a three, do you still think nine is the hardest number to get?

John: Yes.

Kath: Why when 9 came up twice out of three rolls?

John: Because the dice knows I hate that number and so rolled nine on purpose to annoy me!

O/H 2.4

	Number of pupils who thought that 'X' was the hardest to get.						Number of pupils who saw that all numbers were the same chance
Die number	1	2	3	4	5	6	
Prep							
Year 1							
Year 2							
Year 3							
Year 4							
Year 5							
Year 6							

O/H2.5

ACTIVITY 2-5

Jigsaw - Making a Random Generator

Approximate time: 20 minutes

Materials needed: Scrap materials - cardboard, coloured paper, milk cartons

Scissors, glu-sticks, sticky-tape, textas, stapler, ruler, paper clips, paper bags, playing cards, calculator.

Decimal squares, grid paper, MAB base 10.

Overhead transparency of group organization and task - O/H 2.6.

Step One: Explanation of the task

Use overhead O/H2.6 to explain how the following jigsaw activity is to be organised and what the task is.
THE TASK: Each pair is to construct a random generator which gives four selections - theoretically resulting in one selection at 10% chance, others at 20%, 30% and 40%.

JIGSAW
Making a random generator

TASK: To construct a random generator that theoretically results in chances of 10%, 20%, 30% and 40%.
EXAMPLE: The yellow/red/black die results in chances of 50% (yellow - 3/6) 33% (red - 2/6) 17% (black - 1/6)
ORGANIZATION:
Participants work as pairs
Pairs number themselves as '1' or '2'

Before pairs start on the task:
CONSTRUCTION EXPERTS
1's meet together to brainstorm possible random generators (eg, die, coin, ...) and to briefly discuss how they could be made
PERCENTAGE EXPERTS
2's meet together to ensure that all their group understand the concept of percentage and how to convert from vulgar fractions to percentage (and vice versa)

After a few minutes pairs come together to construct their random generator.

O/H2.6

Step Two: Organisation

Pair the participants and number them as one or two.

The 'ones' are to meet as a group: CONSTRUCTION EXPERTS
This group needs to make a list of all the sorts of random generators that they can think of. Talk about how each one could be made and their strengths / weaknesses for making random selections.

The 'twos 'are to meet as a group PERCENTAGE EXPERTS
This group needs to make sure that everyone in the group understand the ideas of percentage and can work out the connections between percentages and fractions.
(Can be supplied with decimal squares, grid paper, MAB base 10

Move the new groups to separate parts of the room for about 5 minutes to complete their EXPERT discussion.

Step Three: Constructing the random generator

Pairs come back together and construct their random generator.

These need to be shown to the group as a whole and perhaps each pair could justify their design.

Step Four: Discussion

Part A:
What year levels could this particular task be undertaken? Years 5/6 would be most suitable.
What would they learn from this activity?
How could this activity be simplified for a lower grade?

Part B:
What are the strengths / weaknesses of JIGSAW?

Discussion points:
STRENGTHS:

- That each individual returns to the home pair or group being recognised as the expert in one particular field.
- Even if the individual pupil had nothing to say in the 'Expert Group' they should feel more empowered to be able to share / explain ideas back in their home pair or group.
- It is the 'Expert Group's' responsibility to ensure that everyone understands - ie making pupils responsible for their learning and the learning of others.
- When returning to the home pair or group each pupil needs to verbalise, use mathematical language, etc.

WEAKNESSES:

- Time consuming.
- There may be some children who find it difficult to return to their home pair or group and verbalise what was discussed.
- Make take a fair amount of time training the class to be able to take responsibility and do this properly - hence it may not work well for lower grades.

Background information:

The following random generators are possible solutions.

- A spinner with four coloured sections showing 10%, 20%, 30%, 40% - like a pie graph.
- Using a pack of cards:
  Take out one ACE, 2 jacks, 3 Queens, 4 Kings
  Shuffle and draw one at random - the queen should come out 30% of the time.
- A bag of counters - 10 red, 20 blue, 30 green, 40 yellow - a blue should come out 20% of the time.

ACTIVITY 2-6

Toss of Luck

Approximate time: 15 minutes

Materials needed: Container with 'unusual' random generators - key, teaspoon, bread tag, button, coin, drawing pin, matchbox.

A counter for each participant.

Gameboard for each group of four.

Step One: Explain Rules

TOSS OF LUCK
<u>Rules:</u>

Each player chooses their 'tosser' (random generator).

Each player designates one side of their 'tosser' as a winning side. For example, for the matchbox it might be the picture side, for the drawing pin it might be the point.

Each player places a counter on a 'start' position on the gameboard.

Each player takes a turn at tossing their own tosser. If the tosser comes down showing their designated winning side, the player moves their counter along one space towards the finish.

If the 'tosser' does not come down on the winning side, the player does not move the counter. The winner is the first person to reach 'Finish'.

<u>Playing board:</u>

Start									**Finish**
Start									**Finish**
Start									**Finish**
Start									**Finish**
Start									**Finish**

Step Two: Play the game

Table groups play the game.

Step Three: Discussion

What year level? What would the learning outcomes be?

ACTIVITY 2-7

Administration

Approximate time: 5 minutes

Materials needed: Handouts: Session 2 evaluation sheet & Session Handouts (refer page A-29)

Step One: Explanation of between-session work

- The first activity is to plan and trial a chance activity that makes use of the jigsaw strategy and to reflect upon its value for encouraging pupils to talk about the mathematics involved in the activity.

Step Two: Complete session 2 evaluation sheet

End of Session 2 Evaluation:

A Give an example from today's session of where you have extended your personal understanding in chance.

____

____

B Give an example form today's sessions of a new teaching idea that you intend to implement in your classroom.

____

____

C Give an example from today's session of something relating to children's understanding of chance that you found interesting.

____

____

D From today's session jot down something that a colleague mentioned to you that you thought was interesting and worth thinking more about.

____

____

Of the four explanations above which aspect will have the most impact on your future teaching? Circle **A B C D**
Justify your choice.

____

____

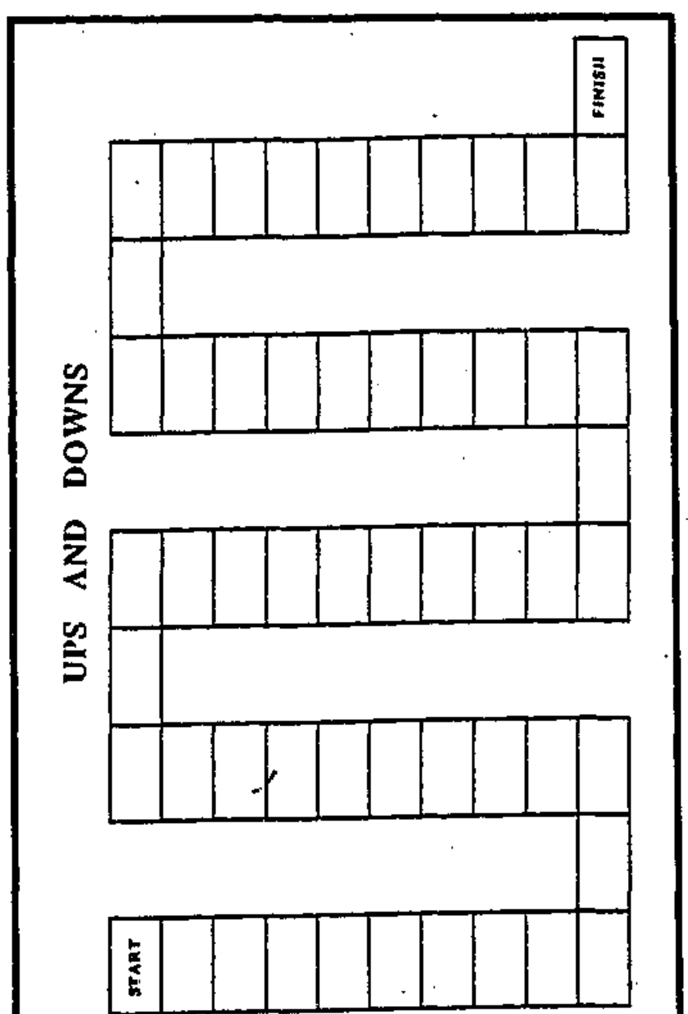
List of handouts

- Cover page
- Notes on three 'Quick Games', Ups and Downs gameboard (for 'Your Choice' refer to page A-17.
- Rules for the game 'Toss of Luck', 'Toss of Luck' gameboard (as for Activity 2-6)
- Dalton, J. & Smith, D. (1986). The jigsaw technique, from *Extending Children's Special Abilities,* Ministry of Education, Victoria, page 92.
- Page of suggested activities to use with the Jigsaw strategy (sample below)
- Between sessions classroom trialing sheet (page A-30)
- Tennis clothing problem, worksheet (page A-30)
- Mystery Balloons, from *The Arithmetice Teacher,* February, 1991.
- Bellingham, J. (1995), Dice Fun, In J. Bellingham, *Super Solvers: Mathematical Problem Solving Tasks, Introductory Level Grade P/K,* Melbourne: Dellasta, pp.62-65
- Acey, twosey & Heads and Tails, From the 1995 consultation draft of the *Mathematics Course Advice* , Ministry of Education, (Unit 1, Level 3 Chance and Data 4; Unit 1, Level 4, Chance and Data 5)

QUICK GAMES

FIVE YELLOWS
Materials: biased die: 3 yellow sides, 2 red sides, 1 black side.
Whole class can play this game. Each player writes down how many rolls they think it will take to roll 5 yellows. The teacher / leader rolls the die until five yellows have been rolled. The player/s with the closest guess score a point.
The game is repeated - always guessing how many rolls are needed for 5 yellows - players can select a new guess / number if they like. Play the game ten times and the winner is the player with the highest score.

UPS AND DOWNS
Materials: 5 random selectors that are all the same, for example, bottle tops, cream lids.
Game board - refer further on.
A game for two players. A counter for each player is put on the START position on the game board. Each player designates a winning side, for example, with bottle tops the coloured side or the screw side. Players take it in turns to toss the five random selectors all at once. They move their counter the number of winning sides they get out of five. The first to reach the FINISH is the winner.



CLASSROOM IDEAS - JIGSAW

- **SNAKES and LADDERS**

TASK: For children to work in pairs to construct a snakes and ladders board. Suggest that the board not be 10 x 10 but some other dimensions for example, 8 x 12 or 5 x 20.
SNAKE EXPERTS: The 'Snake Experts' discuss the best position to place snakes and how long they should be to ensure that a game is produced that will be winnable.
LADDER EXPERTS: The 'Ladder Experts' discuss the best position to place ladders and how long they should be to ensure that a game is produced that will be winnable.

- **TOSSING THREE COINS**

TASK: For children to work in pairs, to predict which combination of coins will come up the most, and then to record the results of 30 trials.
COIN EXPERTS: The 'Coin Experts' discuss the possibilities that might occur and talk about which ones may come up the most.
RECORDING EXPERTS: The 'Recording Experts' discuss various ways to record the results of the trialling and advantages / disadvantages of the ways.

CLASSROOM TRIALING: BETWEEN SESSIONS 2 AND 3

Plan and trial a session for the topic of chance that uses the 'Jigsaw' strategy. The following headings may assist your planning and evaluation.

Problem:

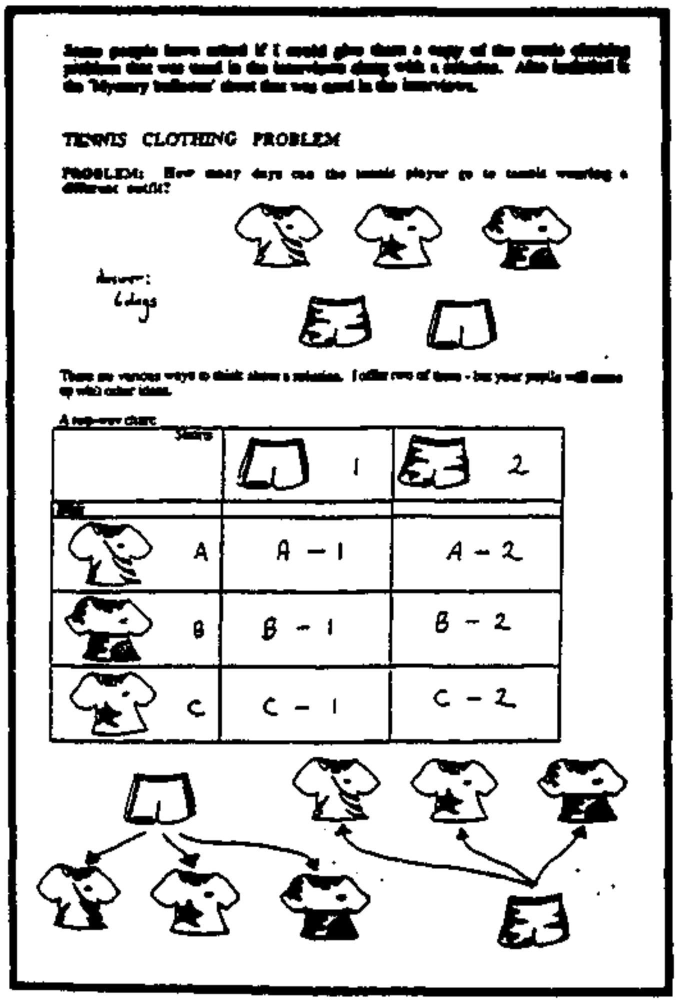
Summary plan:

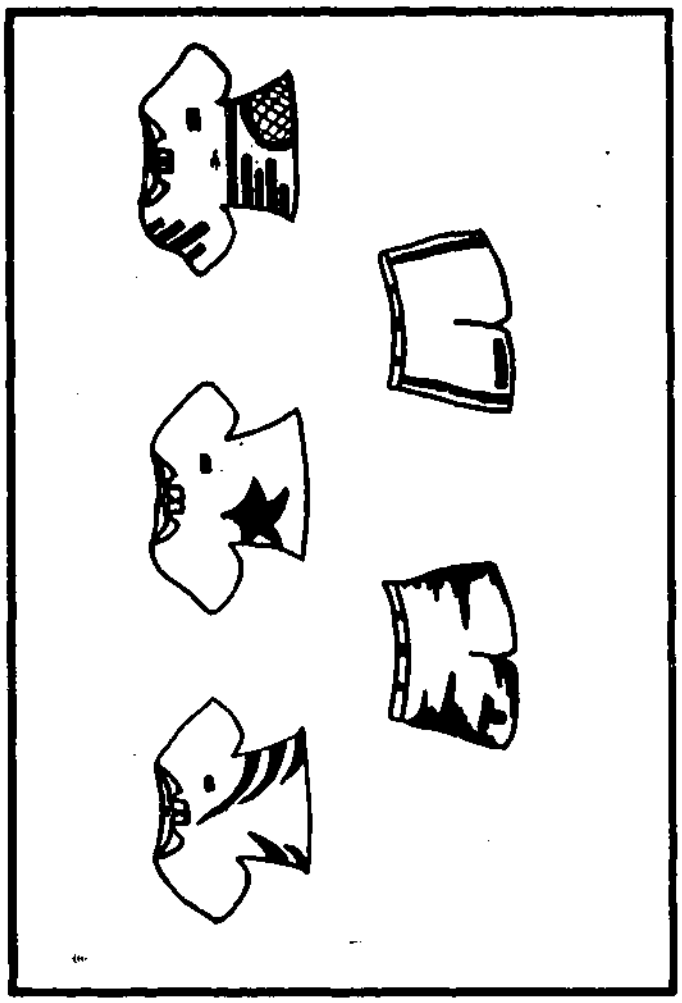
Resources needed:

Intended learning outcomes:

Pupil reaction:
- to the chance content
- to the 'jigsaw' strategy

How could it be improved the next time:





SESSION 3

CLUE CARDS AND COMBINATIONS

Activity Number	Page reference	Activity Handout	Workshopped activity (W) and/or Handout (H)	Major focus M/T/C M*
3-1	A-32 to 33	• Game - "Colour Matches'	W/H	M
	&41	• Video clip	W	M/C
3-2	A-34	Between Sessions Sharing - Jigsaw Lesson	W	M/T/C
3-3	A-35	Clue Cards - Finding combinations	W/H	M/T
	& 40			
3-4	A-36	Jigsaw & Clue Cards	W/H	M/T
	& 40			
3-5	A-37	Ten Green Bottles	W/H	M/T/C
	& 41			
3-6	A-38	Hat, scarf & belt	W/H	M
	& 40			
3-7	A-39	Administration		
		Various articles (Chandler, AAMT, Burns & Tank, Burns, Smith)	H	M
		Article by Shaughnessy (refer to video clip in Session 4)	H	M/C
		Game of 'Ticking Off'	H	M

(M-mathematics content; T-teaching strategies content; C-constructivist notions content; M*-mathematics content aimed at extending participant's knowledge)

ACTIVITY 3-1

A Quick Game - Colour Matches

Approximate time:	10 minutes
Materials needed:	'Colour Matches' Boards (copy in 'List of Handouts')
	Spinners (equal amount of red/blue/green)
	Overhead transparency explaining rules - O/H3.1
	Counters (red/blue/green)
	Overhead transparency for 'Session Overview' - O/H3.2

Step One: Playing the game

Explain the rules using O/H3.1.
Participants play game.

Step Two: Brief discussion

Discussion points:

- What is the mathematics that's involved? What's the connection to the topic of chance?
- What are possible learning outcomes for chance?
- Which year levels is it best suited to?
- Would this game work in your classroom?
- What language might this game generate?
- Note the connection - still using a random generator.

Step Three: Video clip - Girls matching up coloured counters

Show video clip of second girl (Year 3) in Colour Combinations.
General discussion on the skills and desired outcomes involved in such tasks.

Step Four: Session overview

Go through overhead - O/H3.2.

COLOUR MATCHES

2 or 3 players

MATERIALS:
The group need a spinner and a container of counters.
Each player needs their own game board.
HOW TO PLAY:
Players take it in turn to spin the spinner. A counter the same colour as what has been spun is taken by the player and placed in one of the spaces on the gameboard.

The aim of the game is to complete the nine gameboard 'layouts' with different matching colours (including pairs of the same colour) - eg blue-red, blue-green, blue-blue, ...

At some point in the game some spins will act as a lost turn because the player will not need that colour to complete their 'layouts'.

The winner of the game is the first to complete the nine 'layouts' successfully.

O/H3.1

SESSION 3

- Quick game - Colour Matches
- Between sessions sharing - Jigsaw
- Clue Cards
- Clue cards and jigsaw
- Ten Green Bottles
- Hat, Scarf and Belt

O/H3.2

ACTIVITY 3-2

Between Sessions Sharing - Jigsaw Lesson

Approximate time: 15 minutes

Materials needed: None required

Step One: Organising groups for discussion

Sort the participants into the following table groups based on year levels / and mixing up the participants from the same school.

TABLE 1	TABLE 2	TABLE 3	TABLE 4
Teresa	Dianna	Megan	Tasha
Sally	Karen	Gail	Kaye
Deidre	Olivia	Nora	Neva
Bianca	Gerry	Helen	Malcolm
			Trevor

Step Two: Sharing of between sessions trialling

Each participant to share with their group the activity that they trialled.
Each table group to come up with a list of the strengths / weaknesses of Jigsaw as a teaching strategy.

Step Three: Whole group discussion

PART A: Sharing of highlights of other participant's trialling.

PART B: Discussion on strengths / weaknesses of Jigsaw - use overheads to record ideas.

Step Four: Return to own tables

ACTIVITY 3-3

Clue Cards - Finding Combinations

Approximate time: 20 minutes

Materials needed: Sets of clue cards - double header ice-creams

Step One: Explanation of the clue cards strategy

Each participant in a group is given a clue card. (For a group of 5, the fifth person can be the recorder) In a group of four a recorder needs to be appointed - one sheet of paper for the group. They are allowed to read the clue to the rest of the group. The problem needs to be solved as a group, so the group should appoint a recorder who keeps notes on decisions, etc being made. Clues can be re-read on request or otherwise but no member of a group should pass their clue to someone else in the group. Clues should not be tabled in the centre of the group. The group must ensure that all members understand the decisions being made.

Step Two: Clue cards - double header ice-creams

Give out the clues to each group. Groups solve the problem. Discussion re the answer.

Step Three: Clue cards - discussion on strategy

Whole group discussion on the clue cards strategy noting its strengths and weaknesses.

CLUE CARDS : DOUBLE HEADER ICE-CREAMS

How many double header ice-creams are possible?

Sally had a double header ice-cream with chocolate and strawberry.

Clue 1

How many double header ice-creams are possible?

Robert had a double header ice-cream with vanilla and strawberry.

Clue 2

How many double header ice-creams are possible?

Georgina had a double header ice-cream with orange and macadamia.

Clue 3

How many double header ice-creams are possible?

The ice-cream shop does not sell any more flavours than what the three children had chosen.

Clue 4

ACTIVITY 3-4

Jigsaw and Clue Cards

Approximate time: 10 minutes

Materials needed: Clue cards - Coloured Dice

Step One: Explanation of the task

Groups of three or four. Number the participants as 1, 2, 3, or 4. Before each 'home' group considers the clues all those with clue 1 meet together to discuss their clue, etc. After a few minutes the 'home' groups come back together to solve the problem.

Step Two: Run the activity

Run the task according to the above organization.

Step Three: Discussion

Discussion points:

STRENGTHS:

- That each individual returns to the home pair or group being recognised as the expert in one particular field.
- Even if the individual pupil had nothing to say in the 'Expert Group' they should feel more empowered to be able to share / explain ideas back in their home pair or group.
- It is the 'Expert Group's' responsibility to ensure that everyone understands - ie making pupils responsible for their learning and the learning of others.
- When returning to the home pair or group each pupil needs to verbalise, ie. use mathematical language.

WEAKNESSES:

- There may be some children who find it difficult to return to their home pair or group and verbalise what was discussed.
- May take a fair amount of time training the class to be able to take responsibility and do this properly - hence it may not work well for lower grades.All those with clue 1 meet together to discuss their clue.

CLUE CARDS : COLOURED DICE

Draw the net for a six-sided die that you would expect to give results that match the clues.

When the die was rolled six times it always came up blue.

Clue 1

Draw the net for a six-sided die that you would expect to give results that match the clues.

When the die was rolled thirty-six times there were seven results that were red.

Clue 2

Draw the net for a six-sided die that you would expect to give results that match the clues.

When the die was rolled one hundred times the only colours that came up were red and blue.

Clue 3

Draw the net for a six-sided die that you would expect to give results that match the clues.

When the die was rolled eighteen times it came up red twice.

Clue 4

ACTIVITY 3-5

Ten Green Bottles

Approximate time: 10 minutes

Materials needed: Green bottles

Children's work on chart

Step One: "Show and tell"

Relate the following classroom scenario. Use the green bottles and children's work when appropriate.

Year 3.

We sang the well-known song 'Ten Green Bottles', but they were stopped at the end of 5 bottles to show them the four green bottles. The bottles are all very different and there was much discussion about shape and height.
The song then continued from four and was "modelled" usin' the four bottles on a ledge.
The question "How many ways could I have put the bottles on the ledge?" was put to the class. Individual children went off and did one sketch of a possible order keeping in mind the shape and height of each bottle.
When they had completed this everyone showed their work. They were amazed to find that only a few of the pictures doubled up on the order. They expressed surprise that there were so many combinations.
The next question asked was "Do we have all of the possible combinations?" They thought that they had most of them but that there would be a few not found.
After much discussion on how to find out the class decided that if all the pupils who had started with a certain bottle got together it would be easier to check. So those who started with the COKE bottle got into a group and checked and drew the missing ones. Ditto with the Olive Oil bottle, beer bottle and the wine bottle.
Each group then put their group's drawings onto a chart. In some cases they had to decide where there were two the same (from the first individual activity) which drawing they were going to use on the chart.
The four charts produced clearly showed that a pattern or rule was evident and this was discussed.

ACTIVITY 3-6

Hat, Scarf and Belt

Approximate time: 15 minutes

Materials needed:
Worksheet for each participant
Textas
Spinners used in Activity 2.
Overhead transparency explaining activity (O/H3.3)

Step One: Explanation of the task

Use the overhead to explain the task.

HAT, SCARF and BELT

Use the worksheet provided.

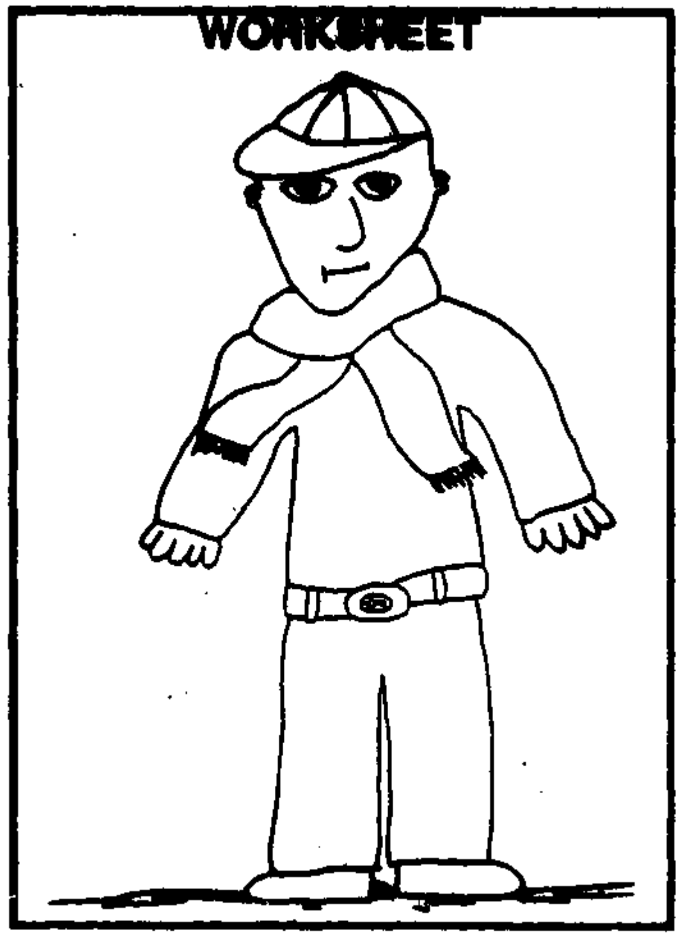
Each person takes it in turn to spin the spinner.

Your first spin denotes the colour you use for the boy's hat.

Your second spin denotes the colour you use for the boy's scarf.

Your third spin denotes the colour you use for the boy's belt.

O/H3.3



Step Two: Undertake the activity

Participants colour the worksheet.

Step Three: Whole group discussion

<u>PART A: Mathematics</u>
Take this in a similar way to the four bottles.
Show the worksheets. Have we got all of the combinations?
How can we check? and so on............

<u>PART B: Curriculum</u>
What year level/s? Learning outcomes? What is the connection to chance?

ACTIVITY 3-7

Administration

Approximate time: 5 minutes

Materials needed: Handouts: Session 3 evaluation sheet & Session Handouts (refer page A-40)

Step One: Explanation of between session trialling

- The between sessions activity is to plan and trial a chance activity that makes use of the clue card strategy and to reflect upon its value for encouraging pupils to talk about the mathematics involved in the activity.

Step Two: Complete session 3 evaluation sheet

End of Session 3 Evaluation:

Name:

A What is your initial reaction to the 'clue card' strategy?.

____

____

B Were you able to trial the 'jigsaw' strategy?
Yes No
If yes, what was your reaction? If no, what got in the way?

____

____

C Give one example from the collection of notes given out at sessions 1 and 2 that has been of use or of interest to you. Give a reason.

____

____

D What would you like to see improved or included in the remaining sessions?

____

____

E Any other comments about this session.

____

____

List of handouts

- Cover page
- Rules and gameboard for 'Colour Matches' (Rules as for Activity 3-1)
- Instructions and worksheet for 'Hat, scarf and belt' (As for Activity 3-6)
- Rules and gameboard for 'Ticking Off'
- Chandler, C.L. (1994), Butterfly, In C.L. Chandler, *Dice Don't Have Brains,* Melbourne: Mathematical Association of Victoria, pp.14 & BLM9
- AAMT (1993), Cat and Mouse, In *Take a Chance,* Australian Association of Mathematics Teachers, pp4-5
- Clue card problems (as included under respective activities)
- Shaughnessy, J.M. (1992), Blue and green containers problem, In D.A. Grouws, *Handbook of Research on Mathematics Teaching and Learning,* New York: MacMillan, pp. 479-80.
- Burns, M. & Tank, B. (1988), How to make a spinner that really spins, In M. Burns & B. Tank, *A Collection of Maths Lessons from Grades 1 through 3,* New York: The Math Solution Publications, p155.
- Burns, M. (1982), The Exclamation Explanation, In M. Burns, *Math for Smarty Pants,* Boston: Little, Brown & Company, pp. 94-95.
- Smith, R. (1994), Taking a Chance: Songs as Starting Points, In C. Beesey & D. Rasmussen (Eds), *Mathematics Without Limits,* Melbourne: Mathematical Association of Victoria, pp305-10.
- Crazy Animals Worksheet from Lovitt, C. & Lowe, I. (1993), *MCTP Chance and Data Investigations, Volume 1,* Melbourne; Curriculum Corporation, page 22-29.
- Between sessions sheet (page A-41)

COLOUR MATCHES

TICKING OFF

3 / 4 players

Materials: Coin
Worksheet per player
Biased die (1 black side, 2 red, 3 yellow)

Rules:

Each player takes a turn at rolling the die and flipping the coin.

Note the combination that occurs, for example, head / red, head / black, tail / black.

Each player uses their worksheet to tick off the combination that occurs.

Only need to tick off each combination once.

The winner is the first to have each combination ticked off.

Play the game several times to find an outright winner.

TICKING OFF WORKSHEET

GAME 1

		Tick off
Head	Red	
Head	Yellow	
Head	Black	
Tail	Red	
Tail	Yellow	
Tail	Black	

GAME 2

		Tick off
Head	Red	
Head	Yellow	
Head	Black	
Tail	Red	
Tail	Yellow	
Tail	Black	

GAME 3

		Tick off
Head	Red	
Head	Yellow	
Head	Black	
Tail	Red	
Tail	Yellow	
Tail	Black	

GAME 4

		Tick off
Head	Red	
Head	Yellow	
Head	Black	
Tail	Red	
Tail	Yellow	
Tail	Black	

GAME 5

		Tick off
Head	Red	
Head	Yellow	
Head	Black	
Tail	Red	
Tail	Yellow	
Tail	Black	

GAME 6

		Tick off
Head	Red	
Head	Yellow	
Head	Black	
Tail	Red	
Tail	Yellow	
Tail	Black	

CLASSROOM TRIALLING: BETWEEN SESSIONS 3 AND 4:

Plan and trial a session for the topic of chance that uses the 'Clue Card' strategy. The following headings may assist your planning and evaluation.

Problem:

Summary plan:

Resources needed:

Intended learning outcomes:

Pupil reaction:
- **to the chance content**
- **to the 'clue card' strategy**

How could it be improved the next time:

SESSION 4

USING RATIOS AND QUESTIONER TAG

Activity Number	Page reference	Activity Handout	Workshopped activity (W) and/or Handout (H)	Major focus M/T/C M*
4-1	A-43 to 44 & 56	Game - 'Remove'	W/H	M
4-2	A-45	Between Sessions Sharing - Clue Cards Trialling	W	M/T/C
4-3	A-46 to 47 & 91	Writing Your Own Clues	W/H	M/T
4-4	A-48 to 49 & 56	Some Connections to Statistics	W/H	M*
4-5	A-50 to 53	<u>Questioner Tag Strategy</u>		
		• Strategy	W	M/T
		• Discussion	W	C
		• Other 'people' problems	W	M*
4-6	A-54 & 40	Green & White Containers	W/H	M/C
4-7	A-55	Administration		
	A-56	Handout: Bruni & Silverman (1986)	H	M
	A-56	Handout: Perry, (1996)	H	M/C

(M-mathematics content; T-teaching strategies content; C-constructivist notions content; M*-mathematics content aimed at extending participant's knowledge)

ACTIVITY 4-1

Game - 'Remove'

Approximate time: 10 minutes

Materials needed:

REMOVE Boards (refer to Step One below)

Dice with 4 yellow/2 purple sides
3 yellow/2 red/1 black sides
5 yellow/1 green sides

Overhead transparency explaining rules for Remove (O/H4.1)

Each participant needs 12 distinguishable counters

Overhead transparencies for session outline (O/H4.2)

Step One: Explaining the game

Use O/H4.1 to explain how to play the game.

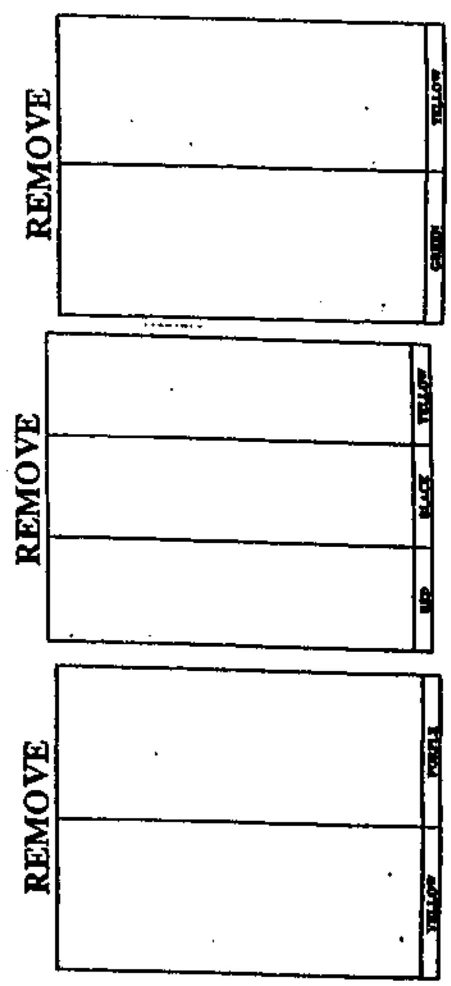
REMOVE

Materials needed:
REMOVE boards - matching particular die
Dice with: 4 yellow/2 purple sides
3 yellow/2 red/1 black sides
5 yellow/1 green sides
Each player needs 12 distinguishable counters

Rules:
2 or 3 players per board /matching die.
Each participant places their 12 counters in any of the columns on the board.
Participants take it in turns to roll the die.
If they have a counter in the column indicated by the roll of the die that counter can be removed (note only one counter per roll).
The winner is the first person to remove all of their counters.

O/H4.1

GAMEBOARDS



Step Two: Playing the game

Participants to play the game and to try at least two of the boards.

Step Three: Brief Discussion

Discussion Pointers

- What are possible learning outcomes? (To do with matching ratios on the die to the number of counters placed in any particular column / as well as chance outcomes)
- Which year levels is it best suited to? - use CSF outcomes O/H

Step Four: Session overview

Use O/H4.2 to outline content of this session.

SESSION 4

- **'Remove'**
- **Sharing - trialling of clue cards**
- **Writing clue cards**
- **Some statistics connections**
- **Questioner tag**

O/H4.2

ACTIVITY 4-2

Between Sessions Sharing - Clue Cards Trialling

Approximate time: 15 minutes

Materials needed: None required

Step One: Sort participants into the following groups.

These groups are based on having one from each level of the school and where possible no one together from the same school.

Table 1	Table 2
Teresa	Dianna
Bianca	Megan
Gerry	Gail
Trevor	Helen

Table 3	Table 4
Sally	Karen
Deidre	Olivia
Kaye	Neva
Nora	Tasha
Malcolm	

Step Two: Explanation of the task

Table groups are to share with each other the clue-cards they trialled and whether it was a good strategy to use to promote children's mathematical discussion. Discuss the strengths and weaknesses of this approach. Compare it to the other strategies - jigsaw, think-pair-share.

Step Three: Whole group sharing

Table groups to share one or two worthwhile points/decisions.

ACTIVITY 4-3

Writing Your Own Clues

Approximate time: 15 minutes

Materials needed: Overhead transparency with demonstration example (O/H4.3)

Problem cards for each group - on overhead transparencies (O/H4.4, 4.5, 4.6, 4.7).

Overhead pens for each group

Step One: Explanation of the task

Table groups to be given an overhead with a 'typical' problem. The group is to come up with a set of clues (3 to 5) so that the question could be dealt with using clue cards. The clues need to have the same question.

A demonstration would be useful - use O/H4.3.
Note that the 'traditional version' of the question has been used to supply some of the thinking for the clues / a new question has been generated - and note how it is more open-ended and the advantages of such a question.
Talk about the idea of including 'questions of none or little value' and asking children to suggest which ones these might have been in whole class discussion.

Traditional' form of question:
Two six-sided dice are rolled. One has three blue sides and three red sides. The other dice has two green, two purple and two yellow. What are all the possible combinations that can be rolled.

CLUE CARDS:
Question: Describe the two dice that fit the following clues?

Possible clues:
- There are a total of five colours on the two dice.
- The chance of rolling red-green is the same as blue-yellow.
- On one of the die the chance of rolling green is the same as it is to roll purple.
- The die that has yellow has two other colours.

O/H4.3

PROBLEM 1

You are making savory biscuits for supper. You have three different meats and four different sauces to use. You want to have at least one of every possible combination of meat and sauce. What is the minimum number of biscuits that you would need?

O/H4.4

PROBLEM 2

A spinner has 30% blue, 50% green and 20% purple. What would you expect to happen in 100 spins?

O/H4.5

PROBLEM 3

Your mother has three different handbags, two different pairs of gloves and two different hats. They all blend together well. How many different ways can she dress using all three types of accessories?

O/H4.6

PROBLEM 4

Jonathan was putting his four toy animals in a line. He kept changing the order of them. How many times could he do this differently?

O/H4.7

Step Two: Groups working

Each group brainstorms possible clues and then indicates which are the best 4/5 clues to use.

Step Three: Whole group sharing

Each group can share their problem and clues on overhead. To be included in the next set of handouts.

ACTIVITY 4-4

Some Connections to Statistics

Approximate time: 15 minutes

Materials needed: A six-sided die for each participant

Step One: Estimation

Pose the question:
If you rolled your die ten times what would be a likely total of the ten numbers rolled? Write this down and share with the group.

Why have you selected your total? How might children answer this?

What would be the range of numbers, i.e. what would be the lowest total? (10) the highest total? (60) (35 would be a middle total and probably the mathematical expectation)

Step Two: Run with the question

Each participant to roll their die ten times and total the ten numbers.
PD presenter writes the totals on the board.
For example:

36	49	51	25	37
53	13	34	36	29
30	43	19	22	36
12	57	39	26	18

Questions:
Did anyone get the guess?
Was anyone within 5 of their guess? etc
What numbers might have been rolled if your total was 15? (a nice mental computation task because there are many answers)

Step Three: Some connections to statistics

Sort the data onto a stem and leaf plot. The stem records the 'tens part' of each item, and the leaves individually record the 'units part.
From example in Step Two:
Stem and leaf plot

STEM	LEAVES
0	
1	2 3 8 9
2	2 5 6 9
3	0 4 6 6 6 7 9
4	3 9
5	1 3 7
6	

Share the following statistics and 'middle measures'.

From example:
Range: 12 to 57

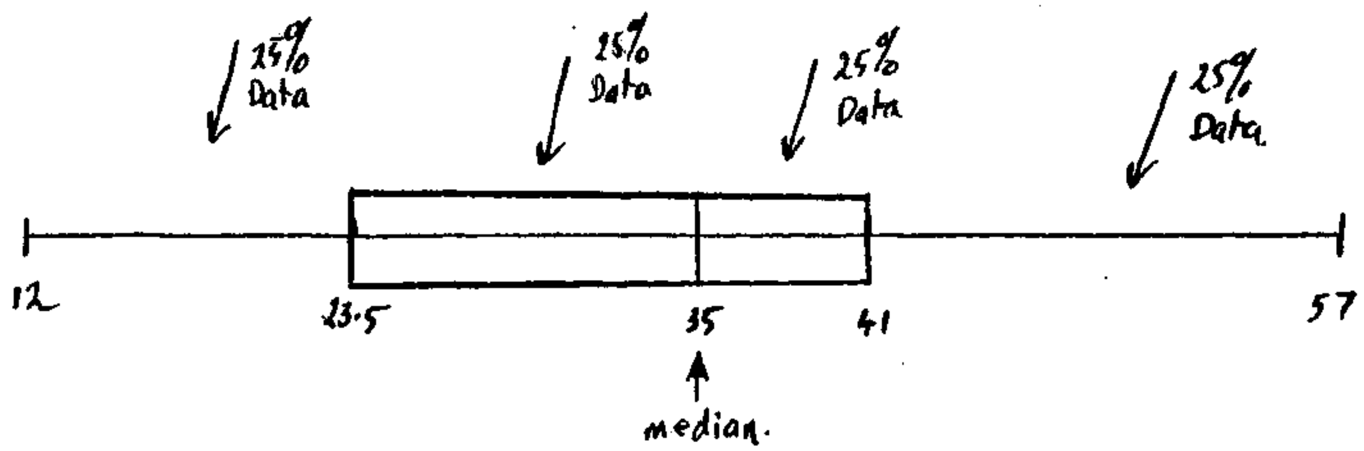
Mode (most common result): 36 (there may be 2 or more modes - hence bi-modal)

Median (the middle result): 35 (i.e. the average of 34 and 36 - will need to average for an even number of results) (to work out the median count along from the first entry 10 items, i.e. half the total items; to check, count up from the last item 10 items) (beware - counting up from the bottom remember to start with the end number in each line).

Mean (average): [22 +23 + 28 + ... + 57] ÷ 20

Which is the best middle measure to explain what happened - mode, median, mean?

Draw a box plot as follows:



<u>Discussion points:</u>
Which year levels should have an understanding of this? CSF substrand Summarising and Presenting Data talks about these statistics but not Box Plots.
Would Year 6 students understand Box Plots?

ACTIVITY 4-5

Questioner Tag Strategy

Approximate time: 15 minutes

Materials needed: Overhead transparency with question (O/H4.8)
Maths Badges

Solution - so that questions can be answered.

Overhead transparencies of 'Other people problems' (O/H4.9, 4.10, 4.11)

Step One: Set the problem / Explain the 'Questioner tag' strategy

Use O/H4.8 to outline the problem that table groups are to solve.

Problem:

On the arrival of their last child the proud parents were delighted that they had ended up with the gender combination that they had wanted.

The father said, "Wow, that must be a chance of one in a million!!!"

"No," said the mother (who is a primary teacher) "Actually the chance is a little more certain than 1 in 3."

What was the gender combination that the parents had wanted.

O/H4.8

'Question Tag' Strategy:
One participant at each table group is given a badge to wear. This person is allowed to come and ask the teacher (pd presenter) questions that the group would like answered.

Note:
The questions must be the groups and not the questions that the badge wearer wants to ask. **Limit the questions to five per table.**

Step Two: Set the groups to work on the problem

While the groups are working on the problem the teacher should stand at one side, away from the working groups, so that when questions are answered the closest group doesn't listen in to the questions/answers.

The teacher must answer the questions honestly but in a way that doesn't make the problem/process to easy.

If you are asked "What gender was the last born?" You'll need to explain that it doesn't matter - but that it's the proportion of girls/boys that they are seeking.

The answer is 2 boys and 2 girls.

Some mathematical background
he following are all combinations for four children:

BBBB	The one way to get 4 boys
GBBB	
BBBG	The 4 ways to get 3 boys/1 girl
BGBB	
BBGB	
GBBG	
GBGB	
GGBB	The 6 ways to get 2 boys/2 girls
BBGG	
BGBG	
BGGB	
GBGG	
GGBG	The 4 ways to get 1 boy/3 girls
GGGB	
BGGG	
GGGG	The 1 way to get 4 girls

Thus there are a total of 16 ways to have 4 children, and 6 out of the 16 ways (ie 37.5%) result in the 2 boys/2 girls.

Note that there are 3/8 ways for getting 2 boys/1 girl OR 1 boy/2 girls in a 3-child family. This % is the same as above - thus they will need to ask how many children are in the family.

BBB
BBG
BGB
GBB
BGG
GBG
GGB
GGG

A 5-child family results in percentages less than 1 in 3.
A 2-child family results in percentages of 50% (for 1 boy/1 girl) or 25% (2 boys or 2 girls).

Step Three: Discussion

Discuss the strengths and weaknesses in using the 'Questioner tag' strategy.
Discussion points
STRENGTHS:

- teacher can monitor what is going on in the classroom by the questions being asked
- the teacher can gain some insights into children's thinking, misconceptions, knowledge previously taught and yet still not really understood by the questions asked
- the groups need to make infonned decisions on which questions they ask
- mathematical language is essential

- the 'questioner' particularly needs to understand and be able to give explanations back to the group

WEAKNESSES:

- some children will feel threatened with the role of 'questioner
- the group may make decisions while the 'questioner' is away from the group

Step Four: Other interesting 'people' problems

Share these problems with the group.

•The chances of having 13 boys in a row??? - show O/H4.9.
The chance is 1 in (2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2) ie 1 in 8 192.
Each event is independent of the other - there are 2 choices for each event.
Show O/H4.9.

•The probability of a brother having a brother
Show question -on O/H4.10:
If a man says, "Of my two children one is a boy, what is the chance that both are boys?"
Allow the group to give their opinion on this - most will probably say 1 in 2 which is wrong.

Solution is on O/H4.11
Answer: 1 in 3

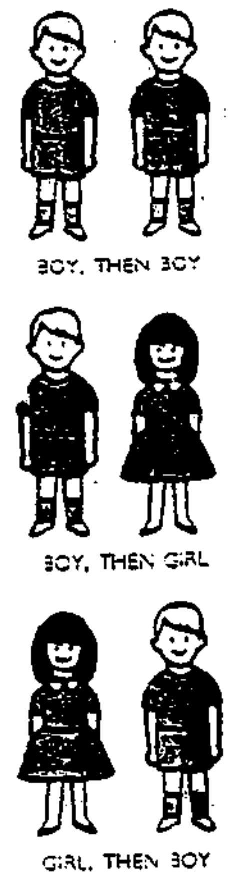
•Birth month paradox / sharing birthdays:
Refer to class handouts and MCTP Chance and Data Vol1.

O/H4.9

PROBLEM

If a man says, "Of my two children one is a boy, what is the chance that both are boys?"

O/H4.10



O/H4.11

ACTIVITY 4-6

Green and White Containers

Approximate time: 15 minutes

Materials needed: Green and White containers with counters

Video

Step One: General discussion

The purpose of this activity is to draw out some ideas on children's conceptual thinking in chance, and to consider further the role of a constructivist teacher.

All the participants have been mailed the article by Patricia Jeffery - so the ideas from that article can be drawn upon.
Perhaps 'Fennema's model' is useful.
2nd page comment/3rd starred item: there is a realisation by the children that the teacher's primary interest is to understand their solutions rather than to judge the correctness of their answers.
•last starred item: children are actively constructing mathematics -the video certainly shows that.

Show video. Replay video if it seems appropriate.
Notes on video:
Two containers are used. The green container has 2 red counters and one blue counter and the white container has 4 red and 2 blue counters. Several children are shown the containers and told that they will win a game if they select a red counter. They are asked which container they would prefer to use in making their selection. Most children initially chose the white container but two of them when they are requested to give an explanation for their choice construct 'new' knowledge and change their selection or say that it does not matter which container is being used.

Discussion points:
Why do some children chose the green container? - because they focus on the greater quantity.

No example on the video but some children did pick the white container because they thought that they had a better chance because there were not as many to 'get wrong'.

The task depends on understanding ratio and seeing that there can be equivalents i.e. 1 in 3 and 2 in 6 are the same.

At about what year level would you expect children to have some real understanding of this problem. Those that investigated this may be able to supply some data on this.

What are the implications for teaching and learning?

Do you know of any activities that would assist children to come to an understanding of this concept?

ACTIVITY 4-7

Administration

Approximate time: 5 minutes

Materials needed: Handouts: Session 4 evaluation sheet & Session Handouts (refer page A-56)

Step One: Explanation of between sessions trialling

- The between sessions activity is to plan and trial a chance activity that makes use of the clue cards strategy and to reflect upon its value for encouraging pupils to talk about the mathematics involved in the activity.

Step Two: Complete session 4 evaluation sheet

End of Session 4 Evaluation:

Name:

A What is your initial reaction to the 'questioner tag' strategy?.

____

____

B Have you learnt some mathematics today that you had not understood before?

Yes No

If yes, state what the new maths was and note whether you think that it will be useful in your teaching.

____

____

C We've had a long break between sessions 3 and 4. What do you see as the advantages or disadvantages of this long break? Advantages:

____

____

Disadvantages

____

____

For you, do the disadvantages outweigh the advantages. YES NO Why?

____

____

D Any other comments about today's session.

____

____

List of handouts

- Cover page
- Rules and gameboard for Remove (refer to Activit 4-1)
- Rules and grids (hexagonal, square) for the game Random Walk.
- Pulse Rates stem and leaf plots student sheets 2 & 3, from *Statistics: Middles, Means and In-betweens,* Dale Seymour Publications.
- Rules and gameboard for 'Dice Differences' (Curriculum Corporation 1993).
- Bruni, J.V. & Silverman, H.J. (1986), Developing Concepts in Probability and Statistics - and Much More. *Arithmetic Teacher, February,* pp34-37.
- Perry, B. (1996), Children Constructing Their Mathematics: Implications for Teachers. *The Mathematics Educator,* 1(1), pp.17-24.
- Between sessions classroom trialing sheet.

CLASSROOM TRIALLING:
BETWEEN SESSIONS 4 AND 5:

Plan and trial a session for the topic of chance that uses the 'Questioner Tag' strategy. The following headings may assist your planning and evaluation.

Problem:

Summary plan:

Resources needed:

Intended learning outcomes:

Pupil reaction:

- **to the chance content**
- **to the 'questioner tag' strategy**

How could it be improved the next time:

SESSION 5

SEQUENCING ACTIVITIES AND ROLE PLAY

Activity Number	Page reference	Activity Handout	Workshopped activity (W) and/or Handout (H)	Major focus M/T/C M*
5-1	A-58 to 59	Problems from Last Session	W	M*
5-2	A-60 to 61	Between Sessions Sharing - Questioner Tag	W	M/T/C
5-3	A-62 & 91	Conditional Probability and Independence	W/H	M*
5-4	A-63 to 64 & 91	Scenarios	W/H	M*/C
5-5	A-65 to 66 & 72	Sequencing Activities	W/H	M*/C
5-6	A-67 to 69 & 72, 91	Role Play	W/H	M/T
5-7	A-70 & 72	Random Walk	W/H	M
5-8	A-71	Administration		
	A-72	Handout: Football Finals & Final Five	H	M
	A-72	Handout: One clue at a time	H	M/T
	A-72	Handouts: Smith, 1995 from MAVRIC & AAMT	H	M/T
	A-72	Handout: Home prices jump	H	M*

(M-mathematics content; T-teaching strategies content; C-constructivist notions content; M*-mathematics content aimed at extending participant's knowledge)

ACTIVITY 5-1

Problems from Last Session

Approximate time: 10 - 15 minutes

Materials needed: Overhead transparency of photo of family with 13 boys (O/H4.9)

Overhead transparency of solution for 'two boys' problem (O/H4.10, 4.11)

Overhead transparency of session overview (O/H5.1)

Step One: General discussion

Remind participants of the two problems introduced at the end of the last session

Step Two: The '13 boys' problem

Ask if anyone has thought about this since last time and wants to share their thoughts about a solution.
•**The chances of having 13 boys in a row**
The chance is 1 in (2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2) ie 1 in 8 192.
Each event is **independent** of the other - there are 2 choices for each event.
Show O/H4.9.

NOTE: That having 7 girls followed by 6 boys **in that order** has the same probability of 1 in 8 192.
OR
that have BGBGBGBGBGBGB in that order is the same probability of 1 in 8 192.
Each event is independent of the previous events.

Having 7 boys and 6 girls (with no concern to the order) has a greater chance because there are a nuber of ways of doing this.

Step Three: The probability of a brother having a brother

Show question -on O/H4.10
If a man says, "Of my two children one is a boy, what is the chance that both are boys?"

Allow the group to give their opinion on this - most will probably say 1 in 2 which is incorrect.
Refer to solution on O/H4.11.

Answer: 1 in 3

Only workshop the following if it seems appropriate.
Worth discussing the idea of modelling the situation.

This problem can be modelled using tossing of 2 items where there is an equal 2-way choice. The most obvious tossers to use would be coins - heads can represent boys; tails can represent girls.

Pairs of students could toss two coins a number of times and record results. The results from the whole class could be compiled and a pattern investigated – i.e. the expected pattern would be that there would be twice as many H/T combinations as H/H combinations for example 72 H/T's and 31 H/H's, making a ratio of H/H out of the total containing a head 31 out of 103 - close to the expected 1 in 3.

Could discuss why this problem created so much interest.
Tapped into a common misconception - created conflict in beliefs and hence discussion became animated because participants were not easily swayed from what they understood of the problem.

Step Four: Session overview

Show the session overview O/H5.1.

SESSION 5

- **Revisiting problems from previous session**
- **Reflection on using 'Questioner tag'**
- **Sequencing activities**
- **Role play**
- **Scenarios**
- **Some brief activities**

O/H5.1

ACTIVITY 5-2

Between Sessions Sharing - Questioner Tag

Approximate time: 10 minutes

Materials needed: Overhead transparency with list of collaborative strategies (O/H5.2)

Step One: General discussion - whole group

Discussion points:

- How many people tried this?
- What were the questions/problems given?
- What were the successes / failures?
- Questioner tag - what are the advantages / disadvantages
- When comparing it to the other strategies (use O/H5.2) what qualities does questioner tag have that the others don't (and vice versa)
- Of the strategies introduced so far does anyone have a preference - and why?

Notes on strengths and weaknesses from last session

STRENGTHS:

- teacher can monitor what is going on in the classroom by the questions being asked
- the teacher can gain some insights into children's thinking, misconceptions, knowledge previously taught and yet still not really understood by the questions asked
- the groups need to make informed decisions on which questions they ask
- mathematical language is essential
- the 'questioner' particularly needs to understand and be able to give explanations back to the group

WEAKNESSES:

- some children will feel threatened with the role of 'questioner
- the group may make decisions while the 'questioner' is away from the group

COLLABORATIVE STRATEGIES

- Think- pair - share
- Jigsaw
- Clue Cards
- Combination of clue cards and jigsaw
- Questioner tag

O/H5.1

ACTIVITY 5-3

Conditional Probability and Independence

Approximate time: 5 minutes

Materials needed: Overhead transparencies for explanations (O/H5.3 &5.4)
Copies of activities from past sessions

Step One: Explanations

Independent and independent events
Use O/H5.3 - Independent and dependent events to explain the difference between these situations.

Participants might like to give other examples.

Conditional probability
Use O/H5.4 - Conditional probability to explain the difference between these situations.

Participants might like to give other examples.

INDEPENDENT EVENTS

Two events are independent of each other if one of them does not change the probability of the occurrence of the other.

For example:
- **the gender of the second child born does not depend on the gender of the first child.**
- **tossing a coin does not depend on the results of previous tosses**
- **a result from rolling a die does not depend on the results from previous rolls.**

O/H5.3

CONDITIONAL PROBABILITY

Sometimes the probability of an event occurring is effected by a previous event.

The most obvious situation is in an experiment when an item is not replaced.

For example:
- **a bag contains a red ball, a blue ball and a yellow ball.**

What is the chance of drawing a red ball on the second draw?

This depends on whether red is drawn out the first time.

If red is drawn out on the first draw the chance of drawing it out on the second draw is zero.

If blue is drawn out on the first draw then the probability of drawing red on the second draw becomes 1 out of 2, (or 50% or 0.5).

O/H5.4

ACTIVITY 5-4

Scenarios

Approximate time: 15 minutes

Materials needed: Overhead transparencies with Scenarios (O/H5.5, 5.6, 5.7 & 5.8)

Step One: Explanation of the task

Explain that each table group is to consider a classroom scenario and come to some consensus on the child's understanding of chance (for the given situation) and how they would then cater for this child.

Step Two: Table groups

Each table group works on their scenario - using one of the overhead transparencies per table.

SCENARIO

Yvette is playing Snakes and Ladders and hasn't yet started playing on the board because she hasn't rolled a six, even though she's rolled the die at least 20 times.

You overhear her say, "I will get a six on the next roll, it must be sixes turn!"

O/H5.5

SCENARIO

Tan Wong has been playing poker at lunch time with his grade 6 class mates. In four games he has had at least two aces in every hand and easily beaten the others.

He whispers to you that it is his lucky day and he is expecting to get at least two aces in every hand.

O/H5.6

SCENARIO

Alice was rolling a die and had rolled a 2, followed by a 3, and then a 4.

She said to you' "My chances of getting a 6 are now better because it's working in a pattern."

O/H5.7

SCENARIO

Dimitra was playing with a spinner which had only red and yellow and both in equal amounts. She had said that there was an equal chance of getting either colour. On her first spin she got a red, but said that for the following spins the chance was still equal.
She got a red on her second spin.

Shen then said to you, "I think there must be something wrong with this spinner I'm going to get red all the time!"

O/H5.8

Step Three: Reporting to whole group

A spokesperson from each table shares their group's summation of the situation. Brief group discussion can be held if appropriate.

<u>PRESENTER'S NOTES:</u>
Yvette doesn't realise that each roll of the die is independent of the previous rolls.
This is a misconception referred to as gambler's fallacy or negative recency effect.

Scenario with Tan Wong: This is the positive regency effect i.e. that his first samples are going to be 'representative' of the remaining samples.

Alice is trying to impose regularity on a situation that has none.

Dimitra has fairly strong knowledge of independence but in the end the representativeness misconception dominates.

ACTIVITY 5-5

Sequencing Activities

Approximate time: 25-30 minutes

Materials needed: Overhead transparencies of notes (O/H5.9 & 5.10)

(Summarised from Jones, G.A., Langrall, C.W., Thorton, C.A. & Mogill, A.T. (1997), A Framework for Assessing and Nurturing Young Children's Thinking in Probability, *Educational Studies in Mathematics, 32,* pp101-125)

Step One: Explanation

Use O/H5.9 & 5.10 to explain the four different levels of understanding of conditional probability and independence.
Participants may have children / experiences that they could talk about that fit these levels.
The scenarios from the previous activity could be slotted in to these levels.

<u>LEVEL A</u>

Characterised by children who
- rely on subjective judgements when interpreting probability situations
- ignore relevant quantitative information
- generally believe that they can control the outcome of an event
- impose their own regularity on what is happening
- predict outcomes with unwarranted confidence

<u>LEVEL B</u>

Characterised by children who
- are in transition between subjective and informal / naive quantitative thinking
- can sometimes make informed decisions but are easily distracted by irrelevant features
- may use the 'representativeness' heuristic
- may revert to subjective explanations when outcomes do not match expectations

O/H5.9

<u>LEVEL C</u>

Characterised by children who
- aware of the role quantities play in conditional probability judgements
- do not usually assign precise numerical probabilities
- can keep track of changing conditional situations

<u>LEVEL D</u>

Characterised by children who
- confidently use numerical reasoning to interpret probability situations and thus hold strong convictions
- can distinguish between independent and independent events
- are reluctant to make predictions when all outcomes are equally likely

O/H5.10

Step Two: Matching activities

Use the following activities:
- Dicetracks
- Hat, Scarf and Belt
- Ticking Off
- Toss of Luck

(A sample will be provided for each group)

Sort out table groups so that the participants working together have trialled (or feel 'knowledgeable' about) that activity. ie there will be one table considering 'Dicetracks', one table considering 'Hat, Scarf and Belt' etc.

Ask the groups to match their activity to one of the outlined levels so that the most learning could be gained from the experience. need to list the sort of questions that they would ask as teachers, or the sort of discussion points that would be included, etc.

Reference to CSF outcomes, handouts from session1, could be useful.

Step Three: Reporting back

Groups to report back on their decisions.

ACTIVITY 5-6

Role Play

Approximate time: 20 minutes

Materials needed: Overhead transparencies with pictures of characters (O/H 5.11 & 5.12)
Story notes
Overhead transparency with 'Basketball problem' (O/H5.13)

Step One: Introductory discussion

Ask whether any of the participants use co-operative groups where the children play out roles such as:

- recorder
- reporter
- gopher (collector of materials)
- encourager
- praiser
- noise level monitor
- time-keeper
- auditor (keeping the discussion on track / checking calculations)

Do they use this teaching strategy in mathematics? How? Why? Why not? Is it successful?

Step Two: Introduce roles and characters

Explain that you are going to extend this idea giving it a mathematical flavour and into the use of role play / possible drama activity and then solve a problem.

Tell the story for character 1 (see following notes) in your own words and then discuss the role for that person i.e. the role that could be taken in group problem solving.

Repeat this for character 2.

Character 1: Freda Five - Encourager
Freda is one of the trainers down at Roger Round's Stables adjacent to Plus Park. She's been into horses since she was about ten. Her first ride on a horse was up at Uncle Dan Divide's farm. She can remember it really well. First Uncle Dan just led her around sitting on the horse, then they went riding as a duo. This was tantalizing, and from then on she was determined to learn to ride. Every possible spare weekend was spent up at the farm and when she was 14 her parents bought her her own horse that was also kept up on the farm. She was soon entering equestrian events particularly show jumping. After Year 11 she went into a TAFE course to do with caring and training animals and she naturalized specialized in horses.

She started down at Roger Round's straight after this TF course in a very junior position – doing all the jobs that no-one else enjoyed. With sheer determination she slowly worked her way up into the position of being lead trainer. Her skills at getting everything possible out of the horses most likely comes form the time with her own horse when she had him jumping obstacles and fences other riders couldn't get their horses to attempt. There was something special about the way she treated her horses, about the rapport she seemed to develop, something in her voice and manner that seemed to make the horse excel beyond normal expectations.

She spends a fair bit of time with the jockeys as well. Her encouraging attitude with them is similar to that with the horses. The jockeys all look to Freda for inspiration for their race.

Freda 'lives and breathes' horses! When she's not involved in training down at Roger's, she's off riding up on the trails of Mount Multiplication, or grooming and caring for the three horses she now owns. Her husband doesn't ride at all, but their children are as keen as mustard – just like Freda was.

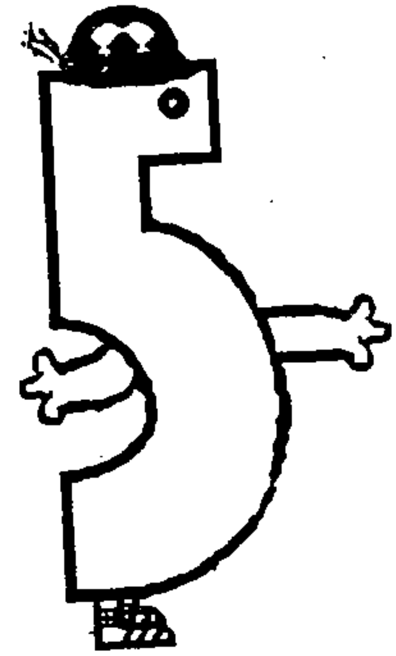
Character 2: Sid Square – Reporter
Sid even from a very young age went to the horse races with his grandpa. Sid has lived in Addville all his life and from the age of about six he would stay overnight with Gran and Grandpa Gradient nearly every Friday and go to the races at Plus Park on Saturdays. Grandpa was a pretty heavy gambler and never admitted to how much he money he really lost. But Sid (and Gran) always heard about the good wins he had. Sid got to know many of the jockeys, trainers, and others who worked at Plus Park. He became skilful at being able to pick each horse and jockey by the colours they were wearing. So it is not surprising that Sid is now employed in the racing industry.

During his secondary years of schooling he was in the school's debating team, not so much for creating logical argument, but for the convincing way he could get across a message. The emotion in his voice, and the clear enunciation swayed many of the judges at the school debating competitions. He's still involved in debating teams and is often engaged to speak at dinners.

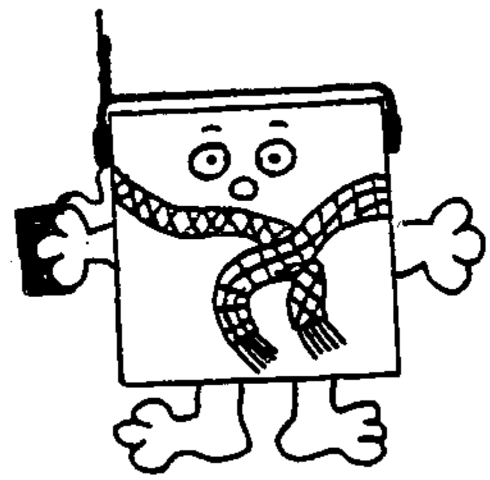
What have these skills got to do with employment in the racing industry? Well he works for 3ADD, Addville's premier FM station, as a race caller. He's now been in this position for seven years, but had over twenty years with 3BOMDAS, Addville's AM sport's station. His winners predictions are taken up by many punters who believe he has the best knowledge of all the callers. His record for predicting the winner of the annual Addville Cup is quite amazing – of the last ten races he's successfully predicted seven winners.

Even though his skills at prediction are good, he's never been one to back horses. Perhaps he had some feel for how much Grandpa lost. He knows from chatting to the bookmakers when he was young that no one ever really wins in the long run except the bookmakers. Besides he's pretty good at maths and realizes that the odds given out when totaled for a race always fall short from the punter's point of view.

You'd probably expect him to enjoy horse riding. Well you're quite wrong there! What he does enjoy riding is his Harley Davidson. Any free day that he has he dons his leathers and he's off to enjoy the fresh country air with some of his mates.



O/H5.11



O/H5.12

Step Three: Working on a problem using the role play strategy

Set the table groups to work on the 'Basketballer problem' - use O/H5.11.

Each group is to have a:
- Recorder
- Reporter
- Encourager

PROBLEM:

Trent has been playing basketball this season and after eleven games his average goal score is 6.

His lowest match scores are 1, 2 ,3 and 5.

His most common match score is 8 and the median score for the eleven matches is 7.

What are the eleven scores?

O/H5.13

Step Four: General discussion

Lead general discussion of the effectiveness of using the role play strategy in problem solving.

ACTIVITY 5-7

RANDOM WALK

Approximate time: 10 minutes

Materials needed: Game boards - 3 different versions

Counters to use as a marker

Six-sided die

Step One: Explaining the rules

Explain the rules of the game:

Materials needed:

- Game boards - varios grid sheets - square and hexagon
- Counter to use as a marker
- Six-sided die

How to play:

This is a 'game' for one person.

GAME 1: Hexagon Walk

On a hexagon grid place a counter in the hexagon with the numbers around the edges (ie a hexagon in the centre of the sheet has sides numbered with 1 2 3 4 5 6). Roll the die and move your counter to the hexagon which is attached to the edge with the number you have just thrown. Continue this process. Plot you movement around the playing board. When your counter leaves the paper (if it ever does!) the game is finished.

GAME 2: Square Walk 1

As above but note the bias. A square in the centre of the sheet has one side with the numbers 1 2 3, second side has 4, third side has 5, fourth side has 6.

GAME 2: Square Walk 2

Note the different bias. A square in the centre of the sheet has one side with the numbers 1 2, second side has 3 4, third side has 5, fourth side has 6.

Step Two: Playing the game

have participants play the various games.

Step Three: Discussion

Discussion points:

- What did you learn as adults from these games?
- What would be the learning outcomes from playing these games?
- What would be the most suitable year levels?
- Is there a 'best' order in which to play the games in order to achieve the most effective learning outcomes - ie is it best to start with the two biased versions the best ones?

ACTIVITY 5-8

Administration

Approximate time: 5 minutes

Materials needed: Handouts: Session 5 evaluation sheet & Session Handouts (refer to page A-72)

Step One: Explanation of between sessions trialling

- The between sessions activity is to plan and trial a chance activity that makes use of the role play strategy and to reflect upon its value for encouraging pupils to talk about the mathematics involved in the activity.

Step Two: Complete session 5 evaluation sheet

End of Session 5 Evaluation:

Name:

A In what way has an understanding of independent events and conditional probability helped you in your teaching of chance?

____

____

B Some researchers would say that pd is best when your principal is supportive. Would you agree with this? Why/why not?

____

____

Has your own principal been supportive towards your attendance at this pd? YES NO Give an example.

____

____

C Was there something from today's session that needed further explanation?

____

____

D Did you find the pace of the session today appropriate, too slow, too fast? Give some reason for your decision.

____

____

E Any other comments about today's session.

____

____

List of handouts

- Cover page
- Notes from O/H 5.9 & 5.10
- Football Finals, taken from *The Age, 18/8/97*
- Rules for the game Random Walk (as for Activity 5-7)
- Ministry of Education (1990), Final Five, In *Reality in Mathematics Education: RIME5&6 Activity Book,* Melbourne: Ministry of Education, pp151-156.
- Smith, R. (1997), One clue at a time!, In R. Smith & J. Mousley (Eds), *Mathematics Education 1 Study Guide,* Melbourne: Deakin University, pp71-72.
- Role play notes - Trixie Trigon; Sid Square (as for page A-67 & A-68)
- Smith, R. (1995), *Encouraging Class Discusion in Mathematics,* A paper presented at MAVRIC - Hamilton '95.
- Smith, R. (1995), Promoting Mathematics Interaction, In A. Richards (Ed.), *Forging Links and Integrating Resources,* Darwin: Australian Association of Mathematics Teachers, pp330-336.
- Home prices jump 11pc, taken from *The Age 18/8/97* p.1 (showed real world use of median)
- Between sessions sharing sheet - role play strategy.

CLASSROOM TRIALLING:
BETWEEN SESSIONS 5 AND 6:

Plan and trial a session for the topic of chance that uses the Role Play strategy. The following headings may assist your planning and evaluation.

Problem:

Summary plan:

Resources needed:

Intended learning outcomes:

Pupil reaction:

- **to the chance content**
- **to the role play strategy**

How could it be improved the next time:

SESSION 6

LINKING MATHEMATICS AND SAMPLING

Activity Number	Page reference	Activity Handout	Workshopped activity (W) and/or Handout (H)	Major focus M/T/C M*
6-1	A-74 to 75	The Paper Clip Game	W	M
6-2	A-76 to 78 & 91	M & M's	W/H	M*
6-3	A-79 to 81	Comparing Group Work Strategies	W	M/T/C
6-4	A-82 to 84	Scenarios	W	M/C
6-5	A-85	Sharing resources	W	M/T/C
6-6	A-86 to 87	Family Feud	W	M
6-7	A-88 to 89	Administration		
	A-90	Handout: Life's big numbers	H	M
	A-90	Handout: Edwards, 1995	H	M
	A-90	Handout: Everybody Wins	H	M
	A-90	Handout: Spinner Sheet and Clue Cards	H	M/T

(M-mathematics content; T-teaching strategies content; C-constructivist notions content; M*-mathematics content aimed at extending participant's knowledge)

ACTIVITY 6-1

The Paper Clip Game

Approximate time: 10 - 15 minutes

Materials needed: Two one metre rulers

Paper clip

Overhead transparency of session outline (O/H6.1)

Step One: Pose the question

Pose the following question:

What is the chance that adults attending the Doveton Heights PD session can blow a paper clip on a table for at least one metre or more?

Responses could be gathered:

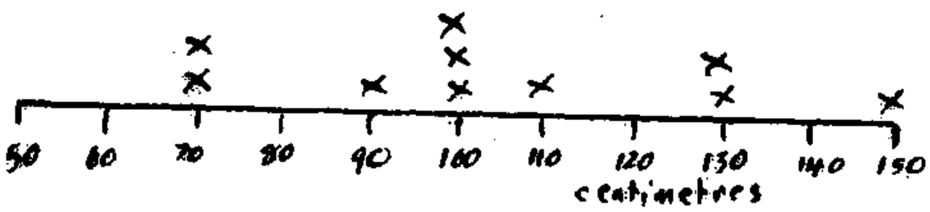
- using chance language - certain, fat chance, fifty-fifty, etc
- as percentages
- in other ways - 1 in 4

Step Two: Collecting data

Run the experiment using the two 1metre rulers as a track for the paper clip to be blown along.

There may be difficulties in how to run this, for example, at what angle do people have to blow, should they trial more than one blow and average (to save time probably 'no!')

Put the data for each participant on to a line plot - example below.



Discuss the middle measures of this data - mode, median, (estimated) mean - the range and how the data is spread.

How could the original question now be answered?

Step Three: Connections to other mathematics

Brainstorm the other mathematics that has been involved in this activity - be specific.

For example,

- awareness of the attribute of length
- measuring to the nearest centimetre / ie rounding off measurements
- comparing lengths
- use of a number line
- collecting and organising data / 'bar graph' type representation
- problem solving - in the running of the experiment

Discussion point:
With a 'lesson' like this, where the 'chance situation' only provided the initial motivation, it is probably the mathematics that will form part of the investigation rather than the chance outcomes that should drive which year level the activity best fits.

And hence, where would 'The paper clip game' best fit?

Step Three: Session overview

Outline the session using O/H6.1.

SESSION 6

- **The paper clip game**
- **M&M's**
- **Comparing collaborative strategies**
- **Scenarios**
- **Sharing resources**
- **'Family Feud'**

O/H6.1

ACTIVITY 6-2

M & M's

Approximate time: 20 minutes

Materials needed: Small M&M packet for each participant

Overhead transparency with percentages of each colour (O/H6.2)

Textas

Step One: Counting the M&M's

Give each participant a box of M&M's.

Ask them to count the number of M&M's in their box.
Place this data onto a line plot.
Work out the middle measures - mode, median and (estimated) mean - the range, and discuss the spread of the data.

Ask questions like the following:

- What is the chance of getting a box containing 16 or 17 M&M's?
- What is the chance of getting 23 M&M's?
- What is the chance of getting more than 13 M&M's?

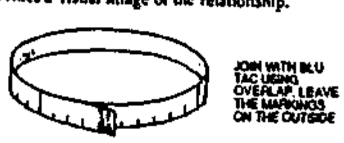
Step Two: Sampling colours

Ask each participant to count the numbers in each colour and to draw an approximate pie graph to show the number for each colour. Write in approximate percentages for each colour.

Share the methods for construction of pie graphs and particularly note the following method if no one in the group has used it.

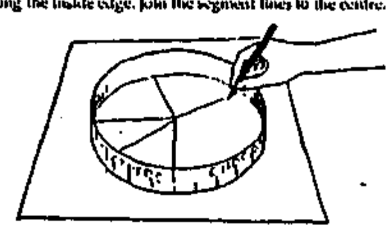
3. Strip graph to pie chart

Do this step slowly and demonstrably. The action from straight line to circle provides a visual image of the relationship.



From Lovitt & Clarke (1988) Vol. 1 p. 145

Place the cardboard ring unto butcher's paper and draw a circle by tracing along the inside edge. Join the segment lines to the centre.



Remove the cardboard ring, and complete the pie graph by labelling it.

Step Three: Comparing pie graphs

Have the participants circulate around the class with their pie graph to see if anyone else has the same (or close) pie graph i.e. same colour sample.

Discuss what a large bag of M&M's might have as their colour percentages. Could this be worked out from the sample pie graphs?

Show O/H6.2 of percentages of each colour as supplied by the M&M factory. Does anyone have a sample that is like this? Why / why not?

Consider whether the samples taken are reasonable and what could be done to get a better picture ie take larger samples. How could this be done for example, pairs could get together to make a larger sample.

Or the whole class could pool their number for each colour - particular participants could be responsible for totalling a specific colour. Then work out the percentage for each colour from this large sample.

M&M's

Red	20%
Brown	30%
Blue	20%
Yellow	10%
Green	10%
Orange	10%

O/H6.2

Step Three; Some general discussion

Discussion points:
- the idea of taking random samples and the probability that these will represent the parent population
- appropriate sample size - how do you decide what to make it?

Refer to the following summary notes on sampling.

Summary notes on the process of sampling
(Taken from Corwin, R.B. & Friel, S.N. (1990), Used Numbers - Statistics: Prediction and Sampling, Calif.: Dale Seymour Publications)

Primary school pupils should experience real mathematical processes - they should act like scientists and statisticians by collecting and analyzing real data and encountering the uncertainty and intrigue of everyday situations.
Mathematicians:
- discuss;
- debate and argue and challenge each other;
- build theories and collect data to support them;
- work co-operatively to refine and develop ideas further.

Most data collected is based on that collected from a sample of the population. The following ideas are the main issues to consider with sampling.

- **Describing the shape of the data**

Pupils describe their results by referring to features of the data (median, range, etc).

- **Understanding relationships between populations and samples**

Ideas need to be developed about the nature of the sample, its representativeness, selection and size.

- **Comparing the results of repeated samples of the same population**

Pupils can explore one population by taking repeated samples of the same size and find that the results of repeated samples can be different. through this they learn that sampling cannot lead to exact answers, but that it provides a way of understanding the approximate distribution of data in a population.

- **Describing and analyzing sample data and inferring the nature of a population**

pupils develop and share techniques for extrapolating from sample data to an entire population.

- **Evaluating the representativeness of a sample**

Whether a sample indeed represents a population is a central notion in statistics. Pupils begin with 'intuitive' ideas about the 'fairness' of a sample refining and developing those ideas through discussion, challenging each others' theories and describing and defending their own.

- **Defining a question and developing a sampling plan**

Pupils experience real-world statistical processes as they refine questions for their own research and develop sampling plans to investigate those questions.

- **Drawing conclusions about a population based on the results of sampling**

Pupil investigations focus on taking the results of a sample and developing conclusions about the population from which the sample is drawn. After those conclusions are reached, pupils make decisions about actions that could be taken based on their knowledge about the population.

Putting together the whole process

A data analysis investigation includes:
- 'brainstorming' or discussion and definition of data collection methods;
- rough draft graphs (etc) of preliminary results;
- analyses leading to refinement of ideas;
- final publication through reports of results.

ACTIVITY 6-3

Comparing Group Work Strategies

Approximate time: 15 minutes

Materials needed: Overhead transparency list of strategies (O/H6.3)

Overhead transparencies list of concerns etc (O/H6.4, 6.5, 6.6)

Step One: Comparing group work strategies

Remind the group of the co-operative group work strategies and role play discussed in the last session.

Discussion points:

- How many people tried this?
- What were the questions/problems given?
- What were the successes / failures?
- Co-operative roles - what are the advantages / disadvantages
- When comparing it to the other strategies - use O/H6.3 - what qualities does co-operative roles have that the others don't (and vice versa)
- Of the strategies introduced so far does anyone have a preference - and why?

STRATEGIES

- **Think- pair - share**
- **Jigsaw**
- **Clue Cards**
- **Combination of clue cards and jigsaw**
- **Questioner tag**
- **Co-operative role play**

O/H6.3

Step Two: General discussion

Discussion point:
Why encourage children to talk about their mathematics

Brainstorm the reasons as to why a teacher would want to encourage their pupils to discuss and talk about their mathematics. (***Hopefully some of the constructivist theory will come out in this).
Use O/H6.4, 6.5, 6.6 as the basis for some of the discussion.

Issues:

- the teacher's role is no longer one of directing the lesson although teachers need to intervene to ensure that genuine argumentation takes place
- learning takes place when pupils discuss differences in views and move from controversy to consensus
- that cooperative skills are not natural and need to be taught
- that interactions between children involve a two-way path with reference to mathematical authority and that this interaction involves 'give-and-take' and genuine exchange

O/H6.4

Advantages:

- more ideas and different solution approaches are generated including tentative suggestions that will help the individual and the group move closer to understanding
- that groups can often solve a more challenging problem that would be beyond the capabilities of the individuals in the group
- greater self-esteem is developed, that is, confidence in themselves as learners
- that greater use is made of mathematical language - talking, listening, interpreting- and through this, intellect and curiosity are challenged and hence learning becomes an active process

O/H6.5

Concerns:

- that the potential exists for groups of students to develop erroneous solutions and that student misconceptions can be reinforced

- that a subset of students will be passive in group work and that this group of passive students is likely to be the low-achievers although it does not imply that a quiet participant in a group is not necessarily being involved in active learning

- that students often want to work alone, especially higher-ability students

O/H6.6

ACTIVITY 6-4

Scenarios

Approximate time: 15 minutes

Materials needed: Overhead transparencies with scenarios (O/H6.7, 6.8, 6.9, 6.10)

Step One: Whole group discussion

Have the group as a whole consider the following scenarios.

SCENARIO 1

Adam needs a 2 on the die to finish the game. He has been trying for a 2 in at least the last 20 rolls of the die.

You overhear him say, "The more rolls that I do where a 2 doesn't come up, means that there's a greater chance for a 2 in the next roll."

O/H6.7

SCENARIO 2

At morning talk Gabrielle brings along a cutting from the *Dandenong Examiner* and the heading reads "Tattslotto win by Doveton Heights teacher".

The pupils talked about Tattslotto and the chances of winning. Mark says that his mum always puts in the numbers 1, 2, 3, 4, 5 and 6. The class all laugh loudly. Spiro says, "You could never win with those numbers!"

O/H6.8

SCENARIO 3

George, who lives in a country town, was visiting his cousin, Rex, who lives at Box Hill. They were comparing their local hospitals and started to talk about the number of births. At George's hospital there are on average 15 births a week whereas at Rex's hospital there are on average 45 births a week. At both hospitals there are weeks where more than 60% of the births are boys. For George's hospital this means more than 9 out of the 15 births; for Rex's hospital, 27 out of the 45 births.

Rex said, "We'd have many more of those weeks than you George."

O/H6.9

SCENARIO 4

At a council meeting for the City of Greater Dandenong discussion was taking place about the formation and the size of council sub-committees. Pan Nguyen said that it wouldn't matter if the sub-committees had either 2 or 8 members as the number of committees that could be formed is the same.

O/H6.10

PRESENTER'S NOTES:

Scenario 1

Conditional probability - each roll of the die is independent of the previous rolls - the current roll doesn't know what the previous rolls have been!!

Scenario 2

This combination has the same chance as winning as any other combination of 6 numbers. The misconception is based on the **representativesness** people tend to associate with the actual event. There is probably no example in Tattslotto where the winning numbers have been six consecutive numbers.

Research shows that 70% of year 5 pupils think that a 'mixed set of numbers' is more likely to win Tattslotto than a set of consecutive numbers. Even 35% of year 11 students and 22% of university students think the same way.

Scenario 3

In fact the reverse is true. Individuals tend to neglect the sample size when estimating probabilities.

Research found that 80% of Year 11 students and 89% of University students agreed with Rex's logic.

Scenario 4

The original research question for this was:

When choosing a committee composed of 2 members from among 10 candidates the number of possibilities is

- smaller than *(incorrect)*
- greater than *(main misconception)*
- equal to *(correct)*

the number of possibilities when choosing a committee of 8 members from among 10 candidates.

Most adults selected 'greater than' (72%) or smaller than (22%).

This misconception is referred to as 'availability' and refers to the ease with which instances can be brought to mind.

ACTIVITY 6-5

Sharing Resources

Approximate time: 10 minutes

Materials needed: Resource books etc

Step One: Sharing

Ask if there is anyone that has brought along a text that they use as a resource for chance activities and to show and talk about the resource.

Show the resources that I have brought along - in most cases there is at least one part from each of these resources in the session handouts. Perhaps there could be 5 minutes for participants to look at these and the others that were brought along.

ACTIVITY 6-6

Family Feud

Approximate time: 15 minutes

Materials needed: Overhead transparencies for 'Family Feud' (O/H6.11, 6.12, 6.13)

Step One: Describe how 'Family Feud' is played

Describe how Family Feud is played and select two teams of four players. Each team to come up with a name for their team and leader and the rest of the participants choose which team they are going to cheer for.

Step Two: Playing the game

Toss a coin to decide which team will go first.

Use the following questions for each round. Scores are on the O/H's.

- **When you hear the word 'certain' what other word springs to mind?**
- **What is a game that is played using a die/dice?**
- **What is a device used to pick out winners at random?**

When you hear the word 'certain' what other word springs to mind?

The survey says:

Likely	59
Possible	21
Never	8
Sure	6
Always	5
Probable	1

O/H6.11

What is a game that is played using a die/dice?

The survey says:

Snakes and Ladders	63
Yahtzee	19
Ludo	10
Bingo	4
Trivial Pursuit	3
Scrabble	1

O/H6.12

What is a device used to pick out winners?

The survey says:

Spinning wheel	**36**
Barrel	**28**
Hat	**20**
Dice	**13**
Spinner	**3**

O/H6.13

<u>STEP THREE:</u> **Discussion**

How could this idea be used in class?

Different topics to what was done here!!
One grade probably needs to organise it for another grade.
Involves making predictions, taking surveys of 100 people (percentage), and making pie graphs could be an extension. Chance is involved - how good are the participant's predictions?

ACTIVITY 6-7

Administration

Approximate Time: 5 minutes

Materials needed: Handouts: Session evaluation sheet and Session Handouts (refer to page A-89 & A-91)

Certificates

Step One: Session evaluation

Participants to complete session evaluation sheet.

End of Session 6:

Name:

A Have you tried any 'sampling activities' with your classes? YES NO
If YES, briefly outline something that you have done.
If NO, state why such activities haven't been part of your teaching repertoire at this stage.

____

____

Do you feel that 'sampling activities' are suitable for the year level that you teach? YES NO Justfy.

____

____

B What are your comments on the spacing/timing of the workshop sessions?

____

____

C Over the six workshops what would say has been of the greatest value to you?

____

____

Why?

____

____

D Any other comments about today's session.

____

____

Step Two: Presentation of certificates

Workshop leader to present a certificate to each participant.

3C's

....

has completed the professional
development course

3C's:
Chance, Constructivism and Collaboration.

Completion of the course has involved attendance at six two-hour after school workshops, between-sessions trialling of activities and undertaking some professional reading.

.... Suzanne Peterson
.... Ron Smith

List of handouts

- Cover page
- Notes on sampling from Activity 6-2, page A-77 & A-78.
- M&M's overhead - page A-77.
- 'Life's big numbers', from *The Sunday Age, 24/8/97,* with some comments on their classroom use in regard to middle measures, chance and sampling.
- Edwards, A.W. (1995), Science for Smarties, *Investigating: Australian Primary Science Journal, 11(3),* pp14-15.
- Copy of problem used in role play situation (refer to page A-69)
- Ideas generated by participants for the clue cards problems (refer to page A-91) (one sample included below)
- Ministry of Education (1989), Everybody Wins, In *RIME5/6 Activity Bank,* , Melbourne: Ministry of Education, pp 25-30).
- Notes From O/H5.3 & 5.4 - Independent Events & Conditional Probability (refere to page A-62)
- Participant's notes on Scenarios (refer to page A-91) (one sample included below)
- Spinner Sheet and Clue Cards, In Erickson, T. (1989), *Get it Together,* Berkley: Lawrence Hall of Science, pp 101-2.

PROBLEM 2

A spinner has 30% blue, 50% green and 20% purple. What would you expect to happen in 100 spins?

Question:
What colours & in what proportion are they on a spinner?

1. There are 3 colours
2. You are more likely to spin blue than purple.
3. You have less chance of spinning a blue than a green.
4. One colour takes up $\frac{1}{2}$ of the spinner.
5. One colour takes up $\frac{1}{5}$ of the spinner.

SCENARIO

Alice was rolling a die and had rolled a 2, followed by a 3, and then a 4.

She said to you' "My chances of getting a 5 are now better because it's working in a pattern."

- awareness of sequencing
- no concept of 'chance' - random
  - independent p.
- play dice games ⇒ dice fun
  ⇒ dice difference
- experiment with a variety of 'random generators' games to evaluate whether it is just '<u>dice</u>' or across the board
  eg. mystery balloons - modify.

APPENDIX B

ABOUT THE PARTICIPATING SCHOOLS AND TEACHERS

Contents:

Schools participating in *3Cs*:

School	Summary description
Rosella Flats PS	Rosella Flats PS had been established on its new site for twelve months. New buildings housed administration, library and other specialist teaching areas. With an enrolment of approximately 400 some pupils were housed in portable classrooms. Grade organization was based upon homogeneous age groupings.
Wattlebird Rise PS	Wattlebird Rise PS was approximately 15 years old and the majority of the 500 pupils were taught in portable classrooms. Almost half of the students came from a wide range of cultural and ethnic backgrounds representing over 30 nationalities. Grades were generally based on year level groups although there were some composite grades.
Spotted Dove PS	Spotted Dove PS was the most established of all the participating schools. The 500-plus pupils were mainly housed in portable classrooms where most of these were integrated into a building complex. Grades were based on year levels.
Spinebill Way PS	Spinebill Way PS was approximately ten years old and had a mix of classrooms in a core building but also a large number of portable classrooms. Grades were based on year levels although there were several composite grades established not because of any educational philosophy but because the pupil numbers at various year levels necessitated them.
Honeyeater Hills PS	Honeyeater Hills PS was established as a result of the amalgamation of two schools but was on the site of one of the initial schools. All the teachers participating in 3Cs were from this initial school. The school philosophy meant that pupils were organised into multi-age grades – prep/1/2, 3/4 and 5/6 groupings. He school population contained abut 10% Koorie students.

Table B.1: Summary details for each participating school

Participating teachers:

Prep/1/2	3/4	5/6
Dianna	Bianca	Gail
Sally	Deidre	Gerry
Teresa	Karen	Helen
	Megan	Kaye
	Olivia	Malcolm
		Merrilyn
		Neva
		Nora
		Tasha
		Trevor

Table B.2: Year levels for participating teachers

APPENDIX C

CASE STUDY TEACHERS:

TRIALLING OF ACTIVITIES

Contents:

Deidre's trialling

Tried	PD session reference	Workshop or handouts	Data source	**Not tried**	PD session reference	Workshop or handouts	Data source
Mathematics	content						
Ordering chance words	1-2 (A-4)	W	Int3	Use of a 2-way chart	2-2 (A-19)	W	Int4
Game of Dicetracks	1-3 (A-7)	W	Int4	Toss of Luck	2-6 (A-27)	W	Int4
Acey-Duecy	1-2 (A-5)	W	Int3	Mystery Balloons	H (A-29)	H	Int4
Tennis clothes problem	H (A-30)	H	Int3	Cat & Mouse	H (A-40)	H	Int4
Game of Your Choice	2-1 (A-17)	W	Int3	Remove	4-1 (A-43)	W	Int4
Hat & Scarf	3-6 (A-38)	W/H	Int4	Handout by Bruni & Silverman	H (A-56)	H	Int4
				Notions of mean, median, mode	4-4 (A-48)	W	Int4
				Sampling with M&M's	6-2 (A-76)	W	Int4
				Family Feud activity	6-5 (A-86)	W	Int4
Teaching	strategies	content					
Think-pair-share	1-5 (A-11)	W	Int4	Questioner tag	4-5 A-50	W	Int4
Making Snakes and Ladders boards using Jigsaw strategy	2-5 (A-24) H (A-30)	H					
Clue cards	3-3 (A-35)	W	Int4				
Constructivist	notions	content					
Dicetracks	1-2 (A-7)	W	Int4	Green & White containers video	4-6 (A-40)	W	Int4
				Green & White containers	4-6 (A-40)	H	Int4
				Classification-Jones et al's(1997)	5-5 (A-65)	W	Int4

Table C.1: Activities trialled/not trialled by Deidre (KEY: W = workshop; H = handouts)

Malcolm's trialling

Tried	PD session reference	Workshop or handouts	Data source	**Not tried**	PD session reference	Workshop or handouts	Data source
Mathematics content							
Ordering Chance language	1-2 (A-4)	W	Int4	Toss of Luck	2-6 (A-27)	W	Int4
Game of Dicetracks	1-3 (A-7)	W	Int4	Hat, Scarf & Belt	3-6 (A-38)	W/H	Int4
Use of a 2-way chart	2-2 (A-19)	W	Int4				
Making random selectors	2-5 (A-24)	W	Int3				
Double Header Ice-creams	3-3 (A-35)	W	Int4				
Drawing die net	3-4 (A-35)	W	Int4 C/Obs4				
Mystery Balloons-with counters	H (A-29)	H	Int4				
Green & White containers video	4-6 (A-54)	W	Int4				
Activity involving sampling with M&M's	6-2 (A-76)	W	Int4 C/Obs3				
Activity based on Family Feud	6-6 (A-86)	W	Int4				
Teaching strategies							
Think-pair-share	1-5 (A-11)	W / H	Int3				
Jigsaw	2-5 (A-24)	W	EofS3				
Clue cards	3-3 (A-35)	W	Int4				
Clue cards & Jigsaw	3-4 (A-36)	W	Int4 C/Obs4				
Questioner Tag	4-5 (A-50)	W	Int4				

Constructivist notions							
Dice Tracks	1-3 (A-7)	W	Int4	Classification-Jones et al's(1997)	5-5 (A-65)	W / H	Int4
Think-pair-share	1-4 (A-11)	W	Int3				
Lucky Die	1-6 (A-12)	W					
Rolling two yellows	2-2 (A-19)	W	Int4				
Jigsaw	2-5 (A-24)	W	EofS3				
Clue Cards	3-3 (A-35)	W	Int4				
Jigsaw/Clue Cards	3-4 (A-35)	W	Int4 C/Obs4				
Questioner Tag	4-5 (A-50)	W	Int4				
Green & White Containers Video	4-6 (A-54)	W	Int4				

Table C.2: Activities trialled/not trialled by Malcolm

(KEY: W = workshop; H = handouts; Int = Interview; C/Obs = Classroom Observation; EofS = End of Session Survey)

Tasha's trialling

Tried	PD session reference	Workshop or handouts	Data source	**Not tried**	PD session reference	Workshop or handouts	Data source
Mathematics	content						
				Use of a 2-way chart	2-2 (A-19)	W	Int4
				Game of Dicetracks	1-3 (A-70	W	Int4
				Toss of Luck	2-6 (A-27)	W	Int4
				Mystery Balloons	H (A-29)	H	Int4
				Hat, Scarf & Belt	3-6 (A-38)	W/H	Int4
				Notions of mode, median, mean	4-4 (A-48)	W	Int4
				Activity involving sampling with M&M's	6-2 (A-76)	W	Int4
				Activity based on Family Feud	6-6 (A-86)		Int4
Teaching	Strategies	content					
Think-pair-share	1-5 (A-11)	W	Int3	Jigsaw	2-5 (A-24)	W/H	EofS3
Co-operative role play	5-6 (A-67)	W	Int4				
Constructivist	Notions	content					
Lucky die	1-6 (A-12)	W /H	C/obs3	Dicetracks	1-2 (A-7)	W	Int4
				Green & White containers video	4-6 (A-54)	W	Int4
				Green & White containers handout	4-6 (A-40)	H	Int4

Table C.3: Activities trialled/not trialled by Tasha
(KEY: W = workshop; H = handouts; Int = Interview)

Gerry's trialling

Tried	PD session reference	Workshop or notes only	Data source	**Not tried**	PD session reference	Workshop or notes only	Data source
Mathematics	content						
Use of a 2-way chart	2-2 (A-19)	W	Int4	Toss of Luck	2-6 (A-27)	W	Int4
Game of Dicetracks	1-3 (A-7)	W	Int4	Mystery Balloons	H (A-29)	H	Int4
Acey-Duecy	1-2 (A-5)	W	Int3	Handout by Bruni & Silverman	H (A-56)	H	Int4
Hat & Scarf	3-6 (A-38)	W/H	Int4				
Sampling with M&M's	6-2 (A-76)	W	Int4				
Final five	H (A-72)	H	Int4 C/ob3				
Random Walk	5-7 & H (A-70)	W/H	Int4 C/ob4				
Teaching	strategies	content					
Think-pair-share	1-5 (A-11)	W	Int4				
Making Snakes and Ladders boards using Jigsaw strategy	2-5 (A-24) H (A-30)	H	EofS3 Int3				
Clue cards	3-3 (A-35)	W	Int4				
Clue cards & Jigsaw	3-4 (A-36)	W	Int4				
Questioner tag	4-5 (A-50)	W	Int5				

Constructivist	notions	content					
Dicetracks	1-2 (A-7)	W	Int4	Classification-Jones et al. (1997)	5-5 (A-65)	W	Int4
Lucky die	1-6 & H (A-12)	W H	Int3				
Green & White containers video	4-6 (A-54)	W	Int4				
Green & White containers handout	4-6 (A-40)	H	Int4				

Table C.4: Activities trialled/not trialled by Gerry

(KEY: W = workshop; H = handouts; Int = Interview; C/ob = Classroom observation)

APPENDIX D

VARIOUS TABLES

Contents:

	Reason for valuing 'Attending as a group of teachers'	I (6)	N (3)	R (7)	Beg. (6)	Ex. (10)	Typical comment
Teachers sharing	Leads to greater sharing	6	3	4	5	8	You can bounce ideas off each other and share and you're not by yourself. (Nora: Interview 3)
	Individuals focus on different parts of the professional development which assists sharing	2		3	2	3	Rod and I went to a workshop and he saw different things to me and the interaction that's happened has been good. (Teresa: Interview 3)
	Trialling different activities or the same activity in different ways enriches sharing	1		2	2	1	I think it's been much better that the four of us went because we all tried different things in a different order and then told the others how it worked. (Deidre: Interview 3)
	Passing on enthusiasm to others	2	1	1	1	3	It's easy to come back to the school and say, "Hey look at this" if there is a few that have done it. (Nora: Interview 3)
	Helps to keep you on task for trialling		1			1	You keep each other going as far as having a go at trialling the activities. (Karen: interview 3)
	Catching up with colleagues because the school day is so busy			1		1	We are both really busy and you don't get time to sit down and talk to people. (Teresa: Interview 3)
Planning	Sharing of resources	2			2		Say if I need something for one of the games from the pd sessions I can see Dianna or Sally or they can see me. So it's good with resourcing. (Trevor: Interview 3)
	Means that because of sharing activities are not forgotten	1		1	1	1	There is always someone that will say, "Remember when we did this. How about we try this?" (Bianca: Interview 3)
	Same wavelength when planning			1		1	My grade 5 team have planning meetings and we are on the same wavelength because we've had all the same pd. (Gerry: Interview 3)

Table D.1: Reasons for valuing 'Attending as a group of teachers'

Session	1	2	3	4	5	6	Total for each *3Cs* participant
Bianca	√	√	√	√	√	√	6
Deidre	√	√	√	√	√	√	6
Dianna	√	√	√	√	√	√	6
Gerry	√	√	√	√	√	√	6
Helen	√	√	√	√	√	-	5
Karen	-	√	√	√	√	√	5
Kaye	√	√	-	√	√	-	4
Malcolm	√	√	√	√	√	√	6
Megan	√	√	√	√	√	√	6
Neva	√	√	-	√	√	-	4
Nora	√	-	√	√	√	√	5
Olivia	√	√	√	√	√	-	5
Sally	√	√	-	√	√	-	4
Tasha	√	√	√	-	-	√	4
Teresa	√	√	√	√	√	√	6
Trevor	√	√	√	-	-	-	3
Total for each session	15	16	13	14	14	10	

Table D.2: Participant attendance at *3Cs* sessions

Teacher grouping	Total in grouping	Term 2 & 3 %	Term 2 %	Term 3 %	Term 2 to 3 % change
All teachers	16	85	92	79	-14
Instrumental	6	83	94	72	-23
Neither I nor R	3	89	78	100	+28
Relational	7	83	90	76	-15
Beginning	6	78	94	61	-35
Experienced	10	88	87	90	+3
Rosella Flats PS	3	72	89	55	-38
Spinebill Way PS	4	88	92	83	-10
Honeyeater Hills PS	6	89	94	83	-12
Wattlebird Rise PS	2	92	83	100	+17
Spotted Dove PS	1	67	67	67	0

Table D.3: Summary statistics for *3Cs* attendance

Session	1	2	3	4	5	6	Total for each *3Cs* participant
Bianca	√	x	x	x	x	x	1
Deidre	√	√	√	x	x	x	3
Dianna	√	√	√	√	√	x	5
Gerry	√	√	√	√	√	√	6
Helen	√	√	√	√	x	√	5
Karen	√	√	√	√	x	√	5
Kaye	√	√	√	x	√	x	4
Malcolm	√	√	√	√	x	√	5
Megan	√	√	√	x	√	√	5
Neva	√	√	√	√	x	x	4
Nora	x	√	√	√	x	x	3
Olivia	√	√	√	√	√	x	5
Sally	√	√	√	x	x	x	3
Tasha	√	x	x	x	√	x	2
Teresa	√	√	√	√	√	x	5
Trevor	√	√	x	x	√	x	3
Total for each session	15	14	13	9	8	5	

Table D.4: Classroom trialling of at least one activity per session

Teacher grouping	Total in grouping	Term 2 & 3 %	Term 2 %	Term 3 %	% change Term 2 to 3
All teachers	16	67	88	46	-48
Instrumental	6	67	94	39	-59
Neither I nor R	3	72	89	56	-37
Relational	7	64	81	48	-41
Beginning	6	58	83	33	-60
Experienced	10	72	90	53	-41
Rosella Flats PS	3	61	78	44	-44
Spinebill Way PS	4	83	100	67	-33
Honeyeater Hills PS	6	53	72	33	-54
Wattlebird Rise PS	2	83	100	67	-33
Spotted Dove PS	1	67	100	33	-67

Table D.5: Summary statistics for *3Cs* classroom trialling

Instrumental for 'pupil working mode'	Extent of trialling of collaborative strategies	Relational for 'pupil working mode'	Extent of trialling of collaborative strategies
Helen	4	Malcolm	5
Megan	3	Gerry	5
Olivia	3	Teresa	4
Diana	3	Neva	3
Nora	2	Deidre	3
Bianca	1	Karen	3
Kaye	1	Tasha	2
Sally	1		
Trevor	1		
Average	2.1	Average	3.6
Median	2	Median	3

Table D.6: Extent of trialling compared to instrumental / relational practice on 'lesson initiation'

Trialling all activities		Trialling 'mathematics content' activities		Trialling 'teaching strategies' content		Trialling 'constructivist notions' content	
Gerry	**19**	**Gerry**	**13**	**Gerry**	**5**	**Gerry**	**11**
Malcolm	**16**	**Malcolm**	**10**	**Malcolm**	**5**	**Malcolm**	**8**
Dianna	**13**	**Dianna**	**8**	**Helen**	**4**	**Dianna**	**7**
Deidre	12	Deidre	8	**Teresa**	**4**	**Teresa**	**7**
Helen	**12**	**Neva**	**8**	**Neva**	**3**	**Helen**	**7**
Neva	**11**	**Helen**	**7**	Deidre	3	**Neva**	**5**
Teresa	**11**	**Karen**	**7**	**Karen**	**3**	Deidre	5
Karen	**11**	**Teresa**	**6**	**Dianna**	**3**	**Karen**	**5**
Olivia	8	Olivia	5	Olivia	3	Olivia	4
Megan	8	Megan	5	Megan	3	Megan	4
Kaye*	**6**	**Kaye***	**4**	**Nora**	**2**	Tasha	3
Trevor	5	Trevor	4	Tasha	2	**Nora**	**2**
Sally	4	Sally	3	**Bianca***	**1**	Trevor	2
Nora	**3**	**Bianca***	**2**	Trevor	1	Sally	2
Bianca*	**3**	**Nora**	**1**	Sally	1	**Kaye***	**2**
Tasha	3	Tasha	1	**Kaye***	**1**	**Bianca***	**1**

Table D.7: Extent of trialling *3Cs* activities according to Experienced / beginning distinction (Experienced teachers in bold / beginning teachers in normal format; * indicates experienced teachers who were observed as lacking confidence in mathematical ability)

Trialling all activities		Trialling 'mathematics content' activities		Trialling 'teaching strategies' content		Trialling 'constructivist notions' content	
Gerry	**19**	**Gerry**	**13**	**Gerry**	**5**	**Gerry**	**11**
Malcolm	**16**	**Malcolm**	**10**	**Malcolm**	**5**	**Malcolm**	**8**
Dianna	13	Dianna	8	Helen	4	Dianna	7
Deidre	12	Deidre	8	**Teresa**	**4**	**Teresa**	**7**
Helen	12	**Neva**	**8**	**Neva**	**3**	Helen	7
Neva	**11**	Helen	7	Deidre	3	**Neva**	**5**
Teresa	**11**	**Karen**	**7**	**Karen**	**3**	Deidre	5
Karen	**11**	**Teresa**	**6**	Dianna	3	**Karen**	**5**
Olivia	8	Olivia	5	Olivia	3	Olivia	4
Megan	8	Megan	5	Megan	3	Megan	4
Kaye	6	Kaye	4	Nora	2	Tasha	3
Trevor	5	Trevor	4	Tasha	2	Nora	2
Sally	4	Sally	3	Bianca	1	Trevor	2
Nora	3	Bianca	2	Trevor	1	Sally	2
Bianca	3	Nora	1	Sally	1	Kaye	2
Tasha	3	Tasha	1	Kaye	1	Bianca	1

Table D.8: Extent of trialling *3Cs* activities according to Relational / instrumental distinction for beliefs on the nature of mathematics (Relational teachers in bold / instrumental teachers in normal format)

Trialling all activities		Trialling 'mathematics content' activities		Trialling 'teaching strategies' content		Trialling 'constructivist notions' content	
Gerry	**19**	**Gerry**	**13**	**Gerry**	**5**	**Gerry**	**11**
Malcolm	16	Malcolm	10	Malcolm	5	Malcolm	8
Dianna	13	Dianna	8	**Helen**	**4**	Dianna	7
Deidre	12	Deidre	8	**Teresa**	**4**	**Teresa**	**7**
Helen	**12**	**Neva**	**8**	**Neva**	**3**	**Helen**	**7**
Neva	**11**	**Helen**	**7**	Deidre	3	**Neva**	**5**
Teresa	**11**	**Teresa**	**6**	Dianna	3	Deidre	5
Olivia	8	Olivia	5	Olivia	3	Olivia	4
Kaye	**6**	**Kaye**	**4**	**Tasha**	**2**	**Tasha**	**3**
Trevor	5	Trevor	4	**Bianca**	**1**	Trevor	2
Sally	4	Sally	3	Trevor	1	Sally	2
Bianca	**3**	**Bianca**	**2**	Sally	1	**Kaye**	**2**
Tasha	**3**	**Tasha**	**1**	**Kaye**	**1**	**Bianca**	**1**

Table D.9: Extent of trialling *3Cs* activities according to Instrumental / relational distinction according to classroom practice (Relational teachers in bold / instrumental teachers in normal format)

Instrumental for 'lesson initiation'	Extent of trialling	Relational for 'lesson initiation'	Extent of trialling
Gerry	19	Diana	13
Malcolm	16	Deidre	12
Helen	12	Teresa	11
Neva	11	Karen	11
Kaye	6	Megan	8
		Olivia	8
		Trevor	5
		Sally	4
		Tasha	3
		Nora	3
		Bianca	3
Average	12.8	Average	7.4
Median	12	Median	8

Table D.10: Extent of trialling compared to instrumental/relational practice on 'lesson initiation' (Data obtained from pre-*3Cs* interviews)

Instrumental for 'making connections'	Extent of trialling	Relational for 'making connections'	Extent of trialling
Malcolm	16	Gerry	19
Deidre	12	Diana	13
Olivia	8	Helen	12
Megan	8	Teresa	11
Kaye	6	Neva	11
Trevor	5	Karen	11
Bianca	3	Sally	4
		Tasha	3
		Nora	3
Average	8.3	Average	9.7
Median	8	Median	11

Table D.11: Extent of trialling compared to instrumental/relational practice on 'making connections' (Data obtained from pre-*3Cs* interviews)

	Qualities of presenter	I (6)	N (3)	R (7)	Beg. (6)	Ex. (10)	Typical comment
I	Knowledgeable and able to answer participants' questions	3	1	5	2	7	A good working knowledge of where maths fits in to the curriculum and with age groups of children. (Karen: Interview 5)
	Good explainer	1			1		If they were doing an activity to be able to demonstrate it or make people understand. (Trevor: Interview 4)
I or R	Places more emphasis on providing practical activities than on presenting theory	3	2	3	2	6	You need someone who is not going to stand up there and lecture you but involve you. (Nora: Interview 5)
R	Responsive to participant reaction including being able to accommodate all participants and being a good listener	2	2	3	2	5	Be very aware of different people in the group and to meet some of their needs as well. To be able to pick up on people's reactions and watching body language is important. (Teresa: interview 5)
	Appropriate workshop management by varying style and changing direction if an activity is not working	1		4		4	Lots of change especially in the afternoon, lots of change, lots of hands-on is really important. (Kaye: interview 5)
	Ability to empower by making participants reflect on ideas and by asking questions			2		2	One that asks questions and gets then to think rather than provide the answers. (Teresa: Interview 5)
	Enjoyment of teaching mathematics is obvious	1			1		We had [some staff pd] two weeks ago and you could tell that [the presenter] just loved teaching maths and it was a reflection of what she does in her job. (Olivia: Interview 5)
	Develops interaction between people		1	1		2	Being able to structure the pd so that there's interaction between people so that you not just sitting there listening. (Teresa: Interview 5)
	Receives feedback		1	1		2	If it's an on-going pd you need feedback so that you know that you're on the right track and you are giving people what they want. (Teresa: Interview 5)

	Someone who has been a classroom teacher because this means that they practice what they are presenting		1	1		2	I can't see someone from a purely academic perspective as a good presenter. You need to have someone that's been or still is a classroom teacher. (Karen: Interview 5)
Other	Enthusiastic	2		2	2	2	Need to be enthusiastic about what they are telling you. (Olivia: Interview 5)
	Maintains interest	2	1		2	1	Someone that can hold your attention but not be dictatorial. (Nora: Interview 5)
	Organized			1		1	Somebody that's well prepared and knows what they want to get out of each session. (Interview 5)
	Entertaining and includes humour	1	1	2	3	2	The way they present it so that it is not dull and boring and monotonous so they need to have a bit of vitality about them. (Helen: Interview 5)

Table D.12: Presenter qualities mentioned by *3Cs* participants
(I = instrumental; N = neither instrumental nor relational; R = relational;
Beg = beginning; Ex = experiences)

APPENDIX E

3Cs PARTICIPANTS SORTED USING THE KEIRSEY TEMPERAMENT SORTER

Contents:

		Sensing		Intuitive	
		With feeling	With thinking	With thinking	With feeling
Introverts	Judging	**ISTJ** Instrumental[1] Instrumental[2]	**ISFJ** Instrumental	**INFJ**	**INTJ** **Relational**
	Perceptive	**ISTP**	**ISFP** **Relational**	**INFP** **Relational**	**INTP**
Extraverts	Perceptive	**ESTP** Instrumental[3]	**ESFP**	**ENFP**	**ENTP**
	Judging	**ESTJ** **Relational** Instrumental[3] Instrumental[2] Instrumental Instrumental[1]	**ESFJ** **Relational** **Relational** Instrumental	**ENFJ** **Relational**	**ENTJ**

Table E.1: *3Cs* participants sorted using the Keirsey Temperament Sorter

Note: Each teacher's instrumental or relational category (according to the classroom practice analysis of Chapter 5) is recorded. For three teachers the Keirsey result indicated two possibilities for each teacher – these are shown using a numbered superscript.