A STUDY OF THE JUNIOR SECONDARY SCIENCE CURRICULUM IN BANGLADESH AND ITS RELATIONSHIP WITH REAL-LIFE SITUATION

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Declaration

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Abstract

In the light of the globally accepted slogan ‘Science for all’ the junior secondary science curriculum (Grades VI to VIII) of Bangladesh was revised in 1995. The aim was to provide science education to all students to orient them to be able to apply science in real-life. This research explores the scope of the relationship of the junior secondary science curriculum to real-life. Teachers in Bangladesh do not usually work with the curriculum. Instead they follow the textbooks as a de-facto curriculum to teach science. Therefore, to understand the relevance of the curriculum to the students’ lives, this study also explored the corresponding textbook content and teachers’ perspectives of implementing the curriculum.

Roberts’ seven curriculum emphases (Roberts, 1982) and three added by Fensham (1994a, 1995), were used as a framework to analyse the specific objectives and learning outcomes of the curriculum and content of the textbook topics to identify whether they had the potential to encourage students to apply their science learning in real-life situations. To explore the curriculum, textbooks and teachers’ teaching practices, this research followed a mixed methods design where qualitative approaches including document analyses, teacher interviews, lesson observations, and students’ focus group discussions dominated the overall research process.

Findings indicate a lack of consistency of curriculum emphases between specific objectives and learning outcomes of the curriculum and textbook content for all grades. Poor representations of real-life aspects were identified both in the curriculum and textbooks. Teachers’ teaching practices revealed content-dominated teaching with poor connections to real-life examples. Teaching practices were ‘talk and chalk’ with limited

use of demonstrations and teaching aids. Learning by doing, scientific enquiry, problem -solving, rational thinking, analysing cause and effect relationships, developing students' creativity and innovativeness were noticeably absent in teachers' teaching practices. This study also identified a number of challenges around implementing the curriculum including: a lack of availability of the curriculum and teachers' guides; teachers' class loads; large class sizes; inadequate resources; and a lack of professional development opportunities for the teachers to teach the General Science course at the junior secondary level.

The study concludes that further revision is required to the published curriculum and textbooks in Bangladesh to accommodate 'real-life aspects' of science in it, and the findings of this research will certainly contribute positively and significantly towards it. The research also would like to recommend considering Roberts' and Fensham's curriculum emphases to ensure that student learning in science is applicable in real-life situations.

Chapter 1
Introduction to the Research

1.1 Introduction

The concept of 'Science for All', developed by Peter Fensham (1985), became a significant focus for international curriculum development in the late 1980s and 1990s. It is a vision of school science that calls for all students to become scientifically literate citizens. In addition it posits that, to achieve this vision, curriculum development requires "a broader knowledge base from which to draw its knowledge of worth than the single disciplinary sciences can provide" (Fensham, 2004, p. 158). Subsequently, 'scientific literacy' has been accepted as a well-recognised educational slogan worldwide and adopted as a fundamental and contemporary goal of science education (Laugksch, 2000), incorporating all the intentions of science education at the school (Holbrook & Rannikmae, 2009). In accordance with this trend, the junior secondary level science curriculum in Bangladesh aims to provide science education for all students with the aim of enabling them to use their knowledge of science in everyday life situations (National Curriculum and Textbook Board, NCTB, 1995). While doubts have been raised whether such science education programs can, simultaneously, ensure to prepare a minority of students for future careers as science professionals, and at the same time prepare all students to become scientifically literate (Fensham, 1988).

It has been claimed that the *multidimensionality* of scientific literacy has the potential to provide a type of integrated science curriculum, which is, at least, a program of balanced and coherent science education (Hodson, 1992). Hodson also points out that if *personalization of learning* is emphasised in the goals of science education, then this kind of educational program is compatible and attainable for all types of students to achieve the goals. Hodson described the three major elements of multidimensionality as: 1) Learning science (acquiring and developing conceptual and theoretical knowledge); 2) learning about science (developing an understanding of the nature and methods of science, and an awareness of the multifaceted interactions between science and society; and, 3) doing science (engaging in and developing expertise in scientific enquiry and problem solving). With regard to these elements he explains the *personalization of learning as* being: learning based on individual learners' personal experiences, person-oriented science, science education imbued with all-encompassing human and environmental values, and students having the opportunity to pursue scientific investigations of their own choosing and design. Hodson and Reid referred to these aspects as *prioritization of the affective* (1988, as cited in Hodson 1992), which ensures that the curriculum meets the emotional and spiritual needs of all students.

In order to make science more meaningful and more accessible to general students a range of *curriculum emphases* have been introduced under the umbrella term of *scientific literacy*. Roberts (1982) mentioned seven such curriculum emphases which are: Everyday Coping; Structure of Science; Science, Technology, and Decision; Scientific Skill Development; Correct Explanations; Self as Explainer; and Solid Foundation. In addition to these, Fensham added another three curriculum emphases: Science in Applications; Science for Nurturing; and Science in Making (Fensham, 1994b, 1995, 1996). These emphases contribute to achieve the goals of scientific literacy for all students and also prepare for those who want to continue with science beyond the compulsory years.

Goodrum (2004) stated that the purpose of school science is to promote scientific literacy to the extent to which people are able to use science in their daily lives. From the 19th century, educators have been trying to promote school science as a subject that is connected to everyday life in society (Aikenhead, 2006). Consequently, with reference to this goal, and using the curriculum emphases of Roberts and Fensham, this research aims to explore how the general science curriculum at the junior secondary level in Bangladesh is related to the real-life situation of the learners. Personal motivations for investigating this issue, the study's research context and significance of the study are presented in the following sections of this chapter.

1.2 Personal Motivation

In science education research a major emphasis has been given to the investigation of students' understanding of scientific concepts (Amos & Boohan, 2002), and their relationship to issues in everyday life. From my personal experience, it has been observed that students are often unable to link basic scientific concepts with real-life problems and issues. Also, they do not demonstrate their ability to apply theoretical knowledge to solve everyday problems. At other occasions, educated people ignore or avoid their responsibilities for protecting the environment despite knowing the causes and effects of environmental issues. The following are some examples of such experiences:

Case 1: As an MSc student at the University of York in the UK, I did research on 15-18 year old students' understanding of acid rain and the greenhouse effect, and how this is related to their understanding of basic scientific ideas (Akhter, 1995). In this study I interviewed science and non-science students in York at school and college-level testing their basic scientific ideas related to acid rain and the greenhouse effect. One question in the test was associated with a picture of a greenhouse with sunlight showing shorter wavelengths entering it, and longer infrared wavelengths emitted from the objects inside the greenhouse, to the glass and bouncing back into the greenhouse. This picture acted as a prompt for students to help them describe the mechanism of the greenhouse effect. The majority of the students understood that the sun's rays passed through the glass into the greenhouse, and that they cannot pass out again, through the glass, into the atmosphere. As a result, the temperature inside the greenhouse gets hotter increasing the temperature to the level required for some plants to grow.

During individual interviews, I asked the students why did the sun's rays pass through the glass on the way in, but could not go out. Only one science student could provide an acceptable response. Students learnt that the sun's rays had a shorter wavelength, and the glass used for a greenhouse allowed visible light and short wavelength radiation to pass through it but did not transmit the longer infrared wavelengths. Unfortunately, they could not relate this knowledge to the greenhouse example. They were unaware of the fact that in the greenhouse, soil and plants absorb light rays and converted that into heat energy during the day, and slowly released this energy as longer infra-red wavelengths at the end of day, and during the night, into the greenhouse. These infrared rays do not readily pass through the glass and so are re-radiated back into the greenhouse resulting in a rise in temperature within the greenhouse.

An effect similar to the greenhouse scenario occurs in the Earth's atmosphere: the atmosphere around the Earth acts like greenhouse glass.[1] The concepts of shorter

[1] As Burton et al. (1994) described, the Earth and its atmosphere absorb part of the sun's radiated energy and part is reflected back into space. The absorbed part helps to heat the Earth which in turn radiates energy as infrared rays back into space. Eventually the Earth radiates energy as fast as it absorbs it and the average temperature of the Earth remains constant. By trapping some of the sun's radiation the atmosphere acts like a blanket. It keeps the average temperature of the Earth high enough to support life (Burton, et al., 1994). This is natural greenhouse effect. In the absence of greenhouse effect and an atmosphere, the Earth's average temperature of 14 degree Celsius could be as

and longer wavelengths of sunlight are important for students to be able to understand the mechanism of the Earth's natural greenhouse effect that makes life on Earth possible, as well as the mechanism of anthropogenic (enhanced) greenhouse effect, which causes global warming. Students need to understand that various human activities like heating and cooking always result in the release of carbon dioxide and water into the atmosphere raising the concentration of carbon dioxide. This, with other greenhouse gases (water vapour, methane, nitrous oxide, ozone and human-made chlorofluorocarbon), absorbs longer wavelength infrared radiations emitted from the Earth's surface, which in turn, radiates and reflected back and pass as heat to the lower atmosphere of the Earth. Consequently, the Earth's temperature is rising causing global warming.

Since the enhanced greenhouse effect is a global environmental issue, if students do not link this issue with basic scientific concepts then, as future citizens, they will not be able to participate intelligently in discussions or decision-making about this issue. This is especially important for Bangladesh as scientists have warned that one third of Bangladesh will go under water in future if the world's average temperature increases at its current rate. The results of my research concur with those of a similar study conducted in Bangladesh (Afrin & Akhter, 2007).

Hence, my concern is about this disjunction between students' acquisition of basic scientific knowledge and their inability to transfer it to real-life situations.

Case 2: In Bangladesh one of my relatives was explaining that her daughter had been suffering from a fever for a couple of days. I asked what her maximum body temperature was and she replied, "I don't know how to read temperature on a

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low as -18 degree Celsius. The Earth's surface and lower atmosphere are warmed because of the greenhouse gases and which consequently makes our life on Earth possible.

thermometer, I felt the temperature by putting my hands on her forehead”. It was surprising that this woman, who holds a Bachelor’s degree, could not read the thermometer! In this case my relative was not interested in learning how to use and read the thermometer scale. According to her, teachers showed them a thermometer in a picture and gave theoretical knowledge of its use. However, my relative could not apply this theoretical knowledge in her practical life. In this case if the teacher had engaged students in using a thermometer to measure their own body temperature, such a case may not have occurred. So, in this case functional scientific literacy had not been acquired although the concept was related to an everyday situation. The students also do not appreciate that something, such as using a thermometer, can be an important life skill.

Case 3: Occasionally, the flow of electric current stops at home due to a short circuit. One night I was present at the house of a relative when the electricity supply stopped and the whole house went into darkness. There was a Bachelor of Science degree holder in that house and yet he did not know how to solve the problem. His mother told him to call an electrician to solve the problem, which he did. The electrician solved the problem within five minutes by repairing the fuse within the main switch and re-connecting the circuit. Once again a problem in a real-life situation was not solved despite a person holding some theoretical knowledge about electrical circuits being present.

Case 4: A polythene bag is really useful for carrying things as it is very light, cheap, available and waterproof. However, it is harmful if, after use, if it is thrown away in our environment as it is not biodegradable, and can block the drainage system while ultimately contributing to environmental pollution. Sometimes in Bangladesh when heavy rain falls, water cannot pass through the drains due to the collections of rubbish including polythene bags. As a result of these blocked drains, roads become flooded and people have difficulty moving from place to place, particularly during the rainy season. Due to this and other disadvantages, the government of Bangladesh has strictly banned the production and use of polythene bags. Instead, people use bags made of jute and cloth or thick paper as these are biodegradable. Although many people know about the harmful effects of polythene they still choose to throw plastic bags anywhere: even educated people do this. This is a social problem. It seems that, as citizens, people are not taking personal and moral responsibility for protecting the environment. It needs personal motivation to act responsibly towards these types of issues.

The experiences presented in the four cases above raise many questions in my mind. What are the purposes and scope in the school science curriculum for students to apply their scientific knowledge, skills, and attitudes and values to their everyday lives? Why are students unable to make links between basic scientific concepts and everyday problems or global issues? Why do students not apply their theoretical knowledge to solve problems in a practical setting? Why do people not take moral and personal responsibility for the environment despite what they know? Where and what are the gaps? How do teachers interpret everyday concepts of science in classroom teaching? How do students perceive everyday concepts of science? Do they think that the knowledge, skills, attitudes and values they acquire in the classroom are valuable? Do they think these concepts are important in solving everyday personal, social, economic or political problems? Does their learning help them in decision-making?

Theoretically, citizens make decisions based upon their scientific understandings. Nevertheless, the four cases described above do not demonstrate that citizens are aware of the relationship between scientific understanding and everyday life. The current state of science education in Bangladesh does not seem to be educating students to acquire knowledge, understanding, skills and attitudes to solve their everyday problems. Consequently, there is a need to analyse the curricula documents to explore how real-life oriented topics, problems and issues are represented in the specific objectives and learning outcomes of the junior secondary level general science curriculum. Moreover, because teachers play a vital role in implementing the curriculum particularly through the use of textbooks, these too require exploration. In particular the content of the textbooks are important to determine how the objectives and learning outcomes are presented. Building on this, it is important to understand how teachers in Bangladesh present context-based knowledge and skills to students to enable them to recognise the links between their scientific studies and solving real-life problems and issues as well as the extent to which students are able to use their science learning in real-life. There is a gap between the scientific theories as taught in the classroom and their application or practice in the students' everyday lives. This is the major issue underpinning this thesis.

1.3 The Context of the Study: Science Education in Bangladesh

In Bangladesh the general education system comprises of three major stages- primary, secondary and higher education. Primary education is a five-year cycle with an entry age of six years. Secondary education comprises seven years of study with three sub-levels: three years of junior secondary (Grades VI- VIII), two years of secondary (Grades IX and X) and two years of higher secondary (Grades XI- XII). The age groups designed for junior secondary, secondary and higher secondary levels are 11-13, 14-15 and 16-17 years respectively (Ministry of Education, 2006). In general education, a Bachelor degree (Pass course) and a Bachelor degree (Honours course) require three and four years of study, respectively. A Master degree requires one year for Bachelor degree (Honours) and two years for Bachelor degree (Pass) holders.

Bangladesh is divided into seven major administrative divisions. Each division is named after the major city within its jurisdiction that serves as the administrative capital of that division: Dhaka, Chittagong, Rajshahi, Sylhet, Khulna, Barisal, and

Rangpur. The large majority (98%) of the institutions of secondary and higher secondary education are non-Government. In total there are 19,208 secondary schools in Bangladesh. Of these, 318 are Government schools and 18,890 are non-Government schools including boys', girls' and co-educational schools (Ministry of Education, n.d-a). The non-Government schools and colleges depend largely on Government grants to meet their expenses (Japan Bank for International Cooperation, 2002).

The National Curriculum and Textbook Board (NCTB) is responsible for renewal/modification and development of curricula and provides textbooks from primary to higher secondary levels of education. Science is taught as a compulsory subject from Grade I to X. In the centralised education system of Bangladesh, diversification of curriculum starts from Grade IX. The science students study physics, chemistry and biology or computer science as compulsory subjects whereas humanities and business study group students study general science as a compulsory subject. In each grade (VI-X), there is a single general science textbook. In the junior secondary level 'General Science' is prescribed as an integrated course approach (NCTB, 2006), comprising different areas of physical and biological sciences, Earth science and technology. However, in the curriculum and textbooks, topics are not arranged based on integrated themes (Rahman, 2011). Emphasis is given mainly to physics, chemistry, and biology related topics. The textbooks are written following the objectives and learning outcomes of the junior secondary level General Science curriculum published in 1995. In 2000 all textbooks were evaluated and revised with updates available in 2008. The 1995 junior secondary General Science curriculum and corresponding General Science textbooks (revised in 2008 and reprinted in 2010) are used in this study for document analysis.

In the curriculum report it was agreed that:

> *The importance of acquiring scientific knowledge and skills is unavoidable for improving the quality of lives, solving day-to-day problems and making decisions. So, in the contemporary world, consistencies of measures are being taken to integrate science and technology with society* (Science, Technology and Society approach) (NCTB, 1995, p. 353, my translation).

> *It is possible to transform the large population of Bangladesh into manpower through life oriented and work oriented education in accordance with personal and societal needs* (NCTB, 1995, p. 352, my translation).

The curriculum aimed:

> *To provide such knowledge and skills to all students, so that those for whom junior secondary level is the terminal education, will be able to acquire necessary knowledge and skills to maintain their responsibility smoothly in their active life or to engage in self-employment, as well it will build a strong foundation for those who wish to go on to further education* (NCTB, 1995, p. 352, my translation).

The National Education Policy 2000 recommended that the:

> *Textbooks will have to be developed and taught in such a way that students can acquire concepts of fundamentals of science, its explanation and application in real-life* (Ministry of Education, 2000, p. 33, my translation).

In the National Education Policy 2010 the recommended aims and objectives of science education were:

> *To prepare the learners in a way that helps them [students] develop their talent, practice of knowledge, and creativity equal to an international standard;* and

> *To provide science education to the learners in a way so that the learners understand that there exists a close relationship between technology and humanities and each of them is complementary to the other; science will be taught as a coordinated discipline* (Ministry of Education, 2010, p. 30).

In the statistical report of the National Education Survey (Post-Primary)-2008 (BANBEIS, 2010) in Bangladesh it was found that for the non-science stream (Humanities and Business Studies group) the enrolment of students in Grade IX was 82.25%, while the percentage in the science stream was 17.75%. These statistics indicate that a large percentage of students were detached from science at the secondary level in Bangladesh. Therefore, a foundational level of science is necessary at junior secondary for all students to understand science and its practice in everyday life.

In the General Science curriculum teachers were advised to avoid lecturing as much as possible and, based on the school environment and facilities, create opportunities for the students to learn science through direct experiences using hands-on activities (NCTB, 1995, p. 401-402). However, most science teachers (85%) are not confident in using teaching strategies other than transmissive approaches (Maleque, Begum, & Hossain, 2004). Moreover, the textbook-oriented examination system demands answers mostly based upon the memorisation of content knowledge (Holbrook & Khatun, 2004, cited in Siddique, 2007). This system forces teacher to encourage students to rote-learn (Tapan, 2010) in order to equip them for public examinations. Teachers mainly use the traditional teaching methods of chalk and talk with few demonstrations. In most cases, teachers are dealing with an excessive number of students (often more than 100 students per class) (Holbrook, 2005), teaching overload (Haque, 1976; Tapan, 2010), covering absent classes, and other administrative responsibilities (Rahman, 2011) while having access to limited resources and lack of infrastructure facilities (e.g., poorly equipped or no science laboratory in schools) (Tapan, 2010). These conditions make the situation more difficult for the teachers to teach science using a student-centred approach. Tapan (2010) points out that a lack of motivation and interest, inappropriate training and lack of supervision of teachers teaching practices are the causes of teachers' reluctance to find ways of establishing student participation in classroom activities.

At the secondary level of education, ineffective teaching was identified as one of the major variables responsible for the declining quality of education and the consequences of such unproductive teaching, which especially affects poor and disadvantaged students (Sarvi, Djusupbekova, Ikemoto, Mahmood, & Sultana, 2004). As a result a large group of students virtually ‘drop out’ from meaningful participation and learning in the classroom (Ahmed, Ahmed, Khan, & Ahmed, 2007), that is, children are seemingly physically present but psychologically and intellectually absent.

The status of secondary education has drawn the attention of the government, educators, national and international NGOs and aid-agencies. There is a common view among stakeholders that professional development training has had little impact on the quality of teaching practices (Asian Development Bank [ADB], 1998). In 2006 the Teaching Quality Improvement in Secondary Education Project (TQI-SEP) was launched in Bangladesh with a goal to improve the quality of students’ learning through improved teaching quality (Sarvi, et al., 2004). It initiated professional development for all in-service teachers of Grades 6-10 for both Government and non-Government registered secondary schools in Bangladesh (Asian Development Bank, 2008). Another non-Government organisation, Bangladesh Rural Advancement Committee (BRAC), initiated a training program for science teachers to teach General Science courses for Grades VI to VIII focussing on subject matter knowledge and pedagogy related to content.

A one-year Bachelor of Education (BEd) is mandatory for the teaching profession in junior secondary and secondary schools in Bangladesh. The minimum qualification required for entry into BEd is a Bachelor of Science. After a BEd, one can continue onto a Master in Education (MEd) in the teachers’ training institutions or universities of Bangladesh. The Directorate of Secondary and Higher Education (DSHE) has specific responsibility for the enforcement of academic standards of secondary and higher education. It is also involved with the recruitment of teachers. Science teachers in non-Government schools are recruited through Non-Government Teachers' Registration and Certification Authority (NTRCA) (Ministry of Education, n.d-b), which was established in 2005. It is empowered to conduct teachers' registration examinations for the selection of competent teachers for non-Government junior high schools, secondary schools, colleges and other parallel educational institutions spread across the country (Ministry of Education, n.d-b). Teachers holding a Master's degree in this study who were employed before 2005 and were recruited through the school management committees may not have appropriate teaching qualifications.

Overall, the aims of science education, the existing context, and my personal experiences raise a number of questions. These questions are about the appropriateness of the general science curriculum at junior secondary level, as well as the textbooks and teaching practices, in implementing the curriculum in relation to real-life science effectively. Consequently, this study is designed to investigate and provide answers to the following questions.

1.4 Research Questions

This research investigates how the junior secondary science curriculum in Bangladesh is related to real-life situations. In order to investigate this issue, three research questions have been formulated:

1. To what extent is the junior secondary science curriculum of Bangladesh real-life oriented?
2. To what extent are the science textbooks in Bangladesh real-life oriented?
3. What are the perspectives of teachers of implementing this curriculum with real-life emphasis?

These research questions provided a framework for planning this study, and collecting and analysing the data. Using an analytical framework following Roberts' (1982) seven and Fensham's (1994a, 1995) three curriculum emphases the junior secondary science curriculum and textbooks were analysed, and teachers' teaching approaches were observed and discussed.

1.5 The Rationale and Significance of this Research

The last renewal and modification of the junior secondary level science curriculum, which has been undertaken, was in 1995. In 2001-2002 the National Curriculum and Textbook Board (NCTB) revised the primary level science curriculum to make it life-oriented. On the other hand, the Secondary Education Sector Improvement Project (SESIP) strengthened the secondary level curriculum (Grades IX-X) in the same year. Normally, revision of the primary curriculum needs to be followed by that of the junior secondary curriculum. Nevertheless, the sequence has not been maintained and when this study was undertaken, no action had been taken by NCTB within the past 15 years (i.e., since 2001-2002) to revise the junior secondary level curriculum. In the meantime, many changes have occurred in social, national, and international perspectives regarding science, technology and environment. These should be reflected in the junior secondary level curriculum to ensure that students become informed citizens able to apply scientific learning in their daily lives. Consequently, there is an urgent need for renewal and modification of the General Science curriculum at the junior secondary level.

Development of quality education depends on effective implementation of quality curricula with an emphasis on science and technology in society. If a science curriculum is not life-oriented and no instruction is given to the teachers then they will overlook the strategies to be taken in teaching science-technology-society related content for the learners. Research shows that the implementation of curriculum at the junior secondary level is not up to the mark (Sarkar & Corrigan, 2013). Teaching methods are still traditional and textbook-based. I have had the opportunity to observe some classroom teaching and learning of science. I did not see any teachers teach science that engaged students using contexts that were related to the topics. Rarely did teachers use teaching aids for clarifying abstract science concepts. Generally, teachers have limited skills in helping students to understand the links between theoretical discussions and real-life science situations (Rahman, 2011).

In the preceding section on my personal motivation for undertaking this study, I observed that the present state of science education did not seem to allow students to learn science in a way that enabled them to apply their scientific knowledge, understanding, skills, and attitudes in everyday situations. Aikenhead (2006) pointed out that the majority of students do not understand science concepts 'meaningfully' and cannot integrate most of the notions with their everyday situations. He explained that this may be the result of a lack of relevance of science content to real-life, or because teachers were unable to explain these concepts to the everyday life of their students. The duty of the curriculum developer is to provide the best possible opportunities for all students to learn…, [and] "should provide meaningful connections between the concepts and processes of science and the personal and social dimensions of students' lives" (Bybee, 1997, p. 139-140). Therefore, science curricula and textbooks need to be improved so that the teaching and learning of science becomes more life-oriented. This study will closely explore possible solutions for addressing this issue.

To the best of my knowledge, there is no research involving real-life orientation of the science curriculum at the junior secondary level in Bangladesh; this is the first initiative. The findings of the research will provide guidelines for curriculum developers to improve the quality of the General Science curriculum at the junior secondary level. In particular, this quality improvement will be related to the specific objectives, learning outcomes, content of the topics, teaching strategies and assessment techniques of the curriculum making it more life-oriented. These in turn may make a significant contribution to updating pre-service and in-service teacher training programs to train teachers to apply context-based teaching strategies in ways that are meaningful to students' real-life situations - this is the contemporary goal of science education. In addition, textbook writers will develop textbooks based on contemporary contexts. Moreover, researchers in science education and the education authorities will be able to recognise the appropriateness of the junior secondary science curriculum, published in 1995, regarding science education for everyday life.

1.6 Organisation of the Thesis

The thesis is arranged in seven chapters. Chapter 1 introduces the study presenting the researcher's personal motivation for conducting the research as well as the context of the study, its rationale and significance, and the organisation of this study. The Literature Review is presented in Chapter 2. An overview of the research design, the research paradigm underpinning the research, and methodological approaches used at different phases of the research are described in Chapter 3. Results of the study are presented in Chapters 4, 5, and 6. Chapter 4 focuses on the results of the analysis of the junior secondary science curriculum (General Science) in separate sections for Grades VI to VIII followed by a summary of the findings for the total curriculum. Chapter 5 then provides the results of the textbook analyses for Grades VI to VIII. The chapter also discusses how the specific objectives and learning outcomes of the curriculum are reflected in the textbooks. Chapter 6 presents teachers' perspectives regarding the implementation of the curriculum with a real-life emphasis. In this chapter a synthesis of the questionnaire results, classroom observations, interviews with teachers and student focus group discussions is presented. Chapter 7 provides a discussion of the outcomes of the research questions, and the associated conclusions. The chapter concludes with recommendations for future research in this area.

Chapter 2
Literature Review

2.1 Introduction

To begin the exploration of the way the junior secondary science curriculum of Bangladesh links to students' lives, this chapter reviews the relevant research literature in science education. The discussion begins with science curriculum reform movements, including those in Bangladesh with an account of the emphasis on 'real-world' science teaching. The next section describes the conceptions of scientific literacy, the nature of science, values and attitudes and curriculum emphases for school science education. These elements are followed by a discussion of the teaching and learning strategies of real-life science for students' meaningful learning and the challenges teachers encounter in teaching science. As much of the study in science education is devoted to the above areas, the findings of this literature review provide guidelines for conducting the present study and preparing the required research instruments.

2.2 Science Curriculum Reform Movements

Since the 1950s, the two main demands of school science education were: (1) to ensure a scientific and technical workforce for the socio-economic development and defence of the country; and, (2) to develop scientifically literate citizens, so that they can contribute appropriately to the welfare of society (Fensham, 1985, 1992). The increased knowledge of science and technology within society and the ability to use this knowledge to make sense of our world raised the prominence of the second demand. As a result, 'scientific literacy', a slogan that first appeared in the 1950s (Jenkins, 1990), flourished in the 1990s. Primarily, this term was used in curriculum planning to refer to the requirement for the 90% of students who were not likely to become scientists to experience a scientific literacy stream (Roberts, 2007).

In the 1960s and early 1970s, the rapid growth of scientific knowledge and associated practical skills strengthened scientific concepts in different science courses at school and at the undergraduate level. The main aim of learning these concepts was to prepare future scientists and elite students for higher study in science-related disciplines. Fensham (1985) argued these concepts were characteristic of the traditional science curriculum and this type of curriculum and content of science education was suitable and useful for selecting a minority of students for higher studies in science disciplines. However, curricula designed for these students were not attractive or appropriate for students unlikely to follow the same post-school directions**.** Learning these scientific concepts took so much time that many of the exciting aspects of contemporary science and its social applicability were overlooked or omitted. As a result, for the majority of the students, science was a ‘mysterious’ subject that was difficult to learn. The result was the emersion of an elite group of peers keen on science who were rapidly being distanced from those for whom science had little meaning. Thus, the second demand of science education reform of the1950s, to make a scientifically literate citizenry, was not fulfilled by this curriculum change.

Both of these demands of science education were, in many science curricula, conflicting rather than complementary. However, the recognition by some educators of the demands for both aspects in the science curriculum led to the campaign ‘Science for All’ that became a slogan for international curriculum development in the late 1980s and 1990s. The vision of this campaign was to prepare all students as scientifically literate citizens through school science with a broader knowledge base than what could be provided by single disciplinary sciences. Fensham (1985) suggested selecting and formulating the subject matter or content with close reference to students' personal and societal needs and based upon their prior knowledge. Similarly, Hofstein and Yager (1982) advocated for a curriculum based on social issues and not for the logic of the scientific disciplines. According to them, content should not only be selected for its disciplinary value but for its utility in helping students deal with real-world problems. Hence, the aim of 'Science for All' was consistent with the aim of scientifically literate citizenry because it highlighted learners' use of science in real-life contexts (Sadler & Zeidler, 2009).

Fensham's 'Science for All' agenda, connecting subject matter or content knowledge with students' personal and societal needs in the light of pedagogical concerns, is very much consistent with students' learning science to use in real-life contexts. The examples given in Chapter 1 (pages 17-22) illustrate, theoretical knowledge acquired from teaching science via rote-learning did not always help individuals apply their knowledge and skills to solve a problem in their everyday life at home or in their community. However, this might not be the case if the subject matter was taught through pedagogic considerations, using a hands-on or enquiry-based approach. All of the examples provided in Chapter 1 demonstrate barriers to creating informed citizens who bear responsibility towards science-related personal, social, local and global issues, if appropriate teaching strategies are not used. It is difficult for students to participate in decision-making and to take responsible action if they are scientifically illiterate or merely learn scientific concepts by rote without developing a conceptual understanding. Hence, pedagogical knowledge is important for the teachers to teach content for learners' use of science in real-life contexts.

Hodson's (2005) views of promoting students' outcomes of democratic decision-making also depend crucially on how scientific literacy is translated into curriculum practice. For instance, some of the big issues for Bangladesh are that dishonest businessmen are adding chemicals to food to increase business profits, fish are injected with formalin to prevent rotting, fruits are mixed with carbide for early ripening, the inner whiteness of rice puffs is due to the addition of urea. While people are very concerned about these adulterated foods, many, if not most, do not truly know the adverse effects of adding these types of chemicals to their food. Yet, the exclusion of these issues from curriculum content and/or textbooks obstructs teachers and students from becoming more aware of the issues.

In a report on the public's understanding of science, The Royal Society (1985) in Britain proposed a significant manifesto - Science is for everybody. It stated that:

> *A proper science education at school…must provide the basis for an adequate understanding of science, which is then to be added to throughout life. This understanding includes not just facts but the methods of science and its limitations, as well as an appreciation of the practical and social implications of science. Some understanding of statistics, including ideas of risk, uncertainty, ratios and variability, are so intrinsic to the method of science and to understanding many personal and public issues, that they should be the goal of science curricula* (as cited in Fensham, 1992, p. 800).

Thus, this manifesto provided strong support for a 'Science for All' goal that recognised a core curriculum of 'balanced science' for all students up to the age of sixteen (Fensham, 1992).

To meet the characteristics of 'Science for All', Fensham (1985) advocated four types of learning content: concepts of science and their applications; science process skills; scientific attitudes; and the nature of science. He suggested ten components be included in the school science curriculum to meet the requirements of these types of learning content. These ten components include-

1. *Knowledge: facts, concepts and principles used in science* (*thus knowledge content becomes a component of the total content, etc*.).

2. *.Applications of knowledge: the direct and less direct use of the concepts and principles of science in real or idealized situations.*

3. *Skills: the intellectual skills like classifying, control of variables, use of models, prediction from data, etc., that are commonly used in science.*

4. *Practical skills: certain psychomotor operations involving various sorts of equipment and instruments, and common ways scientists investigate the natural world.*

5. *Problem-solving: the combination of scientific knowledge and intellectual skills to solve theoretically-presented problems. If practical skills are added, the solution may actually be carried out by the learner.*

6. *Science traits and attitudes: the pursuit and process of science has often been associated with traits like honesty of observation and reporting, open-mindedness regarding explanation and phenomena, sharing of results etc., which, combined, form a science attitude. Another set of attitudes are those that relate the learner to scientists and what science represents in the society locally, nationally and globally. There are also attitudes to science as a subject for study, for pursuit in leisure, and as a potential source of employment.*

7. *Applications of science and technology: an application of science or an example of technology involves scientific knowledge that often comes from a number of science disciplines. The performance of a socially required task is the reason for the application of technology. In practice, there will also be a number of social implications in these performances that extend beyond the initiating task.*

8. *Personal and social needs: in all societies, there is an existing set of personal and social operations that involve scientific knowledge. There is great potential for sharing and harnessing this knowledge so that these needs are met better and more equitably.*

9. *The evolution of scientific knowledge: science is a human invention, which is expanding and changing. Some appreciation of the way this occurs can be obtained in a number of ways that could involve the history of science, especially developed sets of experience, expository accounts, etc*

10. *Boundaries and limitations of science: science and its applications can be helpful but sometimes also harmful. When critically appreciating science, it is important to reiterate that popular knowledge and traditional views are also*

> *powerful and important. Science can only contribute in limited ways to many modern problems.*
>
> (Fensham, 1985, p. 426-427)

Among these components, knowledge, applications of knowledge, uses of science and technology, personal and social needs are linked to the concepts of science and their applications. Elements of process skills include intellectual skills, practical skills and problem-solving skills. The evolution of scientific knowledge and the boundaries and limitations of science can be categorised as ideas of science or the nature of science (NOS), and science traits and attitudes are referred to as scientific attitudes.

Millar (1996, 2002) suggested two central aims for the science content of the school curriculum for students aged 5-16:

- *To help students become more capable in their interactions with the material world, by emphasizing a practically useful, technological way of knowing;*
- *Gradually to develop students' understandings of a small number of powerful 'mental models' (or 'stories') about the behaviour of the natural world.* (1996, p. 12-13; 2000, p. 120)

Millar recommended that students' understandings of science content be relevant to their lives and that methods of learning science ensure they understand using science and technology. Moreover, he advocated for students' understandings of big ideas to explain natural phenomena. These two aims are applicable both to students who will not continue their education in science and those who wish to pursue science further. Fensham (1992) claimed that if the update of the science curriculum fulfils the conditions of both targets enough, students would be interested to continue science to cater for the specialist workforce of tomorrow.

With these aims, Fensham (2004) further proposed that some sort of higher-order thinking of science, related to personal well-being, democratic well-being, socio-economic well-being and the well-being of science, is necessary for students to engage with science and may help students in making decisions in everyday life situations. Personal well-being allows students to deal with science knowledge confidently in their daily lives. For example, individuals can make decisions about their diet, health and safety by evaluating manufacturers' claims to make sensible consumer choices based on their understanding of scientific knowledge (Millar, 1996).

Scientific knowledge regarding democratic well-being acknowledges an individual's right to know and express an opinion about scientific activities that affect their lives. As the products of scientific and technological research require public funds and may impact on public and private life, members of the public have the right to know what is going on and what may be the consequences of scientific products in their lives. Such an understanding, or scientific literacy, allows people to exercise effective decision-making (Thomas & Durant, 1987).

Individuals are better able to fulfil their roles in society (i.e., as citizens and consumers) by acquiring scientific knowledge necessary in a wide variety of social contexts that affect their personal or economic welfare (e.g., nutrition, health, energy usage) (Jenkins, 1994). Such scientific knowledge is known as being in the realm of socio-economic well-being.

Understanding the well-being of science in science education provides a sound comprehension of science, including its limitations (Jenkins, 1994; Laugksch, 2000). Importantly, the limitations of science mean it cannot always provide answers or solve every problem; therefore "the more the public understands about the objectives, processes, and capabilities of science, the less likely the public will be to acquire unrealistic and unrealizable expectations of science" (Laugksch, 2000, p. 85). As a consequence of unrealistic expectations of science, the public may lose their confidence in science and eventually withdraw their support. A better understanding of science and its limitations may counteract this potential dissatisfaction with science (Laugksch, 2000).

Each of these four areas of 'well-being' is necessary in students' thinking if they are to deal productively with science and enjoy the benefits of scientific knowledge. Arguing in favour of teaching 'Science for All', Milner (1986) maintained that science contributes distinctive skills, concepts and perspectives that other subjects do not offer. Science is important and it is of value to acquire these skills, if one is to be a scientifically literate citizen. As these skills can only be acquired through formal instruction (Milner, 1986), content relating to personal, democratic, socio-economic well-being and the well-being of science needs to be included in the school science curriculum (Fensham, 2004).

In an alternative approach, Roberts (1982) proposed seven 'curriculum emphases' as a set of coherent messages about science— each of which introduces a particular purpose for learning science and represents the content of science teaching in a context. These emphases are mentioned in Chapter 1 (page 16). He introduced these emphases at a time of curriculum change in western countries, particularly in the USA. These curriculum emphases were elaborated in such a way so that they could be applied "in analysing curriculum policy debate, in guiding the development of instructional materials, and in studying curriculum implementation in the classroom" (1982, p. 245-246). However, with the Science, Technology, and Society (STS) movement that followed this work of the early 1980s, Fensham extended Roberts' frame by adding another three curriculum emphases (Fensham, 1995, 1996): Science as Application;

Science for Nurturing; and Science in Making (Fensham, 2004). But, this raises a number of issues. Whether students get these messages; whether the messages are incorporated into science curricula as specific objectives and learning outcomes for developing instructional materials; whether the teaching and learning materials are helpful for the teachers to teach science; whether the teaching and learning strategies are helpful for students to:

- learn how to apply scientific principles and generalisations to cope with individual and collective problems;
- experience, understand and express the nature of science, its growth and development;
- know the products of science for providing scientific explanations for natural phenomena;
- understand the limitations of science in coping with: practical dealings; differences between science and technology; and scientific/technological considerations associated with value-laden personal and political decision-making;
- engage in their own ‘theory building’ about natural phenomena;
- acquire competence in intellectual and practical skills or processes in science;
- engage with cultural and contextual considerations to address relevance and comprehension;
- gain sufficient knowledge to progress to the next level of study in science;
- acquire knowledge regarding Science for Nurturing to improving quality of life and the environment;

- acquire knowledge of the science involved in the materials and the production process for technological capability.

The above messages will be assessed in the specific objectives and learning outcomes of the Bangladeshi junior secondary science curriculum. Are these messages reflected in the content of corresponding textbook topics and applied in teachers teaching practices--will be assessed as well.

In addition to Roberts' curriculum emphases, in the early 1980s attention was given to balancing the traditional science curriculum by adding the complex relationships between science, technology, society and the environment to the structure and processes of traditional science. "This new curriculum emphasis has even acquired its own acronym, STS (for science, technology and society)", which brought radical changes in the selection of important scientific content and the ways in which students are expected to interact with that content (Orpwood, 2001, p. 138). This curriculum reflected a worldwide shift of science education towards teaching science as a human endeavour.

Aikenhead (1994) explored four features of STS curricula:

- Function - goals of teaching science through STS;
- Content - the teaching topics;
- Structure **-** how should science and STS content be integrated; and
- Sequence **-** design of STS instruction.

These features of STS curricula draw on much of the other literature that was generated during the same period.

Function: This curriculum is expected to increase the general interest in science and public understanding of science, particularly among bright and creative students, especially girls. Another expectation of STS curriculum is to ensure social responsibility around issues related to science through collective decision-making practices that were rarely considered in traditional science curriculum. For making complex decisions, such as "the application of scientific knowledge, technological expertise, social understanding, and human compassion" (Kranzberg, 1991, p. 238, cited in Aikenhead, 1994, p. 49), society needs a harmonious mix of a scientific, technical elite with an informed citizenry. A number of STS curricula were developed with relatively similar goals but, in each, different priorities were emphasised in the goals. Generally, balanced STS curricula focus on the following three goals:

- *Acquisition of knowledge (Concepts within, and concepts about, science and technology) for personal matters, civic concerns or cultural perspectives.*

- *Development of learning skills (process of scientific and technological inquiry) for gathering information, problem-solving and decision-making.*

- *Development of values and ideas* (dealing with the interactions among science, technology, and society*), logical issues, public policies and global problems.*

(Bybee, 1985, p. 85, as quoted in Aikenhead, 1994, p. 50)

Content: STS curricula contain both concepts and knowledge of traditional science and skills associated with the generation of such knowledge and skills. STS curricula emphasises students' meaningful learning by integrating science content into social and technological contexts (Aikenhead, 1994).

Fensham (1988) proposed three approaches to determine science content for STS materials:

> Science determined including a description of the use of technology as a motivational aid to learn science; factual references to randomly-chosen examples of technology that involve the concepts of science topics; and factual references to selected examples of related technologies in relation to the societal functions the technologies perform or to aspects of the STS issues.

> Technology determined embracing a broad STS theme or relevant technology in context as the object of study; construction of a technological model or practise of technological processes for learning scientific facts, principles and scientific skills for using the model or process; and the social and in-depth scientific concepts related to a technology based on the science topic that are significant in the society of technology.
>
> Society determined including discussion about scientific aspects of technology or of socio-technical topics, and science and society. The former should give more emphasis to broader scientific principles with details of its social and economic context. The latter comprises one or more societal aspects of a major technology or a broad field of applied science with appreciation of the possibilities and limitations of the underlying science.

Fensham classified the STS curriculum based on content, which he thought of as *knowledge of worth* in various curriculum approaches. Rosenthal (1985) and Ziman (1984) adopted a different approach, emphasizing two types of social issues in STS science:

1. Social issues *external* to the scientific community ("science and society" topics; for example, energy conservation or pollution).

2. Social aspects of science—issues *internal* to the scientific community (the social epistemology of science; for example, the nature of scientific theories or the cold fusion controversy) (cited in Aikenhead, 1994, p. 52).

Structure: Aikenhead (1994) proposed a scheme "categories of STS science" (p. 53) describing the diversities in STS science in terms of the extent and manner in which it is integrated with traditional science content. These categories include:

> *Category 1: Motivation by STS content: Traditional school science, plus a mention of STS content in order to make a lesson more interesting. (The low status given to STS content explains why this category is not normally taken seriously as STS instruction). Students are not assessed on the STS content. Example: What many teachers do now to spice up the pure science content.*
>
> *Category 2: Casual infusion of STS content: Traditional school science, plus a short study (about ½ to 2 hours in length) of STS content attached into a science topic. The STS topic does not follow cohesive themes. Students are assessed mostly on pure science content and usually only superficially (such as memory work) on the STS content (for instance,*

5% STS, 95% science). Examples include Science and technology in society (SATIS, U.K.: Association for Science Education) and Consumer Science (US: Burgess).

Category 3: Purposeful infusion of STS content: Traditional school science, plus a series of short studies (about ½ to 2 hours in length) of STS content integrated into science topics, in order to systematically explore the STS content. This content forms cohesive themes. Students are assessed to some degree on their understanding of the STS content (for instance, 10% STS, 90% science). Examples: Harvard Project Physics (US: Holt, Rhinehart and Winston).

Category 4: Singular discipline through STS content: STS content serves as an organiser for the science content and its sequence. The science content is selected from one science discipline. A listing of pure science topics looks quite similar to a category 3 science course, though the sequence would be quite different. Students are assessed on their understanding of the STS content (for instance, 20% STS, 80% science). Examples include ChemCon (U.S.: American Chemical Society) Chemical Education for Public Understanding (US: Addison-Wesley).

Category 5: Science through STS content: STS content serves as an organiser for the science content and its sequence. The science content is multidisciplinary. A list of important pure science topics are selected from a variety of traditional school science courses. Students are assessed on their understanding of the STS content, but not as extensively as they are in relation to pure science content (for instance, 30% STS, and 70% science). Examples include Logical Reasoning in Science and Technology (Toronto: Wiley of Canada) and Global Science (US: Kendall/Hunt*).*

Category 6: Science along with STS content: STS content is the focus of instruction. Relevant science content enriches this learning. Students are assessed about equally on the STS and pure science content. Examples: Exploring the Nature of Science (London: Blackie & Son); Society Environment and Energy Development Studies (SEEDS) modules (US: Science Research Associates)

Category 7: Infusion of science into STS content: STS content is the focus of instruction. Relevant science content is mentioned, but not systematically taught. Emphasis may be given on broad scientific principles. (The materials classified as category 7 could be infused into a standard school science course, yielding a category 3 STS science course.) Students are primarily assessed on the STS content, and only partially on pure science content (for example, 80% STS, 20% science.) Examples: Studies in a Social Context (SISCON) in Schools (UK: Association for Science Education), Perspectives in Science—a video series (Canada: National Film Board of Canada)

> *Category 8: STS contents: A major technology or social issue is studied. Science content is mentioned but only to indicate an existing link to science. (The materials classified as category 8 could be infused into a standard school science course, yielding a category 3 STS science course.)Students are not assessed on pure science content to any appreciable degree. Example: Science and Society (U.K.: Association for Science Education), Innovations: The Social Consequences of Science and Technology program (US: BSCS).*
>
> (Aikenhead 1994, p 55)

In this proposed scheme, categories one to three followed traditional characteristics to select and arrange science content, on the other hand, the categories four to eight followed a sequence dictated by the STS content to organise science content (Aikenhead 1994).

Sequence of teaching STS Science: The STS science content is generated from a real-life situation where traditional science content is not diluted but is embedded in a socio-technological context. Aikenhead (1994) suggested a sequence of teaching STS science (Figure 2.1). STS instruction begins in the realm of society. The context can be identified on the basis of its meaningfulness to students as well as the science content that is generated by the context. For example, in Bangladesh, it could be a study of the social issue of the availability of alternative sources of fuel at home and in industry for electricity generation, other than the currently used natural gas, coal and imported oil.

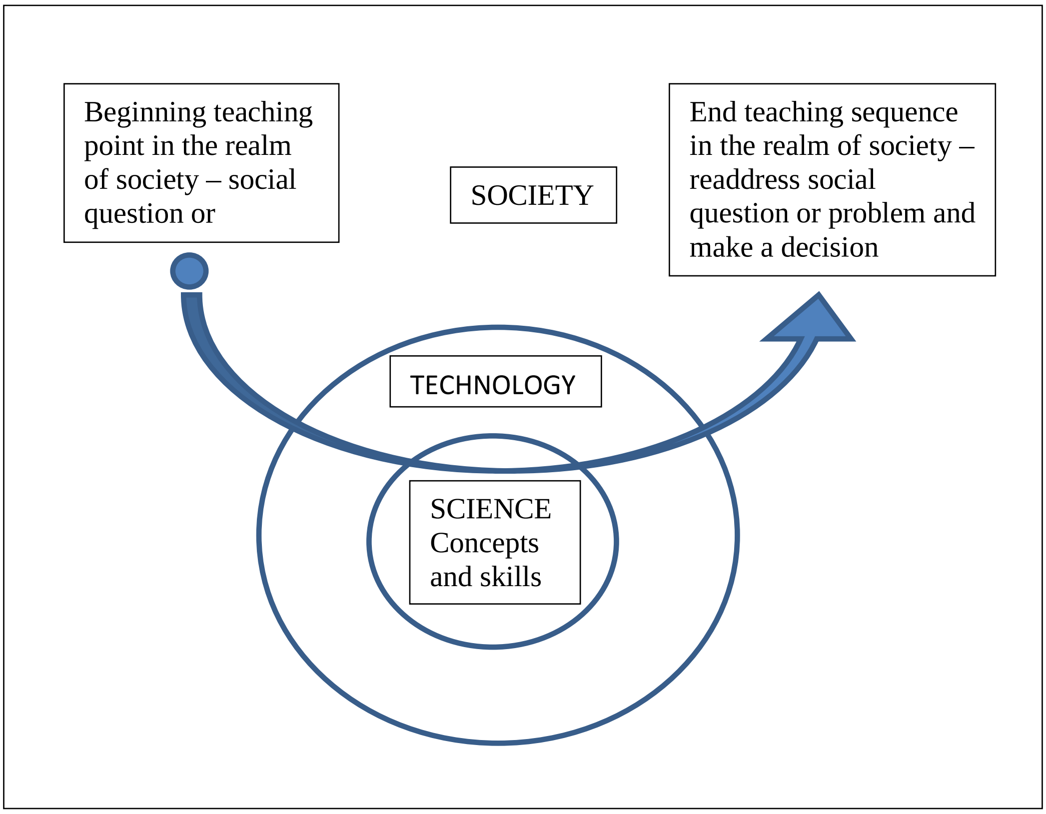

Figure 2.1: A Sequence for STS Science Teaching (Source: Aikenhead, 1994, p. 57

Such a study might include examination of these fuels, how they are used and their social, economic and environmental limitations, and explore prospective technologies, such as solar energy conversion and storage, and science concepts, such as electromagnetic energy and nuclear fusion.

Understanding societal problems and issues requires knowledge of some technological and science concepts (the central circle of the Figure 2.1). After grasping the deeper meaning of the science and the technology, for example, solar panel technology, students can revisit the social issue as a finishing point. At this stage, students can collectively make a decision addressing the key issue informed by the knowledge they have acquired in the process. The possibilities offered by such a teaching sequence are extensive, limited only by the teachers' choice and are beyond the scope of this discussion that will focus on the intended curriculum, the curriculum as translated or enacted by the teachers in their lessons and the students' experienced curriculum that refers to the formal learning actually experienced by students.

In recent years, the goals and content of the curriculum are stated in the form of outcomes expressed in a range of domains, including knowledge, understanding, skills and competencies, values and attitudes.

According to Orpwood (2001, p. 141), the outcomes of goals and content involve three elements:

1. *Understanding the core concepts of science and technology;*
2. *Acquiring the skills important for life and work in the 21st century; and*
3. *Being able to relate the knowledge and skills acquired in school to real-life situations.*

By acquiring these domains every student receives the opportunity to develop scientific literacy and technological capability for the real-world. Such outcomes will be challenging for classroom teachers if their teaching load, class size, materials and equipment facilities with conducive learning environment are not ensured, and range of teaching approaches, types of assessment strategies with their professional development are not provided.

Much has been discussed on science curriculum reform movements. The entire discussion regarding Science for All, STS curricula, Roberts' and Fensham's curriculum emphases provide guidelines about aims and objectives of science education. This also provides insight about different aspects of curriculum reform such as the nature of content and teaching approaches of science that is suitable to enable the students to apply their scientific knowledge in various aspects of real-life situations. Finally, it reflects the features of such curriculum that would meet students' needs and interests to learn science meaningfully while addressing both national and international concerns (Guo, 2007).

All of these aspects may be (or not) reflected in the educational goals of policy documents and in the specific objectives and learning outcomes of the curriculum in Bangladesh. Review of these aspects will provide insight about the effectiveness or shortfalls of the 1995 curriculum at the junior secondary level science curriculum.

2.3 Impact of Science Curriculum Reform Movements in Bangladesh

In the early 1980s, the revolutionary change affecting curricula of western countries also gathered significant momentum in many countries of the developing world, including Bangladesh. As Gray stated, "in an increasingly global community, it would be unwise to ignore developments in the developed world" (1999, p 262). But developing countries should have confidence in their ability to produce curricula that are not simply emulating the developed world's curricula. Developing countries must advance their own policies that should be "authentic, contextually relevant, and affordable in their own particular country" and have close links "with local technologies, problems and issues" (p.262).

The Bangladesh Education Commission report stated that:

> *The purpose of science education was not only for empowering a class of people by educating them through scientific knowledge and its application, but to attract all students to utilize their education for the well-being of the society* (Kudrat-e-Khuda, 1974, p. 108).

This statement reflects the notion of Science for All by Fensham (1985) as discussed in the previous section. In the report, committee members proposed an integrated science course for junior secondary level, comprised of biology, physics, chemistry and earth science. They also advocated that the science course be such that students can understand the applications of science in everyday life situations and, as far as possible, the curricula should be at the same standard of science education as in developed countries. Following the recommendations of this report, the National Curriculum and Textbook Committee in Bangladesh developed its science curriculum and accordingly integrated General Science textbooks for the junior secondary level and secondary level (for non-science students). In the early 1980s, these General Science courses were introduced as compulsory for students.

In 1995, to address emerging social needs and make it more contextualised to accommodate the new concept of Science, Technology and Society (STS), the Junior Secondary Level Curriculum was revised and learning outcomes based upon a new set of textbooks which were introduced in 1996-97. The textbooks were reviewed and revised in 2000, to face the challenges and prospects of the new century and respond to the advancement of science and technology, on which modern civilization largely depends.

> *Our daily life is inseparably related to science and technology. With this end in view, various important and life-related topics of science have been incorporated in the [text] books to impart many of the basic knowledge on science.* (Shamsudduha, Miah, Wahab, & Khan, 1997)

Qualitative change in an education system is of paramount importance. Consistent with this, the National Education Policy 2010 of Bangladesh has given much attention to providing science education in a way learners can understand the close relationship between science, technology and the humanities (Ministry of Education, 2010). However, in reality in Bangladesh as in other developing countries (DomNwachukwu & DomNwachukwu, 2006; Gray, 1999), the majority of schools are poorly equipped for hands-on science, which results in textbook-oriented, theory-based teaching and rote-learning (Tapan, 2010). The following section describes the key components of the curriculum, which are used for studying the connection of the curriculum to real-life.

The aim of the junior secondary science education in the 1995 curriculum and the National Education Policy 2000 and 2010 that are mentioned in Chapter 1 may be successful in Bangladesh if the curricula and textbooks are designed and developed in keeping with science, technology, and society with life related topics. Therefore, this research explores to what extent the specific objectives and learning outcomes of the curriculum and content of the textbooks are related to real-life, and how these are implemented in the classroom for real-life orientation of the students. The following section describes the key components of the curriculum that are used for studying the connection of the curriculum to real-life.

2.4 Components of the Bangladeshi Curriculum

The junior secondary science curriculum (NCTB, 1995) of Bangladesh requires the following three key components to be implemented for each topic in Grades VI to VIII:

- Specific objectives: the purposes behind learning particular science content; this is a precise statement of the educational intent for a single unit/topic. There might be more than one specific objective for a single unit.
- Learning outcomes: the behavioural objectives that students will be able to demonstrate through their knowledge, skills and attitudes after learning the content. Learning outcomes are very specific and, based on specific objectives, represent “observable indicator(s) of student achievement” (Brady & Kennedy, 2010, p. 139). Outcomes describe the changes of learners’ observable behaviour.

- Content: the topics to teach. Following the specific objectives and learning outcomes of the curriculum, content is developed.

The following table includes an example of a specific objective, associated learning outcomes and the content of one topic ‘Magnetic Energy’ from the Grade VI curriculum (NCTB, 1995).

Table 2.1: Specific Objectives, Learning Outcomes and Content of “Magnetic Energy”

Specific objective	Learning outcomes	Content
To acquire knowledge about general properties, preparation process and uses of magnet.	Describe the story of the discovery of the magnet. Tell what a natural and artificial magnet is. Tell what they understand by magnetic pole. Tell what are north pole and south pole. Demonstrate by experiment the attractive-repulsive properties of a magnet. Describe methods of magnetisation by rubbing and electrical method. Mention the uses of magnets in our everyday life in the electric bell, electric fan and compass.	Story of discovery of magnet, Natural and artificial magnets, Different kinds of artificial magnets, Properties of magnet: Magnetic pole, Methods of magnetisation Method of rubbing, Electrical method, Use of magnet

2.5 Emphasis on the ‘Real World’

Students acquire scientific knowledge skills and values from many sources including school science, watching television, using the internet, reading printed materials other than textbooks and through co-curricular activities in schools, such as playing sport or field trips to botanical gardens, museums, the planetarium, the zoo and industrial sites. However, in many developing and developed countries of the world, science education is seen to be in crisis (Braund & Reiss, 2006). Students are losing their interest and developing negative attitudes towards studying science across the age range of secondary schooling and at higher levels resulting in fewer students following on with science as a career (Braund & Reiss, 2006; Luehmann, 2009). One of the reasons behind this is the way scientific concepts are communicated to the students, which is decontextualised and scientist-centred. It is often boring and outdated to the students. They rarely find relevancy of scientific concepts in their personal and social life (Braund & Reiss, 2006; Lindhal, 2003; Goodrum, 2001).

Often, teachers encourage students' learning of science through memorising concepts and knowledge and demonstrating this learning through solid performance in their examinations (Braund & Reiss, 2006). With this approach, after examinations the ideas are most often lost from students' memories and so are not really learned. According to Ross, Lakin and Callaghan:

> *At best they (pupils) have a scientific system that is good enough to pass examinations. But after the crops have been harvested the land is bare, the ideas are lost and everyday life is unaffected*. (Ross et al., 2004, p.56 as cited in Braund & Reiss, 2006, p. 1375)

The themes 'transmissive pedagogy', 'decontextualised content', and 'difficulty' in school science were commonly reported by students in studies conducted independently by Lindahl (2003), Osborne and Collins (2000), and by Lyons (2006) in the countries of Sweden, England and Australia respectively. Comparison of their findings revealed that students in different countries and contexts were experiencing similar problems and not only in these countries but also in Canada, Denmark, France, Germany, India, Ireland, Japan, Korea, The Netherlands, Norway, New Zealand and the USA. Literature from different countries highlights that perception of experience of school science has a large influence on choice of students electing science or not in the future (Lindahl, 2007; Lyons, 2006; Maltese & Tai, 2010).

Declining student interest and enrolment in science courses across the age range of secondary schooling is an area of concern for science educators, who are facing school science which is often limited by a narrow selection of pedagogies that too often ignore the realities of students' own lives and interests (Tytler, 2007; King & Ritchie, 2012). Aikenhead (2006) agreed that traditional school science is not meeting the needs of students because the curricula lacked relevance. He suggested that curricula with humanistic science components were more likely to be of interest to students and would encourage more meaningful learning in science.

When students are offered learning within a sociocultural context, their learning will be enhanced. Bowen emphasised that students' understandings depend on knowledge of the sociocultural context because "all knowledge is socially constructed and highly influenced by the social context of its construction" (2005, p. 1). Bennett (2005) argued that, in a context-based teaching approach, context and applications of science are used as the starting point for the development of scientific ideas. If science is communicated to students through their active engagement in the learning process such as examining, characterising, analysing and evaluating or discovering something new within the contexts of the subject, this method, in contrast to traditional approaches, can influence and stimulate students to build their interests and enjoyment in learning. Campbell and Lubben (2000) identified student's positive attitudes towards learning science and participation in classroom transactions in three types of lesson contexts, that is, when teachers "allowed students: to work on personally useful applications of science; to own the lesson activities by contributing their expertise and knowledge; and to discuss contentious issues" (p. 134). Using a context-based learning process, students find answers to their own questions that are appealing and meaningful to them (Bowen, 2005). King and Richie (2012) claimed that context-based teaching is more than the transfer or application of concepts to the real world. Context-led approaches encourage and stimulate students' learning by nurturing their sense of wonderment while improving learner enjoyment (Campbell & Lubben, 2000). They also observed that context-based learning did not only help learning but also teaching. For example, when teachers invite students to provide possible explanations of an everyday situation they could identify students' misconceptions and, thereby, develop students' conceptual understanding.

The above discussions suggest that students' engagement with the learning process "is often seen as exciting, challenging, and uplifting" (Braund & Reiss, 2006, p. 1374). For example, they opined that when students watch multi-channel television or use the internet, they are often fascinated by eye-catching information about science and issues of relevance to their life based on their needs, interests, aspirations and experiences. Thus, when they learn science from informal settings or based on their experiences within various contexts, this significantly influences their learning because they find answers to their own questions from their real-life situation. These opportunities make students curious, they think critically, clearly and creatively which helps them to remember and apply their learning.

Dierking and Falk (1994; Falk & Dierking, 2000) detected improved understanding of school science of force and motion from museum visits by using pre-tests and post-tests with the students. Similarly, visiting industrial sites improved students' knowledge of industrial processes, which they remembered over a longer-term

(Parveen, 1999, Parveen & Stephenson, 2004 cited in Braund & Reiss, 2006). Environmental activities, such as watching bird and wild life, provide opportunities to impact on learner's performance of tasks around animal classification. Thus, science learning can be enhanced when presented in conjunction with or through real-world experiences.

There are a variety of interpretations of contexts and applications of science for developing scientific understanding. Applications of science occur in social, economic, political, environmental, technological and industrial arenas. The Science-Technology-Society (STS) (Yager, 1996) movement recognised the value of a context-based approach and applications of science for developing scientific understanding in learners. Accordingly, contexts are selected on the basis of learners' perceived relevance in their immediate and future lives. From Fensham's (1985) point of view, this means students engage in issues of science and technology in everyday life from different points of view which then prepare them for understanding scientific developments in their cultural, economic, political and social contexts. This awareness contributes significantly to making science accessible and meaningful to students while engaging them in real-world issues (Aikenhead, 1994; Fensham, 1985; Hodson, 1998).

Science educators and researchers are increasingly focusing on socio-scientific issues (SSI) through the STS movement for as a means of providing learning contexts to promote scientific literacy (Monsur, 2009; Sadler & Zeidler, 2005) by offering opportunities for individuals to use scientific ideas, processes and reasoning (Sadler & Zeidler, 2009). "The SSI movement seeks to engage students in decision-making on current social issues with moral implications embedded in science contexts" (Zeidler, Sadler, Applebaum, & Callahan, 2009, p. 74). Use of these social issues offer students a context that gives them confidence and allows "active reflection and examination of relevant connections among science, their own lives and the quality of life in their community" (p. 74). By these means, students may appreciate and understand the relevance of scientific discoveries and the impact of science and technology on their everyday life rather than simply concentrate on learning the facts and theories.

The above discussion about context-based teaching and learning indicates that the vision of school science education and 'Science for All' was not only about building a foundation for further study towards prospective careers but also for preparing students to act as responsible citizens (for example, to take part in making decisions). This was reflected in the aims and objectives of science education in Bangladesh's 1995 curriculum, and National Education Policy 2010. Hence, the intended junior secondary level science curriculum in Bangladesh allows students to look critically at personal and societal problems and issues, at its values and at their engagement with science and technology in everyday life and in real-world issues. It is, thus, enabling students to become scientifically literate citizens but does not, of course, guarantee this will occur.

Chapter 1 explained that, although citizens acquired knowledge of and about science, the lack of contextualised teaching and learning and active involvement in science-related topics often resulted in students who lacked confidence and were unaware about how to use their knowledge, skills, attitudes and values in everyday related issues. If they are unable to apply their science learning in everyday life situations at this stage, how will they deal with bigger science-related local, national and global issues and how will they apply science and technology in their decision-making? It can be seen, then, that it was necessary for the researcher to focus on and elaborate on the phrase 'real world' (or 'real-life situation').

2.6 Scientific Literacy

The common goal of all curriculum reform movements is to achieve scientific literacy (Lederman & Khishfe, 2007). It represents what students know and are able to do as a result of their science learning experiences (Sadler & Zeidler, 2009). Hazen and Trefil point out that it helps individuals to place new developments or information about science in a meaningful context (as cited in Laugksch, 2000), to take part in national debates and to make personal and societal decisions (Lederman & Ledarman, 2005). The Organization for Economic Co-operation and Development [OECD] has developed a commonly-quoted, updated description of scientific literacy for the purpose of the Program for International Student Assessment (PISA) 2006 project. This refers to an individual's:

- *Scientific knowledge and use of that knowledge to identify questions, acquired new knowledge, explain scientific phenomena and draw evidence-based conclusions about science-related issues;*
- *Understanding of the characteristic features of science as a form of human knowledge and enquiry;*
- *Awareness of how science and technology shape our material, intellectual, and cultural environments; and*
- *Willingness to engage in science-related issues and with the ideas of science, as a reflective citizen.*

(OECD, 2006, p. 23, box 1.2)

The PISA framework of scientific literacy is guided by students' need and consists of four interrelated aspects:

- Context: Refers to students' engagement in science in a variety of situations. Citizens require an understanding of basic science concepts and science processes to use in circumstances that individuals encounter in life. Context, in the PISA framework (p. 26), assesses students' knowledge, competencies and attitudes in personal, social and global, real-life situations, e.g., health, natural resources, environment, hazards and frontiers of science and technology.

- Knowledge: Citizens' understandings of the natural world should be based on scientific knowledge consisting of, not only, cognition of the natural world but of science itself.
- Competencies**:** Refers to citizens' demonstrations of aptitudes in identifying scientific issues, explaining phenomena scientifically, and drawing evidence-based conclusions.
- Attitudes: It is expected that citizens demonstrate an interest in science, support for scientific enquiry, and have the motivation to act responsibly towards natural resources and environment.

An understanding of science and technology is the central aim of PISA 2006. It stresses young people's preparedness for understanding and awareness of life in modern society, enabling them to participate fully in a society where science and technology play an important role. This understanding also empowers them to participate appropriately in determining science-related public policies that have significant impact on individuals' personal, social, professional, and cultural lives.

The authors of Twenty First Century Science (2008, as cited in Dillon, 2009, p. 206) expect that a scientifically literate person should be able to:

- *Appreciate and understand the impact of science and technology on everyday life;*
- *Take informed personal decisions about things that involve science, such as health, diet, use of energy resources;*
- *Read and understand the essential points of media reports about matters that involve science;*
- *Reflect critically on the information included in, and (often more important) omitted from such reports; and*
- *Take part confidently in discussions with others about issues involving science.*

Thus, there is established support for scientific literacy in students, providing them with the ability to understand and apply scientific ideas in real-life situations.

Some definitions of scientific literacy put emphasis on the preparation of students to be life-long learners in science (e.g., Norris & Phillips, 2003; Rennie, 2006).

From the 1970s, many science educators achieved consensus about the primary foci of scientific literacy: (1) nature of science; (2) concepts of science; (3) processes of science; and, (4) attitudinal aspects of science (see, for example, AAAS, 1989, 1993; Agin, 1974; Arnos, 1983; Bybee, 1997; Millar, 1996; NRC, 1996; OECD, 2006; Pella, O'Hearn & Gale, 1966, and Showalter (1974, cited in Laugksch, 2000, p. 77).

Lederman (2007) argued that understanding the nature of science is essential and a pre-requisite for achieving scientific literacy. The contemporary meaning of scientific literacy depends on how concepts of the nature of science have shifted over time, which becomes the focus of attention in the next section.

2.6.1 The nature of science

The understanding and appreciation of the nature of science (NOS) is a perennial objective of science education and is regarded as an instructional outcome in science education documents worldwide, for example, Australia, Canada, South Africa, United Kingdom, and United States (Lederman, 1992, 2007). It helps students develop views and conceptions about the key ideas of science, helps them develop awareness of the cultural impacts of science, and facilitates decision-making on issues based on science and technology (Bell, 2004). Lederman defines the nature of science as "the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge" (2007, p. 833). This definition reflects three basic principles of the NOS:

1. *An accumulation of the systematized body of knowledge (i.e., products of science such as facts, scientific vocabularies, theories, laws etc.);*

2. *A scientific method of inquiry (i.e., process skills or activities used to collect and analyse data for drawing conclusion to develop knowledge);* and
3. *A scientific attitude.*

Lederman (2004, p. 304) used three criteria to determine the aspects of NOS that can be included in science curriculum and instruction including:

1. *Whether the aspects of NOS are accessible to students (can they learn or understand?)*
2. *Whether there is a general consensus regarding this aspect, and*
3. *Whether the aspect is useful for all citizens to understand.*

Further, seven aspects of the NOS are identified as essential to include in science curricula and instruction (Lederman, 2004). Some fall under the characteristics of scientific knowledge that is based on observations of the natural world. These include:

1. *Observation and inference*: Students should have a clear idea about the distinction between observations and inference. Observations are descriptive statements of the phenomena that are directly accessible or extensions of the senses and require consensus of the observers. On the other hand, inferences are statements about phenomena that are not directly accessible to the senses. For example, objects thrown above the ground tend to fall and hit the ground, which is observable and accessible to the senses. However, the tendency of objects to fall to the ground is due to gravity. The notion of gravity is inferential because it is not accessible to the senses.

2. *Scientific laws and theories*: Laws are statements and descriptions of the relationships between observable phenomena. For example, Boyle's law, - at a constant temperature, the volume of a gas is inversely proportional to its pressure'- relates the pressure of a gas to its volume at that temperature. In contrast, theories are inferred explanations of observable phenomena, such as, when the kinetic molecular theory of gases is used to explain Boyle's law.

3. *Knowledge of science is empirically based*: All scientific knowledge is at least partially based on, or derived from, observations of the natural world. This knowledge is varied by empirical observation. If the observations are not consistent with predictions derived from existing theories and laws, scientists search for alternative descriptions and explanations, potentially generating new laws and theories.

4. *Scientific knowledge necessarily involves human inference, imagination and creativity*: Although scientific knowledge is empirically-based, it involves human imagination and creativity. In this aspect of science, scientific concepts, such as concepts of atoms or black holes, are theoretical models involving human inference rather than faithful copies of reality.

5. *Science is subjective and theory-laden knowledge*: Scientists' theoretical commitments, beliefs, previous knowledge, training, experiences and expectations influence what they investigate, the way of conducting their investigations, data collection or interpretation of data. Thus, it is subjective and theory-laden.

6. *Scientific knowledge is socially and culturally embedded*: Science affects and is affected by the elements of intellectual spheres of the culture in which it is practiced. These elements include: social values, power structures, politics, socio-economic factors, philosophy and religion. For example, the practice of acupuncture, used and accepted as efficacious for centuries in the East based on empirical experiences, was regarded sceptically by Western science because the practice had not been scientifically tested and proved and was not accepted until scientific explanations for its success were provided.

7. *Scientific knowledge is tentative*: Any scientific claims can change as new evidence comes through advances in theory and technology or old evidence is reinterpreted in the light of new theoretical advances.

Some aspects of the NOS are common, with nine specific themes found by Osborne, Collins, Ratcliffe, Millar and Duschl, 2003 (p. 705) in their study of what 'ideas about science' should be taught in school science. These are categorised under three topics:

a) Nature of scientific knowledge
   1. Science and Certainty
   2. Historical development of scientific knowledge

b) Methods of science
   3. Scientific methods and critical testing: the "core process on which the whole edifice (construction/structure) of science is built"
   4. Analysis and Interpretation of Data
   5. Hypothesis and Prediction

6. Diversity of Scientific Thinking: This theme offered opportunities to develop an understanding that “science is not rigid - a number of methods may be used to solve the same problem”
7. Creativity
8. Science and questioning: “part and parcel of the process of science”. It was stressed that the explicit teaching of questioning should form an integral part of teaching in science - “the more pupils question, the more they understand the thinking behind the scientific knowledge”.

c) Institution and social practices
   9. Co-operation and Collaboration in the Development of Scientific knowledge

Corrigan and Gunstone (2007) described epistemological and sociological perspectives of the nature of science as “contemporary views” (p. 139) that these are also present in Lederman’s components of NOS. Science education reform documents, for example, Science for All Americans (American Association for the Advancement of Science [AAAS], 1993; 1990) and National Research Council (National Research Council [NRC], 1996) in the USA, emphasise aspects of the NOS as pre-requisite for achieving scientific literacy (Shamos, 1995). These perspectives inform the goals of science education. Millar’s (2004) article, on the role of practical work in the teaching and learning of science broadly summed up the two main aims of science education:

- *To help students gain an understanding of as much of the established body of scientific knowledge as is appropriate to their needs, interests and capacities;* and

- *To develop students’ understanding of the methods by which this knowledge has been gained and of our grounds for confidence in it (knowledge about science).* (Millar, 2004, p. 1)

Clearly, the first aim is about understanding science content and the second one is about understanding the nature of science. The second one includes elements of science as an enquiry process and as a social enterprise, taking the position that the nature of science “should be an integral and substantive element of any contemporary course in science" (Fuller, 1997; Irwin, 1995; Jenkins, 1997; Millar, 1996; Ziman, 2000 cited in Osborne, et al., 2003, p. 93).

In Roberts' curriculum emphases referred to earlier and integral to this study, one of the seven purposes of learning science is the Nature of Science/Structure of Science, without which it is not possible for students to acquire knowledge of science and its application in everyday life situations. Considering the importance of educationists' views around the nature of science, this study will explore its emphasis in the specific objectives and learning outcomes of the curriculum and in the textbook content of Bangladesh.

2.6.2 Values and attitudes

'Values' are beliefs that people hold, whereas 'attitudes' focus on people's positive or negative responses or feelings (Koballa, Thomas & Glynn, 2007; Simpson, Koballa, Oliver & Crawley, 1994; Petty & Cacioppo, 1981) or "certain opinions or their consistent patterns of behaviour" (Hildebrand, 2007, p. 51) exhibited towards objects, persons, places, ideas, events or issues. Attitudes guide people's behaviour in making moral decisions (Rennie, 2007).

Science educators often use scientific attitudes and values together or interchangeably. Sometimes values are seen as more abstract (Simpson, et al., 1994), complex, or broader so tend to be more enduring than attitudes (Trentham, 1989; cited in Koballa, et al., 2007). Throughout the world, recent reforms in science education have initiated an emphasis on attitudes and values within the objectives of the school science curriculum as a "part of everyday practices of science" (Lehr, 2007, p. 29). The PISA (Program for International Student Assessment) definition of scientific literacy also included attitude as one of the characteristics of the four interrelated aspects.

Hodson (1998) asserted that personal characteristics and attitudes are essential for the successful pursuit of science and include: superior intelligence, objectivity, rationality, open-mindedness, a willingness to suspend judgement, intellectual integrity and communality.

At the junior secondary level in Bangladesh, NCTB includes the attributes "logical thinking, open-mindedness, respect for other's opinion and intellectual honesty" (1995, p. 354) in the objectives of science education to acquire scientific attitudes and values. This may encourage teachers to teach and students to learn science topics paying regard to values and attitudes. This study will explore values related aspects in teachers teaching approaches related to the lessons.

2.7 Curriculum Emphases

The concept of 'curriculum emphases' in science was first introduced by Douglas Roberts in 1982 in Canada as a category system to describe, explicitly, the aims and objectives of science education courses. He established the concept after examining a large number of North American school science curriculum materials used in science education practice during the previous eighty years (1900-1980). He stated that:

> *A curriculum emphasis in science education is a coherent set of messages to the student* ***about*** *science (rather than* ***within*** *science). Such messages constitute objectives which go beyond learning the facts, principles, laws, and theories of the subject matter itself—objectives which provide answers to the student question: "Why am I learning this?* (1982, p. 245)

This concept is closely related to the purposes of learning science. Roberts (1982) argued that students need to be interested in learning science and, to convey science meaningfully; messages need to be communicated both explicitly and implicitly.

Explicit messages are communicated through subject matter, for example, the topic, while implicit messaging about science is a contextual phenomenon that can be communicated by what is not stated-- this can be supported as a ‘fringe benefits lesson’ or ‘meta-lesson’ to the main lesson (Roberts, 1982, 1988). Roberts claimed that “it is not possible to teach content without at the same time expressing, often indirectly, messages about the purposes of studying the subject” (Roberts, 1995, p. 496).

Roberts (1982, 1998a, Roberts & Ostman, 1998) identified seven curriculum emphases in the history of science education as described below. Each of these expresses “a broad, general purpose for learning science” and each reflects a different meaning of science (Roberts, 1995, p. 497).

> *Solid Foundation:* stresses science as cumulative knowledge
> *Structure of Science:* how science functions as a discipline
> *Science/Technology/Decisions:* the role scientific knowledge plays in decisions that are socially relevant
> *Scientific Skill Development:* the ‘science as process’ approach
> *Correct Explanations:* science as reliable, valid knowledge
> *Personal Explanation [Self as Explainer]:* understanding one’s own way of explaining events in terms of personal and cultural (including scientific) influences
> *Everyday Applications:* using science to understand both technology and everyday occurrences.

Roberts stated that these “seven emphases do not necessarily constitute a set of mutually exclusive categories” (Roberts, 1982, p. 246), but are open to change as fashions in education come and go (Roberts, 1995). Their representation depends on current trends of a country’s jurisdiction that are influenced by contemporary political, social and economic factors. Roberts also indicated that no one emphasis is any more ‘true’ or ‘correct’ or ‘academically respectable’ as an outcome of science education than any other as each embodies an area of educational learning that has a counterpart/complement in human affairs and academic studies. Roberts' conception of curriculum emphases was further extended by Fensham (2004). From curricular materials developed after 1982, he identified three more emphases of learning science as follows:

> *Science in Application:* Science as useful knowledge and practices in society
> *Science in Nurturing:* The science of taking care of humans and the environment
> *Science in Making*: Making things-learning the science involved in the materials and in the making process.
>
> (Fensham, 2004, p. 40)

These curriculum emphases shape the aims and objectives of school science, as well as influence, explicitly and implicitly, content determination, the changing role of science teachers and students in the classroom when teaching and learning science and the manner of assessment (Fensham, 2001). Additionally, a curriculum emphasis "to a certain extent controls the depth and breadth of subject matter treatment and the inclusion/exclusion of some optional subject matter" (Roberts, 1982, p. 251).

Roberts' and Fensham's concept of curriculum emphases for students learning were used in this investigation to study how far these emphases were in the Bangladeshi junior secondary science curriculum. The influence of curriculum emphases through the specific objectives and learning outcomes of the prescribed curriculum, choice of content in the textbooks and the implementation of the curriculum emphases in the classroom teaching and the relationship of the curriculum with real life situations were evaluated.

2.7.1 History of curriculum emphases

In the history of science curriculum, the 'curriculum emphases approach' was originally developed to describe the teaching approaches of two dominant physics programs at Harvard and Massachusetts Institute of Technology (Roberts, 1998a). A number of researchers investigated changes in the overall aims of science education over time and identified essentially the same curriculum diversity in North America (Rosen, 1954, 1955, 1956, 1957, 1959, 1963; Hurd, 1969; and Bybee, 1977 cited in Roberts, 1982). For example, Rosen's analysis of science curriculum determinants in America was powerful enough to incorporate in a science textbook by Brandwein, Watson, and Blackwood in 1958. Hurd examined American biological education in 1961 and American science education generally in 1969. Bybee, in his work (1977), used the term 'transformations' to conceptualise the variations in the aims in science education that occurred periodically. But Roberts' intention was different in the sense that he wanted to invent and elaborate the concept of curriculum emphases for active and productive application to areas of practical concern, such as in analysing curriculum policy debate, in guiding the development of instructional materials, in studying curriculum implementation in the classroom, which go beyond the perspectives historically influencing science education practice. He stated his seven curriculum emphases were not exhaustive in terms of what is theoretically possible in science education but seemed to be exhaustive in terms of what had been tried.

Roberts (1982) confirmed the categories of curriculum emphases from two independent studies of teaching objectives, one by Ogden in 1975 for chemistry, and another by Ogden and Jackson in 1978 for biology. Referring to professional literature, he identified that nine major categories discerned from chemistry objectives (Ogden, 1975) and seven major categories elicited from biology objectives (Ogden & Jackson, 1978) were close enough to his seven categories of curriculum emphases to describe the goals and objectives of science education. He also explored Gabel's (1976) eight categories of science education objectives under the definition of scientific literacy

(Roberts, 1983; cited in Hodson, n.d) to gain support for his emphases. Gabel used the term ‘scientific literacy’ as an umbrella term to “represent comprehensive, balanced and composite goal statements which cover all curriculum emphasis for science education” (Chu, 2009 cited from Roberts, 1983, p. 19). A comparison of these categories (see Table 2.2) supports Roberts’ seven categories of curriculum emphases as a credible framework for interpretation that has become valued in science education (Chu, 2009). By applying the concept of curriculum emphases to 1960s school science, Fensham claimed that Solid Foundation, Correct Explanations and Scientific Skill Development were given importance as a source for content and pedagogy in teaching programs, while the other four emphases were rejected or quite under-used (Fensham, 1997; Wei & Thomas, 2006). In the meantime, some science curricula began to place more prominence on content for different reasons, consistent with Roberts’ emphases (Fensham, 2001). For example, Personal Coping [Everyday Coping] in the *Salter Chemistry Project,* Science/Technology Decisions in a secondary text used in some Canadian provinces and in some PLON (Physics Curriculum Development Project) units, Self as Explainer in *The Science Framework* in Victoria, Australia and in the *Science Plus* materials from the Atlantic Science project in eastern Canada (Fensham, 2001).

It is an accepted notion that science curricula plays a vital role in developing and sustaining students’ interest in science and preparing citizens for the 21st century (Guo, 2007; Sjoberg, 2001). Guo (2007) claimed that, in many countries, traditional curricula suffer shortcomings: mostly a massive body of authoritative and unquestionable knowledge; lack of relevance and deeper meaning for the students in their daily lives; and students do not make the commitment that is necessary to learn science. For example, the Chinese curriculum is knowledge-centred and teachers fail to inculcate scientific attitudes, values, processing skills and higher-order thinking skills in students (Guo, 2007).

Table 2.2: Comparison of Emphases, Dimensions, and Categories of Science Education

Roberts: Seven science curriculum emphases for science (1982)	**Gabel:** Eight dimensions of scientific literacy (1976)	**Ogden:** Nine major categories of chemistry objectives (1975)	**Ogden & Jackson:** Seven major categories of biology objectives (1978)
Correct Explanations	Organization of Knowledge	Specific Topics in Chemistry Scientific Methods of Thinking (skill and willingness) Scientific Habits and Attitudes	Specific Topics in Biology Scientific Methods of Thinking
Solid Foundation		Major Facts, Principles, or Fundamentals Career Development	Major Facts, Principles, Concepts or Fundamentals Career Development
Structure of Science	Process of Inquiry	Nature of Science and Scientists	
Scientific Skill Development	Intellectual Processes	Processes, Skills and Techniques of Inquiry	Processes, Skills and Techniques of Inquiry
Self as Explainer	Values and Ethics Human Endeavour		Interest and Hobby Development
Everyday Coping	Interaction of Science and Technology	The applications of Chemistry to Daily Life	Applications of Biology to Daily Life
Science, Technology, and Decisions	Interaction of Science and Society Interaction of Science, Technology and Society	Sociological Implications	

Note. Adopted from Chu, 2009, p. 35

It appears, from the above discussion of the concept of curriculum emphases and their accentuation in the curricular materials of different countries, that it is essential to examine how the curriculum emphases are given importance when developing the General Science curriculum in Bangladesh. Also, to determine how these emphases in the specific objectives and learning outcomes are used to select context-based content in the curricular materials for early adolescent students and how they are implemented in the classroom. The identified aspects of curriculum emphases will provide evidence for judging the relationship of the junior secondary level science curriculum to real-life. The next section describes the value positions of the curriculum emphases in the levels of schooling.

2.7.2 Curriculum emphases for science in the levels of schooling

Roberts' (1982, 1988) appreciated that the curriculum emphases are genuine purposes for school science, but some of these emphases are more relevant and meaningful for particular content and topics at different levels of students' school careers (Fensham, 1996). He pointed out that a number of substantial periods of class attention are needed to achieve the learning intentions linked to any emphasis. It is possible for students to achieve at least two to four emphases per year. To ascertain possible purposes at different stages of schooling for making sense of students' learning, Fensham (1994a, 2001) explained the characteristics of the ten emphases to teachers and asked them to identify at least three emphases from the list of ten for each stage of schooling. Surprisingly, a high degree of consensus among the groups of teachers emerged about the patterns of curriculum emphases for different stages of schooling (see Table 2.3).

Table 2.3: Curriculum Purposes for Science in the Levels of Schooling

Level of schooling	Curriculum emphases
Early Childhood (Grades 1-3)	Everyday Coping; Science for Nurturing; Science for Making
Primary (Grades 4-6)	Everyday Coping; Science for Nurturing; Science for Making and/or Everyday Coping; Self as Explainer; Scientific Skill Development
Lower secondary (Grades 7-10)	Everyday Coping; Scientific Skill Development; Science, Technology Decisions; Self as Explainer; Correct Explanations
Upper secondary (Grades 11-13)	Solid Foundation; Correct Explanations; Structure or Science; and Science, Technology Decisions

Source: Fensham, 1994a, p. 81

Fensham acknowledged that this progression of changing purposes is useful to select science content for learning in order to explore themes, solve problems, understand concepts to describe phenomena, and explain questions to the students. This, in turn, might help to determine the appropriate pedagogies. As concepts usually associated with school science, applying this type of content to different contexts would enable students to become aware of and gain a deeper understanding of these emphases. Fensham suggested that "if we do want a science education that makes sense and optimally serves all students in schooling, then a variation in purpose for science in schooling" (Fensham, 1994b) is needed, as is demonstrated in the Table 2.3. Later, there was strong agreement among the teachers to add the emphasis, Structure of Science (originally Nature of Science) and Science in Application in the final two or three years of secondary schooling, considering the majority of students do not intend to go on to science in tertiary education (Fensham, 1996).

As this study will explore the curriculum emphases in the junior secondary science curriculum and textbooks for Grades VI to VIII, the emphases in Table 2.3 for the primary and lower secondary stages, along with Science in Application, should be applicable for Bangladeshi students if they are to be aware of these emphases. It might be argued, however, that a variation of these emphases could occur for content selection in the context of Bangladesh. Curriculum emphases are used in this thesis as a framework to understand which aspects of the emphases are given importance in the junior secondary level science curriculum and in the textbook content for the students of Bangladesh, and it is worth investigating how teachers prioritize each of these emphases in their own teaching.

2.7.3 Roberts' Vision I and Vision II approaches

Roberts (2007) presented a heuristic device for understanding the ideologies attached to scientific literacy (SL), which are related to Roberts' curriculum emphases. According to him, scientific literacy is a continuum between scientist-centred and student-centred policies. He named scientist-centred as Vision I policy and student-centred as Vision II policy. The aim of Vision I was to introduce students to scientific disciplines and that of Vision II was to familiarise students with the cultures of local, national and global communities (Aikenhead, 2008). The Vision I policy document/curriculum contains two variables-- products and processes of science for teaching and learning, for example, science subject matter, which is conventional, academic and decontextualised. It encompasses the curriculum emphases, Structure of Science and Scientific Skill Development. These two emphases consist of Science as Inquiry, History and Nature of Science, under the National Science Education Standards (NSES) in the US (Roberts, 2007).

On the other hand, Vision II of SL is context-driven, related to science subject matter from students' everyday worlds. Vision II contributes to four curriculum emphases, Solid Foundation, Correct Explanations, Structure of Science, and Scientific Skill Development, and also the other three emphases: Personal Explanation, Science, Technology, Decisions and Everyday Coping/Applications (Roberts, 2007). Personal Explanation and Science, Technology, Decisions are found in 'Science in Personal and Social Perspectives' and 'Science and Technology', and Everyday Coping /Applications is found in 'Science in Technology' under the standards of the U.S. NSES (Roberts, 2007).

Roberts (2007) argued that the Vision I curriculum can be developed without addressing Vision II, namely Science in Personal and Social Perspectives and Science and Technology. This type of science curriculum within the scientific discipline is abstract in nature, as content comes mostly from pure science. The representation of a Vision I policy leads to a Vision I type of practice in teaching and assessing science learning with narrowly defined SL (Aikenhead, 2008). In this situation, the content is focussed on decontextualised science and irrelevant to students' practical lives, which, provides little help in absorbing scientific knowledge for later application. Aikenhead argued that a Vision I approach might lead to decreased student interest and enrolment in school science. In contrast, the context-based Vision II approach provides students with life-related school science with a corresponding, significant increase in SL (Aikenhead, 2007) and in students finding science culturally relevant.

Roberts (2007) indicated that "Vision II subsumes Vision I" (p. 768) but Vision I does not incorporate Vision II. Vision I-II type of policy and practice, as recommended by Roberts, is seen as "a balance between two extremes" (Aikenhead, 2007, 2008), which serve the dual purposes of science education. He suggested that Vision II policy led to a combination of Vision I and Vision II types of practices and enhancement of students' abilities to function as life-long, responsible and astute citizens able to use science and technology.

The 21st Century Science course in England and Grade 10 course in the Netherlands is evidence of Roberts' Vision II approach (Roberts, 2007). However, due to politics among the academic scientists in curriculum committees in the Netherlands, the Vision II approach was not implemented but was reframed as a Vision I-oriented course. The curriculum committees adopted a 'science-plus' or 'science-oriented' approach that could not rid itself of the shadows of traditional science teaching (De Vos & Reiding, 1999).

It might be possible to serve the dual purposes of science education for all in Bangladesh if the National Education Policy documents, curriculum and teaching practices of science paid attention to Roberts' Vision I-II approach with incorporation of both Roberts' (1982, 1988, 1995, 1998a, 1998b) and Fensham's (1994a, 1994b, 1996) curriculum emphases. It might reasonably be expected that more students would continue to further study in science and choose science-related careers, along with using functional knowledge of science in real-life.

2.8 Teaching and Learning Strategies for Real-Life Science

Learning involves an interaction between students' existing ideas and the knowledge and experiences they are exposed to inside and outside the classroom (Tytler, 2004). Students construct and reconstruct their own understanding from what they see and hear on the basis of their existing knowledge (Hodson, 1993). Teaching facilitates learning and it is the responsibility of the teacher to improve students' learning (Rennie, Goodrum, & Hackling, 2001). Becoming a science teacher is a creative process as it involves a teacher's selection of appropriate teaching methods (Hassard and Dias, 2011). Millar and Osborne (2008) suggested teachers use varieties of teaching methods and techniques when teaching science to promote scientific literacy to appeal to a broad range of students and to better help as many students as possible apply science learning in real-life. Some scholars suggested inquiry-based teaching encourages students' creativity (Carin, Bass & Contant, 2005; Church, 2000; Goodrum, 2004; Hoisington, Sableski & DeCosta, 2010; Longo, 2010). Other scholars emphasised teachers' creativity in arranging the learning environment for students' active learning through experience by hands-on activities (Braund & Reiss, 2006a, 2006b; Chandler & Swartzentruber, 2011; Chiappetta & Koballa, 2006). Setting appropriate contexts motivates students to learn science. It is, therefore, necessary to connect cognitive activity to context. Stinner (1995, p. 556) argued that "learning methods embedded in context are not merely useful; they are essential," but textbook-centred teaching in science stubbornly ignores this.

Goodrum (2004) suggested that teachers consider two significant aspects: why science is taught in schools and how people learn science. This sense of 'why' and 'how' is given much importance to help teachers decide what to teach and why and how to teach to encourage meaningful learning. The first question, 'what to teach and why', is related to the products and purposes of learning science and relevance to students' everyday lives. Giving importance only to the products of science resonates with Roberts' Vision- I practice of scientific literacy, and 'why to teach' mirrors Roberts' and Fensham's curriculum emphases. On the other hand, emphasising what, why and how in teaching requires products and processes of teaching scientific content using various types of teaching and learning resources based upon context. This type of teaching helps students to apply their learning in real-life situations. Such types of emphases illustrate student-oriented teaching and learning and supports Roberts' Vision I-II practice of scientific literacy.

The junior secondary science curriculum in Bangladesh emphasised student-centred and activity-based science teaching in context (NCTB, 1995) from which explanations and meaningful understanding might be generated (Tytler, 2004; cited from Rogoff & Lave, 1984). Therefore, if acquired knowledge from school science is to be useful for students, it is necessary to relate classroom experience and social uses of science learning.

Goodrum and Druhan (2012) stressed that inquiry-based teaching is required in order to encourage meaningful learning, which subsequently requires more emphasis on certain aspects of teaching during science lessons. This may be particularly pertinent when, for example, learning broader concepts so as to be able to apply science in new situations. Emphasis should be laid on students' active involvement in inquiry through group work to investigate problems and issues or group discussions. The use of information from multiple sources, including textbooks, is important to stress as is the promotion of values in relation to the context. Assessment of learning outcomes should be related to higher-order thinking with less emphasis on remembering scientific terms and facts and transmissive pedagogy of teaching. Students should receive feedback to assist their learning. Table 2.4 illustrates the outline required for inquiry-based teaching in a context that is relevant and applicable to students' lives.

Table 2.4: Outline of Enquiry-Based Teaching

Inquiry-based teaching requires *less* emphasis on	**Inquiry-based teaching requires *more* emphasis on**
Science being interesting for some students	Science being interesting for all students
Covering many science topics	Studying a few fundamental concepts
Theoretical abstract topics	Content that is meaningful to the students' experiences and interests
Presenting science by talk, text and demonstration	Guiding students in active, extended student inquiry
Asking for recitation of knowledge	Providing opportunities for discussion among students
Individuals completing routine assignment	Groups working cooperatively to investigate problems or issues
Activities that demonstrate and verify science content	Open-ended activities that investigate relevant science questions
Memorizing the names and definitions of scientific terms and facts	Learning broader concepts that can be applied in new situations
Learning science mainly from textbooks provided to students	Learning science actively by seeking understanding from multiple sources of information, including books, the internet, media reports, discussion and hands-on investigations
Assessing what is measured easily	Assessing learning outcomes that are most valued
Assessing recall of scientific terms and facts	Assessing understanding and its application to new situations, and skills of investigation, data analysis and communication
End-of-topic multiple-choice test for grading and reporting	Ongoing assessment of work and the provision of feedback that assists learning

Source: Goodrum and Druhan, 2012

Similar features of effective teaching and learning were provided by the 'Science in Schools' [SIS] project team, 2003 (Tytler, 2004), to support students' learning and engagement. These included encouraging students to engage actively with ideas and evidence and challenging students to develop higher-order thinking for meaningful understanding. Also, linking science with students' lives and interests, catering to students' individual learning needs and interests and introducing continuous assessment in the science learning strategy was incorporated. Presenting the nature of science in its different aspects, linking classroom learning with the broader community and using learning technologies (e.g., ICT) for students' learning potentialities were also listed.

Goodrum (2004) and Goodrum and Druhan (2012) suggested some principles of teaching that demonstrate a clearer understanding of how students learn. Amongst these were explanations following an experience and recognising students' pre-instructional knowledge and experience. Also, student involvement can be achieved through hands-on activities, peer and/or small-group discussion (followed by teacher explanation and summary of the ideas generated) and general discussion (helpful for a teacher to challenge and refine alternative conceptions or misconceptions of the students). Teachers could help students develop conceptual understanding and questioning techniques, by asking a balance of broad and focused (stimulating and thinking) questions, allowing sufficient time for students to answer, and using evaluation-free responses (great answer, well done, etc.). They advised considering cooperative learning for effective learning by building self-confidence, taking more responsibility for managing social skills of sharing leadership, communicating, building trust and managing conflict and their behaviour. Furthermore, they advised the adoption of some specific teaching strategies and techniques, such as concept mapping, brain-storming, envoy, gallery walk, jigsaw, predict-observe-explain (POE) and post-box strategy (Goodrum, 2004; Goodrum & Druhan, 2012; Rahman, 2003). Several writers and science education researchers, such as Arnos (1989), recommended a 'storyline' approach to the teaching of science (cited in Stinner, 1995). Fensham (2001) supported this view suggesting that story telling is a powerful approach for teaching as there is a story behind every advance in science. Tytler, et al. (2008) suggested students' learning interests can be stimulated by arranging their participation in study tours, science fairs, science clubs, science projects and science competitions.

The above teaching approaches and principles can have a profound impact in teaching real-life science but research results are disappointing. A national study in Australian schools indicates that science taught in high school is neither relevant nor engaging and teaching is not connected with students' needs, interests and prior experiences (Rennie, et al., 2001). This is reflected in the declining rate of science students in the upper secondary schools (Rennie, et al., 2001). The US experiences similar tends where the teaching and learning process is teacher-directed - mostly 'chalk and talk' - centred on explanation, copying notes and working from an expository text. Student engagement in minds-on and hands-on activities is generally not emphasised in schools (Rennie, et al., 2001). Other studies (Hume & Coll, 2009; Wang & Lin, 2009) identified similar results.

Likewise, in many Asian countries, for example, Vietnam (Ng & Nguyen, 2006), Taiwan (Pong & Pallas, 2001) and Bangladesh, teachers use transmissive teaching approaches such as lecturing (Babu, 2010b; Gomes, 2004). Teachers do not ascertain students' prior knowledge or share ideas with students during teaching (Hossain, 1994). Discussion, demonstrations, learning by doing, and inquiry approaches are not used in teaching science (Asian Development Bank, 1998; Gomes, 2004; Haq, 2004; Hossain, 2000; Krishna, 1997; Nina, 1992; Sadat, 2001). Even though teacher-centred methods of giving lectures or reading from textbooks have been characteristically ascribed to less effective teachers (Çakiroglu, Çakiroglu, & Boone, 2005), Babu (2010a) identified that the majority of teachers still use the lecture method. Even experiments are taught verbally, drawing figures of experiments on the board instead of engaging students directly in conducting the experiments. As a consequence of this approach, students were not engaged in observing, hypothesising or collecting data by doing experiments to test neither a hypothesis nor where they involved in rational thinking to create scope for analysing the cause and effect relationship. Chowdhury (2008) pointed out that teachers' presentation style in the science classroom is unappealing to students, and most teachers (85%) are not confident about using appropriate teaching strategies in their teaching of science (Maleque, Begum, & Hossain, 2004).

Everywhere in Bangladesh, science is taught using traditional methods with little attention paid to student participation and interest. Indeed, teachers encourage students to rote-learning (Tapan, 2010) practiced even though curriculum and policy documents in Bangladesh advise against this approach. Caillods, Gottelemann-Duret and Liwin (1996) reported that rote learning is also followed in other developing countries.

Morris (1986) pointed out that policies and strategies of curriculum development in developing countries have little impact on the teaching approach in schools. Most of the teachers do not use officially recommended teaching approaches though their attitudes are favourable to those approaches. Siddiquee and Ikeda, in a study in Bangladesh (2013), found that teachers who received in-service training from TQI (Teaching Quality Improvement[2]), along with short-term overseas training and CPD (Continuous Professional Development) had a greater awareness of contemporary teaching strategies and while professing modern beliefs that teaching and learning of science should be student-centred compared to participants with BEd training and

[2] mainly focuses on the participatory teaching approach to develop students' understanding of and thinking skills in science

Subject Based Cluster (SBC) backgrounds. This group of teachers tended to possess traditional beliefs of teaching and learning. Most of the teachers in their study stated that they teach the facts because students have to achieve high scores to be promoted to the next grade or to pass the examination. Similar findings for Bangladesh teachers were found by Holbrook (2005). While some science teachers in Bangladesh have modern beliefs about the curriculum and teaching and learning, they may be unable to act on these beliefs due to constraints such as social expectations. When there are constraints (for example, time, scarce resources, control, social expectations), these may suppress changes teachers might consider, even though the teachers show strong personal commitment (Tobin, Tippins, & Gallard, 1994).

The aim of the real-life oriented curriculum is to prepare scientifically literate citizenry and requires a more student-centred and inquiry approaches of teaching so that students use their learning in everyday life situations. In Bangladesh, to make our expanding society suitable to face challenges of the present and future in the field of science and technology, it is necessary to update the science curriculum and teaching approaches. However, research shows that teachers require resources, such as teaching aids, study materials and adequate classroom seating arrangements, to engage students in different activities (Ali, 2011). Along with these, the short duration of class time, teachers' workload and the pressure of completing the curriculum are other barriers to involving students in science tasks (Babu, 2010). Pong and Pallas (2001) pointed out that, although the curricular coverage may be uniform in the centralised system, teachers' teaching practice may vary depending on class size. In Bangladesh, large class size is a challenge for teachers who want to involve students in discussion and hands-on/minds-on activities (Sarkar & Corrigan, 2013). These types of constraints have been identified in other developing countries (Caillods, et al., 1996; Lewin, 2000).

2.8.1 Teaching aids

Creating and maintaining students' attention in lessons by using teaching aids is an important factor for effective learning (Joyce, Calhoun & Hopkins, 2000b). It has been found that students can remember scientific ideas or concepts if these ideas are presented in a way that engage the sensory channels of students, for example, audio and visual representations, pictures, charts, model and multimedia (Nayar & Pushpam, 2000). Visual teaching aids present concrete meanings of scientific concepts, provide explicit connections between science ideas and make lessons more interesting to students (Joyce, Weil & Calhoun, 2000a). For example, models help students to understand abstract concepts while multimedia helps teachers to bring the real-world to the students through the use of sound, video, picture or diagrams. Nayar and Pushpam (2000) reported that using appropriate media for the lessons helped students to achieve higher-learning outcomes. They reported that a film on AIDS helped students to perform significantly higher on a test than those students who had not watched the film. "This is because of the fact that showing films might help in some way to activate students' long-term memory of the subject and the content of the lessons at a later time". Thus "when visual teaching aids accompany verbal explanation, students may pay more attention to the material to be learned, conceptualise and comprehend abstract and difficult ideas, thoughts, and data in their mind, and store and remember more information efficiently" (ÇİMER, 2007, p. 24; cited from Killermann, 1998).

The junior secondary science curriculum in Bangladesh suggested that teachers collect teaching aids and equipment before entering the classroom (NCTB, 1995) but teachers are reluctant to collect teaching aids on their own initiatives (Tapan, 2010). The majority of the teachers did not use teaching aids in their classroom practices (Babu, 2010a; Hassan, 1981; Hasan & Ehsan, 2013). Babu, moreover, identified that, at times, teachers selected inappropriate teaching aids, for example, teachers using posters that were not clear as students' could barely see them. Bari (2007) pointed out that inadequate teaching aid in schools limited teachers' implementation of the curriculum. Most teachers use charts/posters, low-cost teaching aids, models, and real objects, for example, leaves, flowers, insects and rocks, in comparison to mass media and video (Sarkar, 2012 b; Sarkar & Corrigan, 2013).

2.9 Assessment

Assessment is an important component of the curriculum. It is a vital part of teaching to determine the nature and extent of students' learning and achievement (Linn & Gronlund, 2005). It has a powerful influence in the change process in teaching-learning strategies in science. According to Hackling (2004), if education systems focus assessment on factual or recall questions, teachers place more emphasis on content, seeking to finish it within a limited time irrespective of whether students understand it or not, or are able to apply it in real-life situation. The strategy for students is to memories the facts. On the other hand, if assessment focuses on understanding of the concepts and skills that are applicable to make sense of the real world, then teaching-learning encourages a deeper understanding of the concepts of science.

Hackling (2004) describes four main purposes of assessment. Diagnostic assessment helps teachers plan lessons on the basis of students' prior experience and to challenge their misconceptions or alternative conceptions. Formative assessment provides feedback to the teachers and the students for improving teaching and learning. In this process, on the basis of the learning outcomes, teachers communicate what the student is doing well, what needs to be improved and how to improve their learning and their level of achievement. Summative assessment determines students' levels of achievement of the learning outcomes in terms of grades at the end of semester/year. It provides relatively valid, reliable and equitable grades because teachers use a range of sources of evidence to determine these grades, such as paper-pencil tests, quizzes, assignments, projects, reports of investigations and experiments, portfolio of work samples, and observations of a student's performance. This type of assessment is necessary for certifying achievement and for selecting students who will go to the next level of education as well as for reporting to the parents. Evaluative assessment is helpful for curriculum appraisal and review of the performance of teachers, schools and the school system against defined standards.

All these types of assessment Hackling discusses are under the rubric of qualitative assessment. Qualitative assessment should have the characteristics of validity, reliability, authenticity, fairness and equity, comparability (in standards) and be educational (Hackling, 2004). For improving teaching and learning, Goodrum (2004) recommended formative assessment over summative assessment for students applying science in everyday life situations.

Bybee (1997) advised that students should be assessed in terms of their previous knowledge, current achievement and in the context of personal and societal decision-making. A study of science teaching and learning in Australian schools reveals that, in secondary schools, assessment focuses "on traditional testing systems on the extent to which students memorise and recall science facts that hinder the development of meaningful understanding", which leads teachers to teach traditionally (Rennie, et al., 2001, p. 493). They identified this as the cause of many students finding science difficult, uninteresting and lacking in relevance. This 'traditional testing' practice creates barriers to educational reforms and the implementation of a more student-centred and inquiry-oriented approach that promotes scientific literacy (Hackling, Smith & Murica 2010).

Questioning is an important tool for teachers and can be applied to individual students, to the whole class and to small groups. It helps students to understand, think about and act upon the subject matter, stimulates students' curiosity, and attracts students' attention. Asking question develops an active approach, aids diagnosis of difficulties, encourages thinking skills to help students' reflection, provokes discussion and shows interest in students' ideas (Khan & Inamullah, 2011). Since the primary purpose of classroom assessment is to improve teaching and learning, it must be embedded in the teaching and learning process with a focus on learning outcomes in the cognitive, psychomotor and affective domains.

Khan and Inamullah (2011) explored teachers' lower-order and higher-order questions at the secondary level in the light of Bloom's taxonomy. The study showed that the majority of the teachers' questions were lower–ordered questions (mostly facts and information from textbooks). According to Blooms' hierarchy of cognitive domains, "higher order thinking involves the mental processes of application, analysis, synthesis, and evaluation" (McNeil, 2010, p. 74). McNeil argued that higher-order questioning helps students in better learning and that the questioning should consider both teacher and student perspectives. Attention to both perspectives is important in the assessment and feedback process for teachers to adjust their explanatory structure, providing, especially, for students' misunderstanding and disagreement (Aguiar, Mortimer & Scott, 2010).

It should be mentioned here that, in the education system of Bangladesh, the government introduced creative-type questions from 2010 to reduce students' dependence on memorisation and to promote answering by using their intellectual abilities. This type of question starts with a branch of the textbook content. On the basis of the branch, a question is devised comprising segments that are assessed: cognitive (01), analytical (02), application (03) and higher ability (04). Students who thoroughly study the textbooks are able to answer the questions. Research indicates that many teachers are still not clear about the creative approach and that more than one training session is required to make them efficient in developing these type of questions (Habib, 2012). The junior secondary science curriculum in Bangladesh recommends that teachers assess students' knowledge, comprehension, skills, and attitudes but Babu (2010) identified that, in the classroom, the assessment process did not follow the curriculum and teachers placed more emphasis in assessing students' capacity for rote-learning and memorisation. In addition to this, Sarker and Corrigan (2013) found that teachers placed little importance on the application of scientific concepts. One of the reasons for teachers' reluctance to move away from traditional methods may be, as Ali (2011) argued, that large class size in Bangladesh is a barrier in the implementation of formative assessment.

This alerted the author of the present study to be aware of how teachers identify students' existing knowledge, bridge the gaps between previous and current knowledge and perform formative assessment accentuating the ten curriculum emphases when investigating the research questions mentioned in Chapter 1. More importantly, the examination will look at how teachers connect students' learning with the students' personal and social activities.

2.10 Textbooks

Science textbooks are powerful instructional materials. Dependence on textbooks by teachers and students is universal (McComas, Clough and Almazroa, 1998; Yager & Soong, 1996). Textbooks influence how science teachers organise the curriculum and how students perceive the scientific enterprise (Chiappetta, Fillman & Sethna, 1991). Teachers depend on textbooks for determining science content, classroom activities, and student assessment. Research in science education indicates that textbook-based teaching dominates most science classrooms. However, many teachers feel dissatisfied with this approach, but recognise that they are powerless to do anything but use these textbooks on a daily basis (Yager & Soong, 1996).

In Bangladesh, as elsewhere, textbooks play a vital role in the teaching and learning of science. There is a single General Science textbook for each grade. Teachers and students are heavily dependent on these textbooks because students are assessed based on that textbook content. In the official curriculum, teachers have been instructed "to read the textbook content well before teaching in the classroom" (NCTB, 1995, p. 401). But, Rana (2005) argued that the available textbooks are not regarded as good textbooks and are uninspiring because they are laden heavily with facts (Holbrook, 2005). Conversely, Tapan (2010) contended that the textbooks are not the problem; the problem lies in the implementation of the textbooks in classroom practice. Furthermore, Sarker (2012 a) reported that science textbooks are not consistent with an emphasis that connects scientific knowledge with the students' lives.

Any reform in science education usually requires the availability of textbooks with appropriate content to assist teachers in meeting the new goals of school science curriculum. Reference to Yager and Soong's (1996) article "Textbooks with special qualities" indicates that the characteristics of such a textbook should include information and practical activities that are relevant and meaningful to the students' daily lives. According to him sometimes questions and use of primary sources of information other than the textbook, and examples of how science and technology have been used to improve society and, at times, have contributed to current problems should incorporate in the relevant topics. These assets can motivate students to explore issues related to current scientific and technological problems and creates students' awareness of their responsibility towards the environment.

Textbooks with the above characteristics are consistent with Roberts' and Fensham's curriculum emphases in relation to their connections to real-life. Therefore, an analysis of the junior secondary level textbooks (Grades VI to VIII), based on Roberts' and Fensham's curriculum emphases, would provide a solid context for investigating how Bangladeshi science textbooks connect students' scientific learning to real-life.

2.11 The Official Curriculum and Teachers' Guides in Bangladesh

The official curriculum and teachers' guides are important documents for teachers, guiding teachers with the aims and objectives of teaching science, learning outcomes, subject content and the processes of activities for implementing the curriculum/textbooks.

Teachers' guides were developed by NCTB in 1997, following the curriculum and textbooks, but there were insufficient printed to send one to every school in the country. Not only was this apparent from my personal experience but there is evidence regarding the lack of availability of the curricula and teachers' guides in many schools (Babu, 2010b; Nina, 1992; Sadat, 2001; Tapan, 2010). In the meantime, assessment system reform was introduced in 2009 by incorporating 'Creative Questions' and, subsequently, textbooks were revised in 2010. However, neither the curriculum nor the teachers' guides were revised. Consequently, gaps occurred between the curriculum, revised textbooks and teachers' guides. For these reasons, teachers consider the textbooks as their only supporting materials when teaching science.

2.12 Challenges in Teaching Real-Life Science

The main purpose of scientific literacy, Science for All, Roberts' and Fensham's curriculum emphases, and Roberts' Vision I-II approaches in teaching science is to promote the application of students' learning in daily life situations. Section 2.8 discussed engaging students in various teaching-learning processes to help them to acquire meaningful learning and to apply their knowledge in practical situations. There is a crisis in science education around the world. Students are not motivated to study science after the compulsory years of schooling as they think science is a difficult subject, boring and not life-related (Lyons, 2006). According to Lyons, these are the results of transmissive pedagogy and decontextualised content used in teaching science. This is not a new issue with Hurd in 1970 identifying reasons, such as, the overload of factual information, emphasis on rote-learning, emphasis on factual answers to pass examinations, and students required to follow a set of directions for doing experiments. When students are not intellectually stimulated by and connected to activities, they have no sense of achievement and lose interest.

The literature frequently highlights the need to adopt hands-on experiences for learning science concepts. Science educators suggest teachers adopt inquiry-based approaches in teaching science. However, there is evidence that teachers are facing challenges in teaching science effectively. In Australia, for example, inadequate resources, low educational budgets, insufficient time for preparing to teach science, lack of science background knowledge, overloaded curriculum and large class sizes compromise the quality of science teaching (Rennie, et al., 2001).

Class size limits the opportunity for group work and student-centred teaching and presents difficulties in terms of resources and classroom management (Caillods, et al., 1996). In Taiwan, large class size affects teachers' opportunity to use proper instructional and student engagement strategies for effective teaching (Tolley, Johnson & Koszalka, 2012). In Nigeria, inquiry-type teaching approaches are rarely practiced in classrooms due to large class size (Ajewole, 1994 cited in Ogunmade, 2005).

Many of these studies, such as those conducted in Australia (Rennie, at al., 2001), Bangladesh (Holbrook, 2005; Sarkar & Corrigan, 2013; Tapan, 2010) and Nigeria (Ajewole, 1994 cited in Ogunmade, 2005), have similar findings that teachers are limited by teacher-related factors and resource problems that contribute to teachers adopting transmissive teaching approaches.

In addition to large class sizes and limited resources, the heavy emphasis on examination scores for university/college level entrance examinations is another barrier to teachers using an inquiry approach. Under traditional assessment systems, where student learning is measured by rote memorisation, the structure of examinations does not support an inquiry–based approach for teaching. This has been noted in Chinese (Zhang et al., 2003), Indian (Nargund-Joshi, Rogers, & Akerson, 2011; Zhang, et al., 2003) and Turkish (Karamustafaoglu, 2009) teacher practices. Moreover, Turkey is an example where the quality of the school is judged by the number of students passing university entrance examinations. As a consequence, school administrators and teachers feel under pressure and do not support teaching strategies that require students' active participation. As with Turkey, Bangladesh schools are judged by the numbers of students that excel in the public examinations, which results in transmissive pedagogies by teachers. In Bangladesh, the junior secondary science curriculum suggested teachers create an environment for students conducive to "learning science by doing science" (NCTB, 1995, p. 401). However, the emphasis on rote memorisation on the content of the textbooks in the public examinations does not support the curricula (Holbrook, 2005). This examination structure and the conditions for preparing students for public examinations do not support an inquiry approach; rather, they induce teachers to encourage students' rote learning (Siddiquee & Ikeda, 2013; Tapan, 2010). Literature suggests that teachers can teach concepts of science in a variety of ways if they teach less content but encourage students' learning through understanding (Rutherford & Ahlgren, 1990).

To address these issues, teachers need adequate and appropriate training. In Bangladesh, as in many countries, this includes in-service training but one of the common criticisms of in-service training in developing countries is that it has little effect on teachers' actual classroom practice. One reason may be that the duration of the training period is too short to be effective. The actual contextual experiences of many teachers are not considered during training, with little or no follow up or support materials provided (Caillods, et al., 1996). As a result of these shortcomings in the training, teachers' level of subject knowledge and pedagogical skills tend to be seriously affected. Moreover, poor conveyance of the content of the curriculum, inadequate time devoted for teaching and learning science, and questionable quality of textbooks results in science teaching falling below the standard both required and desired.

2.13 Summary

This chapter has examined a range of literature to provide an appropriate background for the proposed study. Special attention has been paid to worldwide science curriculum reform to supplement the discussion of curriculum reform in Bangladesh. In addition, the conception of curriculum emphases was reviewed, which is important as a prelude to exploring the relationship between the Junior Secondary Science Curriculum to real-life, its reflection within the textbook content and in classroom teaching. Furthermore, using teaching approaches that included real-life related science content was understood to be a means of promoting students' learning to apply science in their everyday lives. These discussions form the basis for investigating the research questions outlined in Chapter 1. The methods for the study are presented in the next chapter.

Chapter 3
Methodology

3.1 Introduction

The following chapter discusses the research paradigm that supported the proposed study including a rationale for applying this approach. It includes the research design methods, data collection instruments used in different phases of the project, along with the data analyses. The chapter also discusses how the research methods applied to the study ensured a degree of validity and reliability to the findings.

3.2 Research Paradigm: Mixed Research Paradigm

In this study, a mixed research paradigm was used. The notion of paradigm implies a set of ontological and epistemological assumptions, that is, a set of shared beliefs about the nature of social reality and the 'knowability' of that reality (Denscombe, 2008; Sommer Harrits, 2011). In other words, a research paradigm is the researcher's perspectives about designing and doing research accompanied by "all-encompassing ways of experiencing and thinking about the world, including beliefs about morals, values and aesthetics" (Morgan, 2007, p. 49)

Educators have identified three major educational research pradigms: quantitative, qualitative and mixed (Johnson & Christensen, 2012). The mixed method of research is growing in popularity across all disciplines and is regarded as a third, separate paradigm in the field of social and behavioural research (Alise & Teddlie, 2010; Denscombe, 2008). In a mixed research paradigm, ideas from both quantitative and qualitative research are systematically combined within a single study (Plano Clark & Cresswell, 2010; Johnson, Onwuegbuzie & Turner, 2007) that justifies the use of multiple approaches to address research questions (Johnson & Onwuegbuzie, 2004). It is asserted that a mixed method research approach increases the quality of research by complementing the different strengths and weaknesses of two or more approaches (Johnson & Christensen, 2012). It provides more in-depth data, a comprehensive picture and sophisticated understanding of the research problem that might not be collected through either quantitative or qualitative data alone (Creswell, 2008; Plano Clark & Creswell, 2010). Also, there is flexibility in presenting results that can be convincing and powerful (Lodico, Spaulding, & Voegtle, 2006; McMillan, 2008).

Within a mixed method research approach, the quantitative and qualitative parts can be conducted *concurrently* or *sequentially* (Johnson & Christensen, 2012). In sequential mixed research, each type of datum, whether quantitative or qualitative, is collected at different stages to the other (Castro, Kellison, Boy & Kopak, 2010). Following a mixed research viewpoint, the current study includes both quantitative and qualitative approaches that are conducted concurrently for collecting and analysing data and reporting results. However, qualitative approaches dominated the research process.

The study followed a 'Social Constructivist' worldview. Fundamental to this view is that reality or social phenomena cannot be defined objectively but must be defined subjectively (Creswell, 2009; Robson, 2002) given that reality or social phenomena exist in the mind of a person, each person interprets the reality in their own way. Aligned to this view, constructivism acknowledges that "reality is socially constructed" (Merriam, 2009, p. 8), because subjective understandings are negotiated with others, socially and historically. Hence, the term 'social constructivism' is coined (Creswell, 2007, p. 20). Guba and Lincoln (2004) point out that, as constructed knowledge is modifiable in the light of new experience, knowledge is shaped through the dynamic interaction between researcher and participants. Therefore, the task of the researcher is to understand the multiple social constructions of meaning and knowledge of reality that the participants hold and to employ this in the research. These views are strongly espoused by the researcher as being consistent with the present research paradigm.

This study aimed to investigate the extent of the relationship of the junior secondary science curriculum of Bangladesh to real-life. Use of multiple data sources in different phases of the research helped to shape the insights of the study. In this way, a social constructivist paradigm was adopted to develop a mixed research design over a seven month period in 2011.

3.3 Research Questions

As mentioned earlier, this research study investigated the following research questions aimed at exploring the relationship of the junior secondary science curriculum to real-life situations of Bangladeshi students.

> RQ 1. To what extent is the junior secondary science curriculum of Bangladesh real-life oriented?
>
> RQ 2. To what extent are the science textbooks in Bangladesh real-life oriented?
>
> RQ 3. What are the perspectives of teachers of implementing this curriculum with a real-life emphasis?

3.4 Research Design and Overview

A research design is a plan for collecting, analysing and collating data to understand a research problem (Creswell, 2005). As noted above, a mixed methods research design was adopted to investigate the research questions of this study, which included mapping curriculum and the textbooks, a teacher questionnaire, pre and post-lesson interviews with teachers, classroom observations, and focus group discussions with students. A summary of these and the contribution to the qualitative and/or quantitative component of the study is provided in Figure 3.1.

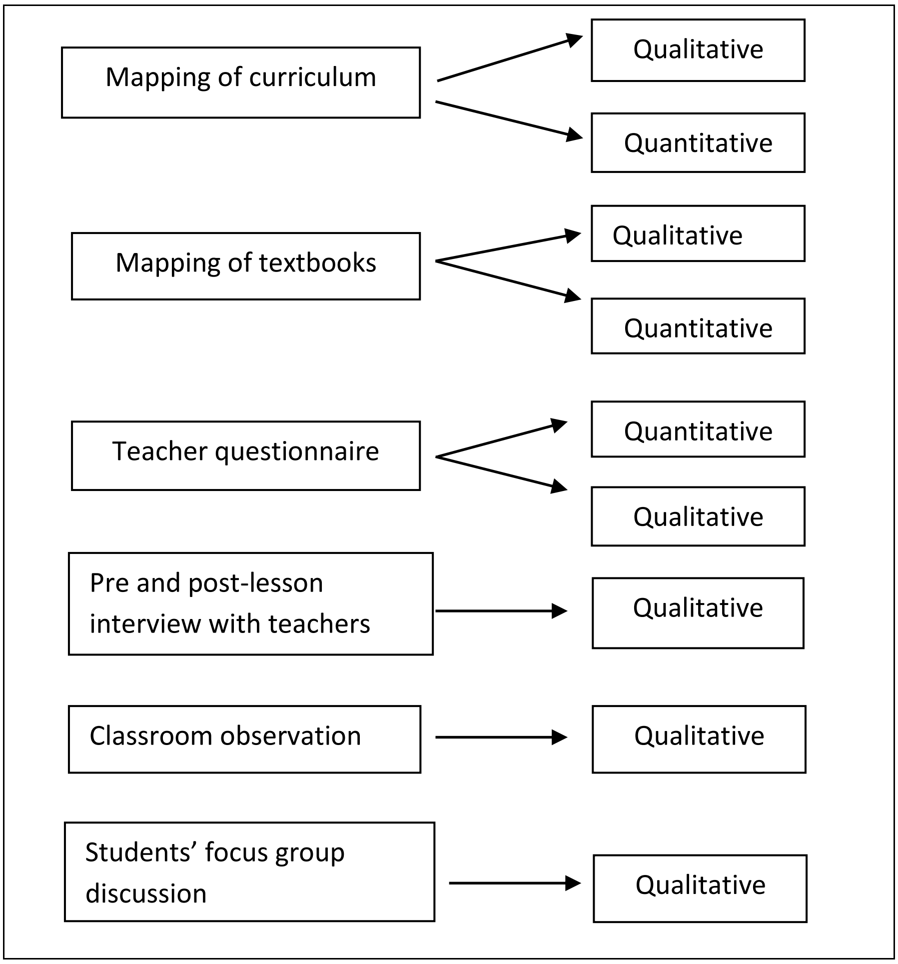

Figure 3.1: Mixed Strategies in the Study

Specific details of the data collection for the study is summarised in Figure 3.2. As viewed in this diagram the study comprised three phases. In Phase 1, there were two stages. In stage one, specific objectives and learning outcomes of the junior secondary science curriculum (Grades VI to VIII) of Bangladesh was analysed using an analytical framework to understand its relationship with real-life. In stage two, the content of the corresponding textbook topics were mapped using the same analytical framework used for analysing the curriculum, with the aim to understand its relationship with students' lives.

In Phase 2, a questionnaire was conducted on teachers (*N*=194) in Bangladesh who taught General Science at the junior secondary level. The purpose of these interviews was to capture their background information and how they perceive teaching aspects to enable students to apply science in relation to real-life.

In Phase 3, there were three stages. In stage one, a small number (N = 6) of teachers were interviewed on two occasions. The first involved before observing their teaching practices and another one was after observing teaching practices. Two to three lessons were observed for each teacher in stage two to perceive how they consider context-based teaching strategies for students' meaningful learning. Students' focus group discussions were conducted in stage three. Data of stages 1, 2, and 3 in Phase 3 were used to validate the data obtained from teacher questionnaire in Phase 2. Triangulation of all these data was used to answer the research questions.

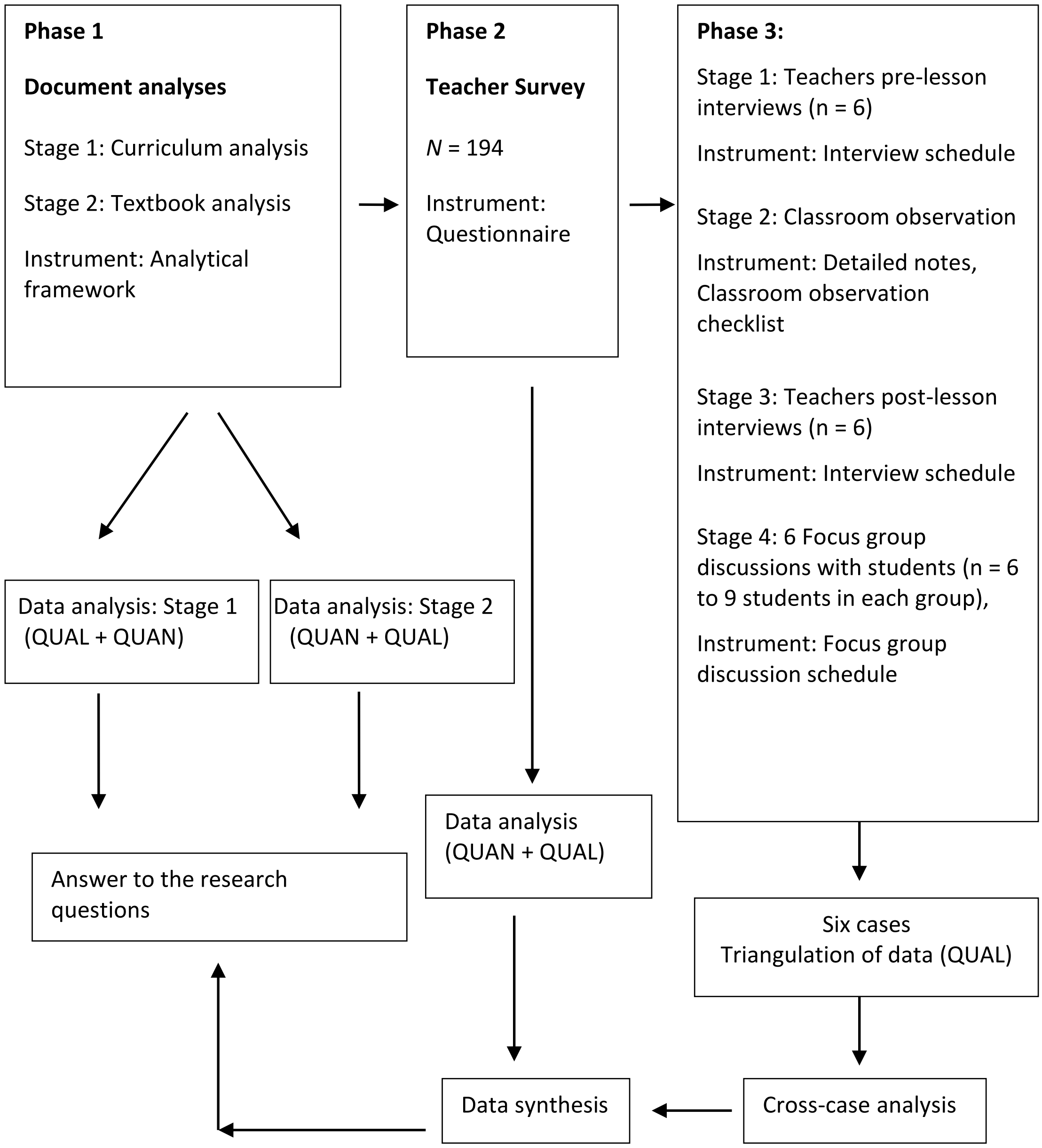

Figure 3.2 Research Design for the Study

The various research instruments and methods employed in the study to address the research questions are summarisd in Table 3.1

Table 3.1: Data Sources for Research Questions

Research Questions	Instruments/methods					
	Analytical framework for document analysis	Questionnaire for teacher survey	Pre-lesson interview schedule for teachers	Lesson observation notes and checklist	Post-lesson interview schedule for teachers	Focus group discussion schedule for the students
1. To what extent is the junior secondary science curriculum of Bangladesh real-life oriented?	✓					
2. To what extent are the science textbooks in Bangladesh real-life oriented?	✓					
3. What are the perspectives of teachers of implementing this curriculum with a real-life emphasis?		✓	✓	✓	✓	✓

The following sections describe the processes of data collection for each phase of the study.

3.5 Phase 1: Document Analyses

As outlined in Figure 3.2, there were two stages in Phase 1. In the first stage, the Junior Secondary Science Curriculum (NCTB, 1995) for Grades VI to VIII of Bangladesh were explored. In the second stage, content from the textbooks (published by NCTB and subsequently revised in 2008 and reprinted in 2010) supporting this curriculum were mapped. An analytical framework was developed to map or analyse these documents.

3.5.1 The analytical framework

The framework used for document analyses was based on an amalgamation of Roberts' seven curriculum emphases (1982, 1988, 1995) and Fensham's three curriculum emphases (1994, 2004; Halai & McNicholl, 2004) as were discussed in Chapter 2. These ten curricular emphases were used to map the Bangladeshi science curriculum and the content of textbook topics. The reason for using this framework was that these emphases represent the purposes for learning science and act as a guide for developing curriculum and instructional materials and for implementing the curriculum in the classroom. The framework facilitated the identification of the real-life curriculum emphases in the specific objectives and learning outcomes of the junior secondary science curriculum and associated textbooks. These ten emphases provide a framework identifying what Bangladeshi students need to learn to grasp the significance of the science discipline as a whole.

Explanations of the ten curriculum emphases and examples of each are outlined below. The code in brackets beside each curriculum emphasis was used to identify the curriculum emphases in the specific objectives and learning outcomes of the curriculum and textbook content.

1. Everyday Coping (EC): Refers to subject matter knowledge in science as a way to make sense of objects or events and the application of this knowledge in daily life situations. *Example:* The use of vinegar or lemon juice instead of yoghurt culture to make yoghurt.

This is a useful example of Everyday Coping because a decision to use vinegar or lemon juice demonstrates an understanding of the function of the bacterial fermentation of yoghurt culture in milk and the production of lactic acid, which in turn, acts on the milk protein casein to coagulate the milk and produce yoghurt. Vinegar (acetic acid) and lemon juice (citric acid) have the same properties as lactic acid (the fermenting agent when using bacteria cultures with yoghurt) and can act on milk to coagulate it in the same way. This example demonstrates the use of scientific knowledge to identify alternative solutions to cope with an everyday situation.

2. Structure of Science (SS): Focuses on the use of evidence (e.g., facts, theories, laws, concepts or models) as a way of making sense of and explaining naturally occurring science phenomena. *Example:* Being able to use a model of water to explain why it is a compound.

Compounds are formed when two or more atoms from different elements combine together. The model of the molecular structure of water consists of two types of atoms from two different elements, two hydrogen atoms and one oxygen atom that have bonded together. This is a suitable example of the Structure of Science because by looking at this model students can gain an understanding that water is a compound.

3. Science, Technology and Decisions (STD): Captures the human values involved in making decisions related to significant societal issues on the basis of scientific knowledge. *Example:* Making a decision about which water treatment system to use in the home to ensure clean drinking water.

Drinking water may contain bacteria, chemicals or other contaminants. This might be an appropriate example of Science, Technology and Decisions because there are many processes to purify water, such as reverse osmosis, activated charcoal, water softeners and distillation. Individuals have to decide what system should be used, based on factors like the existing quality of their water and cost. For example, if their water contains bacteria, salt, very small particles and organisms, the most effective system for removing these contaminants could be a reverse osmosis system. They might make this choice because the semi-permeable membrane used in osmosis strains out all of these impurities in water by repelling them from the surface of the membrane. Understanding the impurities present in water and functions of different purifying processes of water allow individuals to make decisions around which technology cleans the drinking water in their home most effectively.

4. Scientific Skill Development (SSD): Focuses on the correct use of scientific process skills. Manipulative (e.g. observing, classifying, comparing, measuring, experimenting) and cognitive skills (e.g. critical thinking, reducing bias, questioning, hypothesising, making judgement about data, what constitutes evidence) are both considered as contributing to scientific process skills. *Example:* Separating salt, sand and water from a mixture.

This might be a useful example of Scientific Process Skills because, to separate salt and sand from water, students are required to draw upon a number of skills, such as observation, hypothesising and critical thinking. In particular the students need to think critically about the steps involved in the separating process. They may hypothesise, based on their prior knowledge or experiences, that sand is insoluble in water and salt is soluble in water. They may think about using the sedimentation process first to separate sand from the mixture and then the evaporation process to separate salt from water. But, after separating sand from the mixture, they may use their observation skills to notice that the salt solution is not clear enough of impurities from the sand, so think of using filtration process again before evaporating water from the salt solution to get back to pure salt. This demonstrates the uses of a variety of scientific process skills needed to separate components from a mixture.

5. Correct Explanations (CE): Focuses on reaching an age appropriate, scientifically acceptable understanding about natural objects and events in the world.
Example: Explaining how plants obtain food.

Students hold different understandings of how plants obtain food at different stages in their schooling, making this a suitable illustration of Correct Explanations. For example, primary school students might have idea that plants obtain their food by taking water, minerals and fertilizers from the soil through their roots. This is because, from their experience, they have noticed that people apply water and fertilizers at the base of plants in their homes or in agricultural fields when taking care of these plants. So, at this age, this may be an appropriate answer because it is true that plants absorb water and nutrients from soil to produce their food. On the other hand, senior secondary school students might use the process of photosynthesis to explain how plants obtain their food. Thus, this example demonstrates that both the responses of primary and secondary students are age-appropriate explanations of the processes of producing food by plants.

6. Self as Explainer (SE): Emphasises the scientific explanation of everyday phenomena that have been influenced by cultural and contextual considerations. *Example:* Belief in the presence of ghost-lights.

This is a useful example of the Self as Explainer because some Bangladeshi people, especially fishermen in rural areas, believe that the strange light phenomenon, which occurs on marshy lands, is a ghost-light, known as *Aleya*. They believe these lights represent the ghosts of fisherman who have died while fishing. However, the lights are caused by methane gas, which is produced by plants that are decomposing in the water. This gas floats on water until blown away by a strong wind and burns with a blue flame in swampy areas when it comes in contact with oxygen. This explanation reveals the existence of a scientific explanation behind a culturally and contextually influenced belief.

7. Solid Foundation (SF): Focuses on the mastery of science knowledge that assists individuals in developing an understanding on scientific concepts. *Example:* An understanding of particle theory.

This might be a useful example of the development of a Solid Foundation of science because particle theory forms the basis of understanding many aspects of chemistry. For example, if individuals understand the particle model then they can attempt to explain the three states of matter - solid, liquid and gas - according to the packing arrangement of particles in these different states. For instance, solids have the greatest density because the particles are closest together. It cannot flow like gases or liquids because the particles are strongly held in fixed positions. Solids expand a little on heating because a very strong force of attraction restricts the expansion and contraction occurs on cooling. Thus, the particle model underpins the development of a solid foundation for understanding different scientific concepts in chemistry.

8. Science for Nurturing (SN): The focus of this curriculum emphasis is on the use of scientific knowledge that has the potential to impact on health, quality of life and the environment. *Example:* Eating a balanced diet

An appropriate example of Science for Nurturing is balanced diet. Because it should combine different kinds of foods to ensure the required amounts of proteins, carbohydrates, fats, vitamins and minerals are consumed on a daily basis. No single food contains each and every nutrient required for growth and good health. Inadequate amounts of essential nutrients can result in poor physical and mental health and can, potentially, lead to the development of different kinds of diseases. Therefore, eating a balanced diet has a great impact on health. This example represents the knowledge of science that has ability to keep our health in good condition.

9. Science in Making (SM): Concentrates on applying scientific principles and processes to aid the development of products that serve and support human need. *Example:* Making a thermos flask using the principle of insulation.

This is an example of Science in Making because knowledge of insulation as a scientific principle is used in making a thermos flask to keep the content hotter or cooler than the surroundings. Insulators, such as cork, plastic and cotton are used in thermos flasks to prevent heat transfer by conduction. Moreover, a shiny silver coating on both sides of a double walled vessel inside the flask minimizes heat transfer of the content by thermal radiation and thereby maintains its temperature. This example shows the use of applying the scientific principle of insulation to assist people to secure their needs in their everyday living.

10. Science in Application (SA): Focuses on scientific knowledge that has direct and practical applications to society. *Example:* Use of vinegar for tenderising meat.

Some people use vinegar (acetic acid) when cooking meat to make it tender so this might be a suitable example of Science in Application. The tenderisation process works because vinegar breaks the peptide bonds that exist between the amino acids present in the complex protein (collagen) of meat. By breaking the bonds, the amino acids are separated from peptide chain structures of protein, which makes the meat tender to eat. The example demonstrates the application of scientific knowledge that impacts on daily life in a practical way.

The above explanations illustrate non-real-life and real-life curriculum emphases. The emphases Structure of Science, Correct Explanations, Scientific Skill Development, Self as Explainer and Solid Foundation are based upon scientific concepts or pure science content knowledge. As such these emphases were coded as non-real-life curriculum in the analyses of the curriculum and textbooks. Conversely, the emphases Everyday Coping, Science, Technology and Decisions, Science for Nurturing, Science in Making and Science in Application are related to the application of scientific knowledge or concepts and so were coded 'real-life' aspects. Having clarified, by example, the reasoning behind and the way in which sections of the text in both the curricula and textbooks were coded; the following sections describe how the analysis or mapping was undertaken.

3.5.2 Curriculum analysis

The purpose of the curriculum analysis was to explore the relationship between the curriculum and students' real-life. Two interrelated key components, specific objectives and learning outcomes for all topics across Grades VI to VIII of the Junior Secondary Science Curriculum (see Section 2.4 in Chapter 2 for details) were used for analysis using three steps (see Figure 3.3).

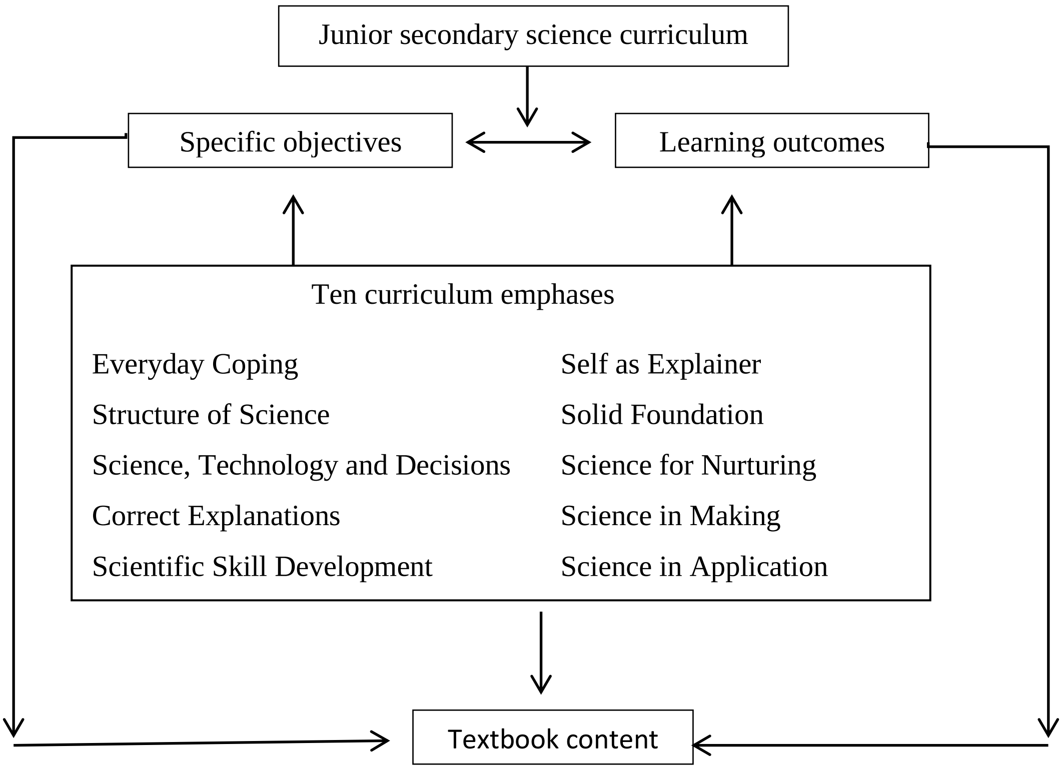

Figure 3.3 The process of Curriculum and Textbook Analysis

First, specific objectives and learning outcomes of the curriculum were read thoroughly and repeatedly so as to identify the curriculum emphases they represented, using the definitions of curriculum emphases from the analytical framework. Following this identification, appropriate codes were assigned to each objective and outcome. Some examples are provided at the end of this section to explain how judgements were made. This analysis allowed gaps or mismatches of the curriculum emphases between the specific objectives and learning outcomes for each topic to be identified.

Second, the total number of occurrences for each of the curriculum emphases in the specific objectives and learning outcomes for each grade was tallied. These frequencies provided a gauge as to the importance given to each curriculum emphasis in the curriculum for that particular grade.

Third, the frequency of alignment between the specific objectives and the learning outcomes for each grade, in terms of real-life and non-real-life curriculum emphases, was calculated separately. These frequencies help to provide a sense of the extent of the relationship of the Junior Secondary Level science curriculum with students' real lives, in terms of curriculum emphases. This is further explained and discussed in Chapter 4.

Making judgements about the representation of curriculum emphases: The specific objectives were read many times to understand the purposes of learning science as highlighted in each objective. These purposes were then compared to the definitions of curriculum emphases explained in Section 3.5.1, as the emphases are representative of the purposes of learning science. This process of insight through comparison led to assigning particular codes. A similar process was followed when assigning the codes for learning outcomes. Examples of how the codes for appropriate curriculum emphases were assigned to specific objectives and learning outcomes are given below.

Specific objective: Example 1 - To acquire knowledge about food and nutrition and eating food for health care provision (Assigned codes for this specific objective are SF and SN).

Rationale for judgement: According to the definition of Solid Foundation (SF) in the analytical framework, this emphasis focuses on the acquisition of scientific knowledge that can assist individuals to understand other scientific concepts. In the example offered, scientific knowledge about food, such as sources and functions of food, will help students understand the concept of a balanced diet. So, this specific objective was coded as SF. Further, the concept of a balanced diet can orient students towards eating the required amount of healthy food to ensure good health. Therefore, according to the definition of Science for Nurturing (SN) in the analytical framework, the second part of the specific objective, i.e*., 'eating food for health care provision'* is coded as SN because eating a balanced diet has the potential to improve the students' quality of health.

Learning outcome: Example 1 - Describe the necessity of a lightning conductor and the process of preparing this (Assigned codes for this learning outcome are SA and SM).

Rationale for judgement: A lightning conductor is a metallic rod with a sharp and tapering upper end that is fitted at the highest point of a building, mounted above the roof. The base of the rod is connected to a thick metal wire that is buried under the earth. During storms, if lightning strikes the top of a building, the building can crack. If a lightning conductor is fitted on top of the roof, it can protect tall buildings against the ravages of lightening discharge. This scientific understanding of the lightning conductor is used to protect buildings from electrification during storms, so it has direct and practical application in society. Therefore, according to the analytical framework, this learning outcome represents the emphasis Science in Application (SA). In addition, Science in Making (SM) has also been emphasised in this learning outcome because knowledge of scientific principles and processes in making the lightning conductor serves and supports human needs.

The above examples illustrate the ways in which the natures of other curriculum emphases were determined for all the specific objectives and learning outcomes of the JSSC. The process for textbook analysis will now be described.

3.5.3 Textbook analysis

The purpose of textbook analysis was to explore the extent to the content of the textbook topics were related to real-life using the same analytical framework for the curriculum analysis (see Figure 3.3). This was undertaken because the curriculum emphases in the specific objectives and learning outcomes acted as a guide for the development of the textbook content. The content analysis stage explored whether the same curriculum emphases identified in the specific objectives and learning outcomes of the curriculum were addressed in the related content of the textbook or whether the content prioritized other curriculum emphases.

There were two stages to analysing the content of the General Science textbooks. In stage one, by reading textbook topics of Grades VI to VIII several times thoroughly the curriculum emphases were identified from the textbook content and assigned codes. One excerpt from Grade VI textbook content is provided in the box below to explain how the judgement was made about the specific content of textbook topics. Before this, the related specific objective and learning outcomes from the curriculum (along with identified curriculum emphases) are provided to indicate the similarities and differences of the curriculum emphases between the specific objectives and learning outcomes of the curriculum and the content of textbook topic.

Specific objective: To acquire concepts and knowledge about properties of air, constituents of air and their necessity (Coded as SS, EC and SN)

Learning outcomes:

1. Explain the necessity of nitrogen in the plant and animal kingdom. (Coded as SN and SF for the next Learning outcome)

2. Explain the presence of nitrogen in some common fertilizers. (Coded as SA)

Content from textbook
Nitrogen has a special need for nutrition of plant and animal body. Some plants...chickpea, take nitrogen directly from air. None of the vast animal and plant kingdom can receive free nitrogen directly from air. Plants receive nitrogen from nitrate salt mixed with the soil. Herbivorous animals directly from plants and Carnivorous animals receive nitrogen as protein. Thus plants and animals all take nitrogen... Urea and ammonium sulphates are the nitrogenous chemical fertilizers. Urea contains 46% and ammonium sulphate contains 21% nitrogen. Use of these fertilizers helps rapid growth of the branches and twigs of the trees. These give deep green colour to the trees and increase their yields. (Source: Shamsudduha, Miah, wahab, and khan, 1997, p.46)

Rationale for judgment: According to the definition of Science for Nurturing in the analytical framework, presentation of the need of nitrogen for plants and animals nutrition in the text suggests its emphasis on SN, because this scientific knowledge has potential to impact on the health of animals and plants which are a source of protein. Along with this knowledge, percentages of nitrogen in ammonium sulphate and urea serve the purpose of understanding the use of nitrogenous fertilizers for nurturing plants. Thus, this content represents the emphasis Solid Foundation (SF). Also, the contribution of fertilizers to yield increase of plants helps society apply this scientific knowledge directly for the nurturing of plants. Therefore, it also emphasises Science in Application (SA).

After identifying the curriculum emphases in the textbook content, total frequencies of the individual curriculum emphases and real-life and non-real-life aspects of curriculum emphases were determined for each grade in the second stage of the analysis. These data were used to explore the relationship of the textbooks to real-life. This, in turn, helped to uncover the extent of the reflection of the specific objectives and learning outcomes of the curriculum in the textbook topics. A detail description of the textbook analysis along with results is presented in Chapter 5.

The textbook analysis provided an understanding of how the content of textbook topics supported teachers in following the ten curriculum emphases during their teaching, which was observed in the third phase of this research (p. 115). The next section describes the teacher questionnaire and selection of participants, along with data collection used in the second phase of the study.

3.6 Phase 2

3.6.1 Teacher questionnaire

In the second phase, a questionnaire (See Appendix 3) was administered to General Science teachers (N = 194) at selected schools. The advantage of using the questionnaire was to collect data from a large number of teachers in a relatively short time. As a questionnaire has limitations, such as giving more freedom to respondents to leave items unanswered or to provide reckless responses (Wiersma, 2000), the data were complemented with open-ended responses. The questionnaire addressed Research Question 3 - What are the perspectives of teachers of implementing this curriculum with a real-life emphasis?

These data were used to gain an overview of teacher demographic information, their perspectives of teaching real-life science for implementing the curriculum to orientate students to apply science in everyday life, and the challenges they face in teaching. Furthermore, the data provided some indication about who might be possible candidates for follow up interviews and classroom observations in the third phase of the study.

The questionnaire comprised four sections, summarised in the following table.

Table 3.2: Sections of the Questionnaire and Areas of Required Questions

Section	Required questions
A	General information about school and teachers' educational and professional information
B	Information regarding class-load, class size and availability of resource materials in schools to support teaching and learning
C	Teachers' ideas about the major purpose of science education, views on various aspects of teaching science, and teachers' teaching practices for real-life orientation of the students
D	Teachers' challenges in teaching science and their suggestions about initiatives to be taken to make science teaching relevant to real-life

3.6.2 Translation of the questionnaire

The questionnaire was developed in English and then translated into Bangla so that participants could understand the question items. The translated questionnaire was verified by a staff member in the Faculty of Education, Monash University, Australia who is Bangladeshi and has the professional expertise to verify this process.

3.6.3 Piloting of the questionnaire

The questionnaire was piloted with ten school science teachers in the Dhaka district of Bangladesh who taught General Science in the junior secondary level. All of them were purposively selected from Dhaka district and agreed to voluntarily participate in this pilot study. Careful piloting was necessary to ensure that all questions and instructions were clear to all respondents and the time required for completing the questionnaire was monitored (Bell, 2010). Any ambiguity found in the teachers' responses for any question items was clarified and notes were taken to revise those questions. Finally, this revised questionnaire was administered to the broader teacher sample. The following section describes the selection of participants for the second phase along with the data collection methods used.

3.6.4 Selection of participants for phase 2

To administer the questionnaire, a list of secondary schools from the Directorate of Secondary and Higher Education (DSHE), Bangladesh, was obtained. As Bangladesh is categorically divided into nine geographical regions and seven administrative divisions, a total of 300 schools were selected equally from urban, semi-urban and rural areas of those divisions through a random sampling procedure. It was considered reasonable to collect data from science teachers from a variety of school contexts in different regions of Bangladesh for maximum variation of responses to increase the generalisability of data. Considering cost-saving and time benefits (Creswell, 2008, 2009), initially the preference was to administer the questionnaire by post for ease of collection of data due to the geographical distance over which the participants were spread.

3.6.5 Method of data collection for phase 2

Questionnaires were sent to 20 schools selected randomly from the listed schools in the Dhaka division of Bangladesh, along with an explanatory statement, consent form, a copy of the letter from the controlling authority of the secondary schools of DSHE giving permission to collect data, an invitation letter to the science teachers, and a postage-paid return envelope. All science teachers of these schools who teach General Science at the junior secondary level were invited and encouraged to respond to this questionnaire. However, not one of the teachers returned the questionnaires, even after reminder letters were sent three weeks later. This issue was discussed with two experienced researchers in the field of education who suggested an alternative plan for collecting data from teachers in each division of Bangladesh on the spot. In accordance with their suggestions, Deputy Directors/District Education Officers of seven administrative divisions were informed about the issue over the telephone. All of those contacted were kind enough to help the researcher. They telephoned the head teachers of listed schools, described the purpose of the research and requested that the heads send volunteer teachers who taught General Science at the junior secondary level to the nominated venue at a given time. With their assistance, eight programs in eight districts were organised for science teachers covering nine regions and seven divisions of Bangladesh. The seminar rooms of the District Education Offices were used for these programs with attendance of 24-40 participants in each program.

At the first stage of this program, informal conversations occurred in a friendly atmosphere, which helped to build a rapport between the researcher and the teacher participants while building enthusiasm for involvement in this research project. Participants were invited to share their experiences about science education in Bangladesh and their teaching experiences and they were introduced to the research project and its purpose. The teachers were given an invitation letter, a copy of the permission letter from the controlling authority and an explanatory statement. They were requested to fill in the consent form if they agreed to participate in the research project. Teachers were, then, invited to complete the questionnaire individually. They were requested not to discuss this with other participants during completion of the questionnaire and to freely ask questions of the researcher for clarity of any items. In total, 194 questionnaires were collected from the participant teachers.

3.6.6 Data analysis for phase 2

As noted earlier, there were two purposes for administering the questionnaire. One was to gather data from teachers from a range of geographical regions and administrative divisions that captured their background characteristics, views of science education, various aspects of teaching real-life science and their science classes, along with their challenges in teaching science. These responses in turn helped to interpret how teachers' perceptions of implementing the curriculum with a real-life emphasis were considered when teaching science. The second purpose was to select a variety of cases for the third phase of the research study. Some items of the questionnaire were considered for analysis to select these cases (e.g., Items 1 to 8). The process of selection will be described in Section 3.7.

In the questionnaire, there were various types of items to produce a range of quantitative responses and qualitative responses. Examples of these items and procedures for analysing different types of items are described below.

Example 1: Alternative response type item

In this item (i.e., 13), teachers were asked to select their response from two alternatives.

In your opinion what should be the major goal of General Science course at the junior secondary level. Please put tick in one box.	
Allow all students to be able to apply their science learning in real-life situations	☐
Build a solid foundation to prepare students for further studies in science	☐

For this type of item, the frequencies of teachers' responses against the alternatives were calculated as percentages and summarised using pie-charts for visual representation of the size of the samples, relative to total sample.

Example 2: Ranking type item

For ranking type items, teachers were asked to rank the given aspects according to their priorities (e.g., Item 18).

Please rank the following aspects as barriers of science teaching related to everyday life and rank these indicating your choice. ‘1’ indicates your first choice, ‘2’ your second choice, and so on. You can put same rank for more than one aspect. Lack of resources------------------------------------ ☐ Big class size--- ☐ Heavy class load--------------------------------------- ☐ Inadequate instructions in curriculum---------------- ☐ Inadequate instructions in teachers guide------------ ☐ Inadequate instructions in textbooks------------- ☐ Please write if any other barriers you face and rank for that. --

To analyse the ranking type items, teachers’ ranks were scored inversely in order to calculate the average rating of the scores. For example, if a teacher put rank ‘1’ for the barrier ‘lack of resources’, then this was scored as ‘6’ and considered as the most dominant challenge. The highest average rating was considered as the top barrier, the next higher average rating was considered as the second top barrier and so on. Thus, a relative picture of teaching barriers was identified using the average ratings (Johnson & Christensen, 2008) of teachers’ responses. This type of item is presented using a bar graph (See Section 6.6, Figure 6.10, p 222). Teachers added multiple responses for other barriers in teaching science in the open-response section of the item but did not mention ranks for their responses. This type of item was provided so that teachers could provide additional information that may be useful for the study. Where teachers provided multiple responses or a number of statements, calculations of frequency of responses were converted to percentages according to the total number of occurrences of each of these responses or statements.

3.7 Phase 3

3.7.1 Classroom observation, teacher interview, and students' focus groups

In the third phase of the study, a small number of teachers were selected from the questionnaire respondents using criteria identified in Table 3.3. Once selected, teachers were interviewed before observing the classes and for a second time after lesson observations. Interviews with the science teachers combined with lesson observations helped to gather actual experiences around curriculum delivery. Following the teachers' second interview, focus group discussions were conducted with their students in order to gather richer and more detailed and contextually-based data. Some of the focus group discussion data were used as supporting data sources for teachers' teaching practices. The following sections describe the selection of teacher and student participants along with data collection methods.

Table 3.3: Demographic Information of the Sampling Teachers

Selection criteria	Participants (Pseudonyms)					
	Jalil	Nabila	Khushi	Shyamol	Bishnu	Sabrina
School location	Semi urban	Urban	Urban	Rural	Semi urban	Rural
School type	Non-govt. Male	Govt. Female	Non-govt. Female	Non-Govt. Co-ed	Non-Govt. Co-ed	Non-Govt. Co-ed
Teaching experience	8 years	17 years	13 years	25 years	33 years	13 years
Gender	Male	Female	Female	Male	Male	Female
Class size	27	50	70	116	117	58

Table 3.3 reveals that the selected teachers represented a range of geographical locations (urban, semi-urban and rural); and school types (Government, Non-Government; boys, girls, and co-education) with different spans of teaching experiences

(from 8-33 years). There were three male and three female teachers and their class sizes ranged from 8 to 117. With these six teachers, ideas about science education and their nature of classroom practices to promote students' learning for using science in real-life situations were investigated in depth using Research Question 3.

3.7.2 Selection of participants for phase 3

Teachers who had responded positively to the questionnaire about participation in the interviews were considered based upon their school location (e.g., urban, semi-urban, rural), school type (boys, girls, co-education), teaching experiences, class sizes and gender. Finally, six teachers were selected and they agreed to be involved in all aspects of the third phase of the study. This "Maximum variation sampling procedure" was followed as suggested by Hackling, 2012; Johnson and Christensen, 2012; and Merriam, 2009. The sample of participants was drawn to represent, a diversity of the potential attributes, was useful to gain in-depth data for understanding teachers' perspectives on science education, their practices and challenges in implementing the curriculum for a real-life orientation of the students in an attempt to inform on a broad basis beyond the sample size.

With the teachers selected, six to nine volunteer students from each of these teachers' classes were purposively selected for focus group discussions. Students were selected based upon their academic ability as demonstrated by their achievements and gender to ensure an equal number of females and males representing the range of schools.

It was expected that, during the focus group discussions, students would think for themselves and talk to the researcher freely, as their participation was independent from their classroom assessment. To avoid undue influence on the students' responses, presuming an unequal relationship might exist between the participating teachers and their students, a precaution was taken to select teachers who were not involved with this research or with teaching and assessing these students. The nominated teacher explained the purpose of this research to the students and distributed the consent forms and explanatory statements. The teacher was briefed that his/her participation was completely voluntary and s/he was not expected to force students to participate in this research. As the students were under 18, their parents had to authorise them to participate in the study by signing another consent form, due to ethical demands for high-risk research.

3.7.3 Methods of data collection for phase 3

As multiple sources were used to collect data in Phase 3, detailed explanations for the instruments used to collect data are now provided.

3.7.3.1 Teacher interview

The main advantage of using interviews was to elicit detailed information about personal feelings, perceptions and opinions about a research problem that cannot be directly observed (Creswell, 2008). The interviews were semi-structured, which Litchman (2006) described as interviews where a general set of questions and formats are developed so that the researcher can alter them as the situation demands. As face-to-face interviews were conducted, there was an opportunity to ask probing questions during conversations to filter or sort out a variety of required information and opinions surrounding the more general information provided (Creswell, 2008; O'Toole & Beckett, 2010) from the interviewees responses. Moreover, face-to-face interviews provided the opportunity to clarify particular answers from the questionnaires of the teacher participants. Thus, interviews were a suitable method for this research to explore teachers' perceptions of science education and their views of teaching science, engaging students in activities, suitability of the curriculum, textbooks and teachers' guides for teaching and their challenges in teaching science.

The first interview was divided into two steps. At the beginning of the first step, as suggested by Patton (1990), trust and rapport with the interviewee was established. This created an environment that was friendly and non-threatening. They were asked questions in an unbiased manner (Yin, 2009). The researcher tried to remain objective (Patton, 2002) and participants' answers were listened to intently and not judged or evaluated (Wiersma & Jurs, 2009) so that they could feel confident and comfortable in answering their questions during interviews. There was no intention or indication that participants structured their answers to what the researcher wanted to hear.

The semi-structured interview schedule developed for the pre-lesson interview consisted of eight guided questions. These questions provided an understanding of teachers' perceptions about real-life science and the way they perceive they should teach real-life-related content. Some examples of the pre-lesson interview questions are provided below. A full list of the pre-interview questions is included in the appendix (Appendix 5). Some questions were provided to teachers in advance in the belief that they would feel more comfortable with providing personal responses if they knew the scope of the questions.

Could you please tell me, what you believe should be the goal of science education?

What are some real-life problems/issues that you used in your teaching?

How do textbooks help you to select teaching strategies of everyday science?

What ideas have you got regarding teaching and learning strategies of everyday science content to be followed from the junior secondary level science curriculum?

The post-lesson interview schedule included 11 questions (see Appendix 6). These questions included lesson-related aspects, teaching approaches, and classroom activities. For example:

> What are the purposes of your today's science lesson?
>
> Do you think that this is an effective way of teaching this topic to promote students' learning enabling them to apply in real-life? Why or why not? Would you like to do so?
>
> How could you engage students in a better way enabling to utilize their today's learning in everyday life?

Teachers were asked these questions in order to understand if they had any intention of linking the particular lesson with real-life and, if so, how they could use other methods for encouraging students to utilize their learning in everyday life. During post-lesson interviews, teachers were given opportunities for self-reflection on their own teaching where they might explain their teaching gaps. They talked about the difficulties they faced in teaching science so that it related to the real-life of their students. There was flexibility in the format for the teachers to express their opinions and they were asked related questions based on classroom occurrences. In this way, a real picture emerged around Bangladeshi science teachers' understandings and perspectives of their teaching of real-life based topics to promote students' learning.

Interviews were conducted in a location on the school premises that was free from noise and interruptions. All the interviews were conducted in Bangla and audio recorded to preserve the natural language of the interviewee and which provided a concrete record of what was said. Hand written notes were also made in case the recording equipment failed and to record any important observations occurring while conducting the interview.

3.7.3.2 *Classroom teaching observation*

Classroom observation allowed the researcher to understand phenomena of "what actually happens within a complex, multi-faceted and dynamic setting" (Kervin, Vialle, Herrington & Okely, 2015, p. 75) and was an important way of collecting information about teachers' and students' activities and behaviours in the natural site of the classroom (Johnson & Christensen, 2008; Johnson & Christensen, 2012). The intention of the classroom observations was to perceive lesson objectives or learning outcomes, teachers' teaching approaches and assessment techniques to explore what science curriculum emphases teachers tend to prioritize to promote students applying their learning in real-life. Another purpose was to monitor the lesson plans or notes against the lessons observed to confirm whether teachers had any intention of using context-based teaching or hands-on activities to engage students.

During pre-lesson interviews, arrangements were made with the teachers to observe lessons for one topic. More importantly, a positive relationship was established so that they would feel relaxed and not threatened by the observation procedure. Teachers were requested to teach lessons from any topic related to real-life from Grades VI to VIII because different lessons might have different curricular emphases. Although this outcome could not be guaranteed, it was made clear to the teachers they were to conduct their classes using their normal practices and not set up a teaching situation that they felt a researcher would be interested in observing. As a "nonparticipant observer" (Bryman, p. 257) (i.e., without disturbing or manipulating classroom activities) the lessons were observed sitting at the back of the classroom.

Overall, two or three lessons were observed for each teacher. During observations, descriptive field notes (Bogdan & Biklen, 2007; Wiersma & Jurs, 2009) were made of the situation being observed, the physical setting, and the kinds of activities and events that occurred. Additionally, reflective field notes (Bogdan &

Biklen, 2007; Creswell, 2008) were completed comprising subjective thoughts and questions to ask participants during the post-lesson interviews. An observation check-list (see Appendix 7) was filled out immediately at the end of each class on the school premises. All field notes were reviewed immediately (Patton, 1990) in order to capture the classroom context as authentically as possible.

As "solo observers are always in danger of accusations of bias or misinterpretation" (Bell, 2010, p. 192) all lessons were observed accompanied by a teacher. This was to ensure the consistency of lesson observations because the researcher might not be able to observe and record everything that occurred in a class. Therefore, what was taught, for what purpose, in what context and how teachers engaged students to promote their learning for real-life orientations was noticed, along with teachers' diagnostic and formative assessment techniques linked with particular lessons. Overall, these observations helped to understand teachers' teaching approaches, how they considered the ten curricular emphases in teaching science to facilitate students' meaningful learning, and how they faced challenges.

3.7.3.3 *Focus group discussion*

A focus group discussion is like an "organised discussion" (Kitzinger, 1994, p.103), where group interaction may "trigger thoughts and ideas among participants" (Litchman, 2010, p.154) about the issue. Six to nine students from each of the science classes comprised the focus groups. In total, six focus group discussions were conducted with students. The main purpose of the students' focus group discussions was to gather information about teachers' teaching practices. The focus groups also provided a range of insights (Morgan & Krueger, 1993) into the way students experienced the curriculum, especially regarding the importance of curriculum emphases given in science lessons and the scope to apply their learning of science in real-life situations.

In this study, focus group discussions were preferred over individual interviews, because they were more likely to engage students in an in-depth discussion of the subject matter in a non-threatening manner. By comparison, individual interviews only provide ideas of any one individual, which may be much narrower in breadth and depth. Focus group discussions also enabled the students to debate and justify their individual opinion within the group thereby taking advantage of group dynamics to produce new and additional data. Finally, but not inconsequentially, it condensed the time demand on the researchers (Straus, 2010).

To facilitate the key role of moderator, a list of guided questions (see Appendix 8) was developed for smooth progress through the focus group discussions. Time was taken, initially, to build a rapport with the students by introducing the project in a friendly manner and explaining the purpose of the research. To reduce their anxiety, they were assured that their responses would not be assessed and confidentiality would be maintained. As a result, they talked freely (Lodico, et al., 2006). Sometimes, the students were asked probing questions to elicit more information. During the discussion, this type of communication created a non-judgemental environment for the participants (Krueger & Casey, 2000).

Focus group sessions were conducted in Bangla as it was easier for students to understand and articulate their responses in their own language. All focus group discussions were audio-taped with the students' consent. The school authority provided a quiet location for conducting the focus group discussions to avoid any kind of noise or interruptions for recording purpose and to keep the flow of discussion free from distractions. As well, field notes were taken during the interviews in case of recorder malfunction. Students were supplied with name tags so the researcher could address them by name for lively discussion and ensure the participation of group members who were less responsive.

3.7.4 Data analyses for phase 3

As noted earlier, data collected through interviews, lesson observations and focus group discussions at phase 3 were qualitative in nature. For analysis, all digital recordings of pre and post-lesson interviews with teachers and focus group discussions with students were transcribed in Bangla. Appropriate sections of these transcripts were translated into English for reporting in this thesis. During lesson observations, notes were taken in Bangla but reports were prepared in English. Bangla transcriptions and English translations of interviews and focus group discussions and lesson observation reports were used for analysis. Samples of translated copies of pre and post-lesson interviews, focus group discussions and lesson observation reports are provided in Appendices 9 to 12.

The interview and focus group discussion data were transcribed by two hired transcribers. As pointed out by Bailey (2008, p. 127), since transcribing is a "straightforward technical task" and involves judgements about the level of detail to include, all transcripts were checked carefully from these perspectives by listening to the recordings. One limitation was that participants' facial expressions, such as laughing or hesitations, were not always included due to differences between oral and written language (Kvale, 1996). Furthermore, to ensure that participants' interview data were accurately transcribed, member checking (Creswell, 2014) was done by sending back Bangla transcripts of interviews to the teacher respondents, which enhanced the credibility of data.

At the first step of analysis of these qualitative data, all the interview transcripts, lesson observation reports and focus group discussion transcripts were read several times for in-depth understanding (Creswell, 2008) of commonalities of ideas before assigning the themes. Second, the common ideas were restructured into major categories and sub-categories from which major themes, useful for finding similarities and differences across teachers' and students' responses and for deeper understanding and explanation of the research problem (Miles & Huberman, 1994) were identified without any preconceived ideas. Colours were used to highlight the categories and sub-categories that allowed identifying similarities and differences of responses in the interviews and in the focus group discussions. In the final step, supporting evidence was selected for the themes in the form of quotations from the raw data. It should be acknowledged that, when moving from raw data to themes, there might be a degree of subjectivity in judging the data. However, this subjectivity allowed the researcher to construct her own understanding from the multiple sources of social constructions that the participants hold.

Finally, data from the teacher questionnaires in Phase 2 were amalgamated with data from the teacher interviews and focus group discussions in phase 3. This provided a detailed picture of teachers' perspectives of implementing the curriculum, of students' orientation of science to real-life and of challenges teachers face in teaching science. These are presented in Chapter 6.

The aim of these analyses was not to generalise findings for all teachers' understandings of real-life science and their teaching practices in Bangladesh but to get insight into the significance or applicability of the findings to other similar settings (Miles & Huberman, 1994).

3.8 Issues of Validity and Reliability

Discussion about validity and reliability are essential criteria for judging the quality of a research. Overall, validity is a complex concept (Bell, 2010) in a mixed methods research. With respect to instruments, the usual meaning of validity is whether an instrument measures or describes what it intends to measure or describe (Bell, 2010; De Vaus, 2002). A reliable instrument is one that produces the same results when its application is replicated in similar conditions (De Vaus, 2002). Wiersma (2000) mentioned two concepts of validity: internal validity and external validity. He considered internal validity as “the extent to which the results of a research study can be interpreted accurately and with confidence” (p. 6), and viewed external validity as “the extent to which research results are generalizable to populations and/or conditions” (p. 7).

As mentioned earlier, this study followed a mixed methods research design in three phases. The use of multiple methods and data sources allowed triangulation in this study to ensure consistency and validity of data by drawing on quantitative and qualitative methods in different phases to obtain in-depth detail, from a range of sources, to make sure of the relationship of the curriculum to students’ lives. Whether the curriculum is related to real-life or not, cannot be identified only by analysing the specific objectives and learning outcomes of the curriculum. It also depends on textbook content and the teacher’s teaching practice. Therefore, a number of instruments were used in this study. Use of an analytical framework to analyse the curriculum and textbooks provided ideas to what extent specific objectives and learning outcomes, and content of the textbook topics are related to real-life. To ascertain how closely teachers’ actions were aligned to the implementation with the curriculum, a questionnaire was applied to elicit teachers’ perceptions about their concepts and practices they thought important in implementing the curriculum. Interviews with teachers were undertaken to find out their views to, and perceptions of, the purpose of curriculum and textbooks, plus what they believed how they were practicing and enacted these by connecting to students’ lives. Classroom observations gave insights around how these perceptions translated into reality. Focus group interviews with students provided feedback on how teachers’ teaching practices were useful to apply their learning in real-life. From the application of this mixture of methods, data was obtained from a variety of viewpoints and approaches, allowing it to be compared and contrasted and, effectively, validated from different directions. The instruments used in these methods were rigorously tested for validity, as shall be explained.

Specifically, in phase 1, an analytical framework was used as an instrument to analyse the curriculum and content of the textbook topics. This analytical framework, that represented the definitions and examples for ten curriculum emphases, was developed from Roberts' (1982, 1988, 1995) and Fensham's (1994, 2004) curriculum emphases and was checked by the supervisors of this research. Particularly, they checked for face validity while ensuring that the essence of each emphasis was correctly represented by the definitions and examples. Following the framework, a sample of identified curriculum emphases coded across the specific objectives and learning outcomes of one topic for the Grade VI curriculum was then prepared, jointly, with one supervisor which was useful for determining the curriculum emphases for the rest of the specific objectives and learning outcomes of other topics. These were the ways of establishing the internal and external validity of the instrument and the results of the curriculum analysis.

Furthermore, to ensure reliability of the framework, the identified curriculum emphases in the specific objectives and learning outcomes of the curriculum in Grade VI were reviewed by two PhD researchers of the Faculty of Education, Monash University, who are teacher educators in Bangladesh. Following the analytical framework, another educational researcher in Bangladesh reviewed all the identified curriculum emphases in the specific objectives and learning outcomes for the Grade VI to VIII curriculum and in the content of corresponding textbook topics. Any ambiguities that were identified were consensually resolved by the researcher with this group and necessary modifications made.

In phase 2, in the preliminary stage of questionnaire development, effort was made to enhance the validity of the questionnaire. The content of the questionnaire, question wording and language for presenting the items were discussed with the Monash University researchers mentioned above to gain insight regarding the appropriateness of the questionnaire. This was also checked by the supervisors. Moreover, the Bangla version of the questionnaire was verified by a faculty member who is Bangladeshi and has the professional expertise to verify this process. For a reliability test, the questionnaire was piloted before administering it. Ten science teachers, selected from urban and rural schools and who were not participants in the main study, were invited to examine whether the question instructions were clear to them or ambiguous. Any ambiguities found during the piloting stage were identified and discussed for further revision of the questionnaire. All ten questionnaires were analysed to check whether the responses indicated the questions asked were appropriate for eliciting data meaningful to the research questions under investigation.

In phase 3 of this study, validity and reliability issues were addressed in different ways. The instruments used for teacher interview, lesson observation and focus group discussion were developed and refined in consultation with the supervisors, as discussed in the previous paragraph. These instruments were tested in two schools and reviewed, based on pilot respondents' responses. Two people were hired to transcribe all interview and focus group discussion data. Each transcript was carefully checked by the researcher against the audio recordings to verify whether the data was captured accurately and in detail. All interview transcripts were member-checked (Mertens, 2005) with the respective participants to establish the accuracy of data. One Bangladeshi colleague was asked to take notes during lesson observations (Bell, 2010) which helped to determine the reliability of data by cross checking with his notes. In consultation with him, classroom observation check lists were completed and lesson observation reports were prepared. Hence, a number of validity and reliability issues regarding quantitative and qualitative methods in different phases were addressed for this mixed method research.

There was voluntary participation of the questionnaire teachers in Phase 2, and teachers and students in Phase 3 (for teacher interviews, lesson observations, and students' focus group discussions) of this study. In educational research there was no option for obtaining ethics approval to conduct this study without their volunteer participation, as they have the right to participate, and they were not against it. It is the norm of educational research. As a consequence of the volunteer participation of the teachers and students, I understand that the data is skewed, and this can impact on validity and reliability of data. This type of data has the potential to impact on reliability and generalisability of the results. To overcome this issue, teacher participants in phase 1 were selected from all seven divisions of Bangladesh, and in phase 2, a "maximal variation sampling" procedure was followed (see Section 3.6.4, and 3.7.1) with diverse backgrounds and experience of the teacher participants.

3.9 Ethical Issues

Ethical considerations are important aspects of all research planning and implementation processes (Mertens, 2005). It is the requirement of research that participants are aware of the purpose of the research and they understand their roles and rights as participants (Bell, 2005).

In this research, normal ethical protocols, as specified by Monash University Research Ethics Committee, were considered. Of particular interest were the following components. A permission letter was attained from the highest authority, Directorate of Secondary and Higher Education (DSHE), Ministry of Education, to get access and collect data from the secondary schools in Bangladesh (see Appendix 2). Explanatory statements were provided to all the participants to explain the purpose of the research, their roles and rights, and the process for reporting to the Monash University Research Ethics Committee if inconvenienced by the study. Another consideration was anonymity, to protect participants' identities and privacy. This was achieved by using pseudonyms in reporting the findings. However, as interviews with teachers and focus group discussions with students were audio recorded, these could not be totally anonymous to all involved in the project. But, the data were not shared with other participants or anyone outside the project to maintain confidentiality.

Participant teachers were asked to sign a consent form after reading the explanatory statement that indicated their voluntary involvement with this research. Student participants who showed interest in participating in this research were under 18 years old. Therefore, they were asked to sign the consent form after reading the explanatory statement and after discussion with their parents/guardians. Explanatory statements were also provided to their parents/guardians to make sure they understood the student's role in this research.

3.10 Summary

This chapter has discussed the methodology adopted to explore the relationship of the junior secondary science curriculum of Bangladesh with real-life situations. At the beginning, it discussed the research paradigm underpinning this research and rationale for using a mixed methods approach for this study. Following this an overview of the research design including the phases involved, purpose of each phase along with the instruments used in conducting the research were explained. The subsequent sections described in detail the methods used at different phases to analyse quantitative and qualitative data originating from this study. Finally, methodology was evaluated in terms of validity and reliability and concluded with the ethical aspects associated with this study.

The next four chapters present the data collected using these methods. Results of curriculum analysis are presented in Chapter 4, which includes how the curriculum emphases were addressed in the specific objectives and learning outcomes of the junior secondary science curriculum and to what extent the curriculum is related to real-life. The results of the analysis of Grades VI to VIII textbook content are presented in Chapter 5. These findings illustrate how the specific objectives and learning outcomes of the curriculum are reflected in the textbook topics, in relation to real-life. Chapter 6 presents data regarding teachers' perspectives of implementing the curriculum with a real-life emphasis. Within this chapter findings from the questionnaire data (qualitative and quantitative) and cross-case analysis of six case teachers (using data from pre and post-lesson interviews with teachers, lesson observation reports and focus group discussion with students) are synthesised to identify teachers' background, available teaching resources in schools, their ideas of teaching real-life science, actual classroom practices and their challenges in teaching science for a real-life orientation of the students.

Chapter 4

Data Analysis: The Curriculum Emphases of Bangladeshi Junior Secondary Science Curriculum

4.1 Introduction

As mentioned in Chapter 3, ten curriculum emphases (Fensham, 1994, 1996, 2004) were used to gauge the extent and nature of a range of emphases in the Bangladeshi junior secondary science curriculum (JSSC). The chapter presents an overview of a mapping of the curriculum using these emphases as a framework to address the research question:

RQ 1. To what extent is the junior secondary science curriculum in Bangladesh real-life oriented?

Two key components in the structure of this curriculum, the specific objectives and the learning outcomes (for details see Chapter 2, Section 2.4) were used to map the intended curriculum for Grades VI to VIII.

4.2 Overview of Curriculum Emphases in the Curriculum

The analytical framework developed in Chapter 3 illustrated that of the ten curriculum emphases five, namely: Structure of Science, Scientific Skill Development, Solid Foundation, Correct Explanations, and Self as Explainer, exemplify science subject matter knowledge. These are considered as non-real-life aspects of the curriculum emphases as they are neither directly applicable to the students nor helpful in solving real-life problems. Alternatively, the curriculum emphases of Everyday Coping, Science, Technology, and Decisions, Science in Making, Science for Nurturing, and Science in Application attempt to link science to real-life. As such, students can apply these types of knowledge to address problems in their everyday lives. So, these emphases are considered as real-life aspects of the curriculum.

An overview of the mapping of the curriculum emphases targeted in the JSSC is provided in Table 4.1. The ticks in the table signify the identified curriculum emphases in relation to the specific objectives and learning outcomes in Grades VI to VIII General Science curricula.

Table 4.1: Mapping Curricular Emphases across Grades VI to VIII

Curriculum emphases	Specific objectives			Learning outcomes		
	Grade VI	Grade VII	Grade VIII	Grade VI	Grade VII	Grade VIII
Everyday Coping (EC)	✓	✓	✓	✓	✓	✓
Structure of Science (SS)	✓	✓	✓	✓	✓	✓
Science, Technology, and Decisions (STD)	-	-	✓	✓	✓	✓
Scientific Skill Development (SSD)	✓	✓	✓	✓	✓	✓
Correct Explanations (CE)	✓	-	-	✓	✓	✓
Self as Explainer (SE)	-	-	-	-	-	-
Solid Foundation (SF)	✓	✓	✓	✓	✓	✓
Science for Nurturing (SN)	✓	✓	✓	✓	✓	✓
Science in Making (SM)	✓	✓	✓	✓	✓	✓
Science in Application (SA)	✓	✓	✓	✓	✓	✓

As indicated in Table 4.1, the curriculum emphases of Everyday Coping, Structure of Science, Scientific Skill Development, Solid Foundation, Science for Nurturing, Science in Making, and Science in Application are the key foci of both the specific objectives and learning outcomes for Grades VI to VIII curricula. Further reference to the table shows three exceptions to this pattern. These exceptions are in Science, Technology, and Decisions, Correct Explanations and Self as Explainer. Science, Technology, and Decisions is represented in the learning outcomes but missing in the specific objectives of Grades VI and VII curriculum. Correct Explanations is represented in the learning outcomes but absent in the specific objectives of Grades VII and VIII curriculum while Self as Explainer is not represented in either the specific objectives or the learning outcomes of the JSSC in any year level. Hence, this mapping clearly indicates which of the curriculum emphases are valued most in relation to the intentions of the JSSC.

The next section examines the curriculum emphases in the specific objectives and learning outcomes for each topic in Grades VI to VIII curriculum using the same analytical framework. The process used for identifying the curriculum emphases for the specific objectives and learning outcomes is described previously in Chapter 3.

4.3 Curriculum Emphases for Topics in the Curriculum

The analysis of the curriculum in relation to topics is completed for three purposes. First, given that not all of the ten curriculum emphases are explicitly linked to real-life, it is necessary to identify those topics in which real-life curriculum emphases are addressed. Second, the mapping process highlights the commonalities of the curriculum emphases across topics in relation to specific objectives and learning outcomes, along with the obvious gaps. Third, calculating the total number of frequencies for each of the curriculum emphases across the specific objectives and learning outcomes in the curricula provides a quantitative perspective to determine the extent of the emphasis between the curriculum and students' real lives. The identified curriculum emphases in the specific objectives and learning outcomes of different topics of Grades VI, VII and VIII are presented in Sections 4.3.1, 4.3.2, and 4.3.3 respectively.

4.3.1 Mapping Grade VI.

The Grade VI JSSC includes nineteen topics representing a range of science subject areas, such as Physics, Chemistry, Biology, and Geography. The total number of each curriculum emphasis in the specific objectives, and in the learning outcomes of a topic is determined by adding the number of occurrences or frequencies of the individual curriculum emphasis. The number of the curriculum emphases identified in relation to the specific objectives (SOs) and associated learning outcomes (LOs) for each topic of Grades VI are presented in Table 4.2. Different colours are used to highlight the pattern associated with the emphases. The real-life curriculum emphases in the first column of the table are shaded in grey thereby showing at a glance the topics that include these perspectives (emphases). To identify clearly the particular emphases in the specific objectives and learning outcomes for a topic, a specific colour has been used. For example, pink was used for the Everyday coping curriculum emphasis. As a result, gaps of particular curriculum emphasis in the specific objectives and learning outcomes are clearly evident.

Reflecting on Table 4.2, it appears from the shading that the majority of topics (sixteen out of the nineteen) address the Solid Foundation emphasis in the specific objectives and learning outcomes. With this exception all other topics in the curriculum comprise different combinations of curriculum emphases. For example, in the specific objectives and learning outcomes for two Chemistry topics (i.e., *Air, Water*) and five Biology topics (i.e., *Plant Kingdom, Morphology of Plants, Features of Invertebrate Animals, Health Rules, and Food and Nutrition*), the three real-life related emphases Everyday Coping, Science for Nurturing, and Science in Application are identifiable. The Physics-related topics pick up a combination of emphases including Everyday Coping, Science in Application, and Science in Making. Alternatively, the emphasis Science in Making represented consistently in the specific objectives of Grade VI curriculum, only

Table 4.2: Emphases in Grade VI Curriculum

Curriculum emphases	**Chapter** →	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
Everyday Coping (EC)	SOs	1*		1		1			1	1			1	1		1		1	1	1
	LOs	1*		1	4	4			1	2			1	1		1		2	3	
Structure of Science (SS)	SOs			1		1	2	1	1			1								
	LOs				3	2	2	2	11	3	2	5	2	1	2		2			
Science, Technology, and Decision (STD)	SOs																			
	LOs																			5
Scientific Skill Development (SSD)	SOs	1			1		1	1											1	1
	LOs	3	3	2	1		3	1		1	1			2					1	3
Correct Explantation (CE)	SOs						1													
	LOs			1			1			2							1			4
Self as Explainer (SE)	SOs																			
	LOs																			
Solid Foundation (SF)	SOs	1	1		1	1		1	1	1	2	1	2	1	2	1	2	1	1	
	LOs	5	3	2	3	1	6	4	8	6	5	2	4	4	8	4	7	2	2	3
Science for Nurturing (SN)	SOs			2		1			1	1						1		1	1	2
	LOs			2		5			1	1						1		3	3	1
Science in Making (SM)	SOs													1						
	LOs	1			1					1			1	1						
Science in Application (SA)	SOs	1		1		1			1	1				1		1		1	1	
	LOs	1		2	5	2			2	2			2	1		1		1	2	
Topic name →		Measurement	Matters	Air	Metal and Non-metal	Water	Living World	Cell	Plant Kingdom	Morphology of Plants	Force, Pressure and Motion	Work, Power and Energy	Electric Energy	Magnetic Energy	Surface of the Earth	Features of Invertebrate Animals: Shrimp	Human Body: Skin, muscle and Bones (Skeleton)	Health Rules: Skin Diseases	Food and Nutrition	Population and Natural environment

*Frequency of corresponding curriculum emphasis

appearing in a topic *Magnetic Energy*. In three topics, namely, *Measurement,* and *Electric Energy* of Physics, and *Metal and Non-metal* of Chemistry Science in Making are addressed only in the learning outcomes.

Real-life related emphases are absent in the specific objectives and learning outcomes for seven topics (i.e., out of nineteen). These include *Matter* (related to Chemistry), *Living World*, *Cell,* and *Human Body: Skin, Muscle and Bones* (related to Biology), and *Force*, *Pressure and Motion*, *Work*, *Power and Energy* (related to Physics), and *Surface of the Earth* (related to Geography). These topics are focused on pure science content represented as the Solid Foundation curriculum emphasis.

Overall, the analysis around topics indicates that the real-life related emphases of Everyday Coping, Science for Nurturing, and Science in Application are targeted in the specific objectives and learning outcomes of the curriculum. In contrast, few references occurred for Science in Making, while Science, Technology, and Decisions is barely presented in the curriculum. Of particular concern is that in some topics, real-life emphases are completely absent (e.g., Science, Technology, and Decisions in the specific objectives).

Looking at Everyday Coping, Science for Nurturing, and Science in Application in greater detail, it is worth noting that they are addressed more prolifically in topics for Biology (i.e., five out of the nine) and Chemistry (i.e., two out of the four). Physics-related topics (i.e., three out of five) address only Everyday Coping and Science in Application while Science in Making is barely identified in the specific objectives of Physics, Chemistry, or Biology topics. One Biology topic and one Chemistry topic focus on Science in Making in the learning outcomes. Only one topic related to Biology concentrates on Science, Technology, and Decisions in the learning outcomes.

Having considered each topic in relation to the curriculum emphases, it is critical to realize that learning outcomes are developed based on the specific objectives. Therefore, it might be expected that all the curriculum emphases present in the specific objectives of each topic should be demonstrated in the learning outcomes for the same topic. However, the data in Table 4.2 illustrates that among the nineteen topics available in the curriculum, the same curriculum emphases demonstrated for the specific objectives and learning outcomes are identified only in five topics. These topics include: *Cell* (three emphases), *Work, Power and Energy* (two emphases), *Features of Invertebrate Animals: Shrimp* (three emphases), *Health Rules: Skin Diseases* (four emphases), and *Food and Nutrition* (five emphases) (see Table 4.2 for more detail). Unlike the pattern for the other topics where there is an apparent mismatch in the alignment of curriculum emphases between specific objectives and learning outcomes, there are no gaps evident between the specific objectives and learning outcomes in these topics in terms of curriculum emphases. In the remaining fourteen topics, two types of gaps between the curriculum emphases in the specific objectives and learning outcomes emerge.

The first major gap includes the presence of a curriculum emphasis or emphases in the learning outcomes and absence in the specific objectives, and the second type of gap is the presence of an emphasis in the specific objectives while being absent in the learning outcomes. It is possible for both types of gaps to exist in one topic, or for a topic to display one type of gap. For example, with *Population and Natural Environment*, the highlighted shading indicates that the emphases Everyday Coping is present in the specific objectives but absent in the learning outcomes. Whereas the emphases Science, Technology, and Decisions, Correct Explanations and Solid Foundation are present in the learning outcomes but absent in the specific objectives. In another example *Measurement*, the shading for Solid Foundation, Everyday Coping, Science in Application, and Scientific Skill Development indicates that these emphases are identified for the specific objectives and learning outcomes while the emphasis Science in Making is only emphasised in the learning outcomes.

While the discussion has identified the degree of alignment of specific objectives and learning outcomes, it is possible to calculate the total number of inclusions for each of the curriculum emphases (see Figure 4.1). These are determined by adding the frequencies of the individual curriculum emphasis provided in different topics in Table 4.2.

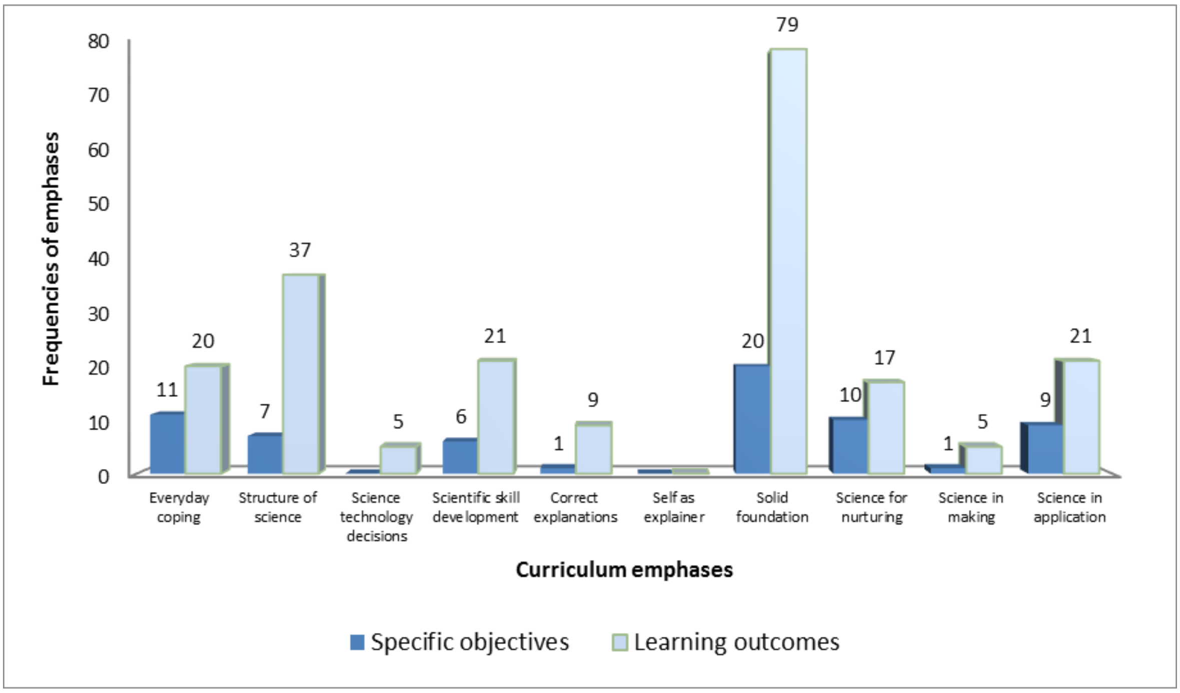

Figure 4.1: Frequencies of Curriculum Emphases in the Specific Objectives and Learning outcomes

The data demonstrates that among the non-real-life emphases, Structure of Science, Scientific Skill Development, Correct Explanations, Self as Explainer, and Solid Foundation greater inclusion has been given to Solid Foundation in the specific objectives (f = 79) and learning outcomes (f = 20) followed by the Structure of Science (*f* = 7, and *f* = 37 respectively). The real-life emphases Everyday Coping, Science, Technology, and Decisions, Science for Nurturing, Science in Making, and Science in Application in terms of frequencies are addressed rarely in the curriculum in comparison with Solid Foundation, which is a non-real-life emphasis.

Another way of representing the curriculum emphases in Figure 4.1 around the specific objectives and learning outcomes in the curriculum is in relation to the real-life and non-real-life aspects of curriculum emphases. The frequencies for the non-real-life and real-life aspects of the curriculum emphases in the specific objectives and learning outcomes for Grade VI are presented in Table 4.3.

Table 4.3: Frequencies of Non-Real-life vs. Real-life Aspects of Curriculum Emphases

Emphases	Specific objectives (*f*)	Learning outcomes (*f*)
Non-real-life aspects	34	146
Real-life related aspects	31	68

These data reveal that marginally more emphasis has been placed on the non-real-life aspects in the specific objectives of the Grade VI curriculum. On the other hand, in the learning outcomes more than double emphasis has been given to the non-real-life aspects of the curriculum emphases than to the real-life related aspects.

Overall, the mapping of Grade VI curriculum demonstrates that there is a greater emphasis particularly in the learning outcomes of the curriculum on pure science content. While the curriculum acknowledges the importance of real-life emphases, the data demonstrate that the degree to which these are articulated in the specific objectives and learning outcomes is minimal and inconsistent on the basis of the frequencies of the real-life curriculum emphases. Results from the mapping also suggest that real-life aspects are addressed more readily in the specific objectives and learning outcomes in Biological topics than in other science subject areas.

4.3.2 Mapping Grade VII.

Within the Grade VII JSSC there are twenty-three topics. Using the same process as applied in Grade VI curriculum, the curriculum emphases across the specific objectives and learning outcomes are summarised in Table 4.4.

Looking at Table 4.4 it appears from the shading that with the exception of Solid Foundation, the majority of topics include different combinations of curriculum emphases in the specific objectives and learning outcomes. For example, one Physics topic (i.e. *Heat*) includes the real-life emphases of Everyday Coping, Science in Making, and Science in Application in the specific objectives and learning outcomes. In another topic (i.e., *Electricity*) Science in Making and Science in Application are emphasised in the specific objectives and learning outcomes, but Everyday Coping is focused on only in the specific objectives. Similarly, Science for Nurturing, Everyday Coping and Science in Application are addressed in one Chemistry-related topic (i.e., *Oxygen*) in the specific objectives and learning outcomes, while another Biology-related topic (i.e. *Microbial World*) includes Science for Nurturing only in the learning outcomes with Everyday Coping and Science in Application in the specific objectives and learning outcomes.

The analysis around topics demonstrates that Science in Application is a focus in the specific objectives and learning outcomes for five Physics topics, three Chemistry topics, and in a single Biology and Geography topic. Everyday Coping is addressed in the specific objectives and learning outcomes of one topic for Physics, Chemistry, and Geography, and in two Biology topics. Even less emphasis is on Science for Nurturing and Science in Making in the topics of the curriculum. The Structure of Science and Scientific Skill Development are identified in the specific objectives of one topic and in the learning outcomes of all five Physics topics. Out of six topics in Chemistry

Table 4.4: Emphases in Grade VII curriculum

Curriculum emphases	**Chapter →**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Everyday Coping (EC)	SOs	2*	1	1	1					2				1	1	2								1
	Los	1*		1	1					3									1					4
Structure of Science (SS)	SOs		1		1	1	1																	
	Los	7	2	1	1			1	6		3			1	1	1	1	2		1				
Science, Technology, and Discisions (STD)	SOs																							
	Los																							5
Scientific Skill Development (SSD)	SOs	1																		1	1			1
	Los	2	2	1	2	2	4	1	1					1						4	1			2
Correct Explantation (CE)	SOs																							
	Los					1		3	1	1		1	1											1
Self as Explainer (SE)	SOs																							
	Los																							
Solid Foundation (SF)	SOs	3	1	2	1	1	1	1	3	4	2	1	1	4	2	2	1	3	1	1	1	1	1	1
	Los	7	3	5	3	3	2	4	12	7	2	9	3	8	3	3	4	5	10	4	3	2	7	6
Science for Nurturing (SN)	SOs				1							1												2
	Los				1					1			1	1				1						
Science in Making (SM)	SOs	1														2								
	Los	2		2												2								
Science in Application (SA)	SOs	1	2	1	1	1	1			2				1	1	2								
	Los	5	1	2	2	1	1	1		3				2	1	2			1					
	Topic name →	Heat	Pressure of a Liquid	Atmosphere	Oxygen	Hydrogen	Carbon dioxide	Solution	Morphology of Plants [Leaf, Stem, Flower and Fruit]	Microbial World	Animal Kingdom	Interdependency of plants and Animals	The Vertebrates	Light	Magnetism	Electricity	Earth Crust and Rock	Sea and Ocean	Weather and Climate	Common Laboratory Processes	Production of Essential Goods from Discarded Raw Materials	Tissue	Human Body: Digestive and Excretory System	Population Growth and Environmental Pollution

*Frequency of corresponding curriculum emphasis

Structure of Science is focussed in the specific objectives of three topics and in the learning outcomes of five topics, and Scientific Skill Development is addressed in the specific objectives of one topic, and in the learning outcomes of all six topics.

Out of the twenty-three topics, real-life emphases are absent in the specific objectives and learning outcomes for seven topics. These included four Biology topics (i.e., *Morphology of Plants*, *Animal Kingdom, Tissue, and Human Body: Digestive and Excretory System*), two Chemistry topics (i.e., *Common Laboratory Process, Production of Essential Goods from Discarded Raw Materials*), and one Geography topic (i.e. *Earth Crust and Rock*).

Given that, the learning outcomes of the curriculum are based on the specific objectives, it might be expected that curriculum emphases present in the specific objectives be demonstrated in the learning outcomes for the same topic. However, major inconsistencies occur across the curriculum emphases. The data in Table 4.4 reveal that out of twenty-three topics available in the curriculum, only three topics highlighted the same curriculum emphases for the specific objectives and learning outcomes. These topics were *Production of Essential Goods from Discarded Raw Materials* (two emphases), *Tissue, and Human body: Digestive and Excretory System* (one emphasis) (see Table 4.4). Hence, there are no gaps identified with curriculum alignment between the specific objectives and learning outcomes of the above mentioned topics in relation to the curriculum emphases.

However, for the remaining topics in the Grade VII JSSC, two types of gaps appear between the specific objectives and learning outcomes. The first type of gap emerges when a curriculum emphasis (or emphases) associated with the specific objectives is missing in the learning outcomes for the same topic. In the second type of gap the curriculum emphasis is evident in learning outcomes but lacking in the specific objectives. These gaps could be in one topic or in separate topics. For example, with *Magnetism, Solid Foundation* and Science in Application emphases are identifiable in the specific objectives and learning outcomes, while Everyday Coping is present in the specific objectives but missing in the learning outcomes. In contrast, the emphasis Structure of Science appears in the learning outcomes but absent in the specific objectives.

Calculating the frequencies for each of the curriculum emphases from Table 4.4 (see Figure 4.2) shows that Solid Foundation (*f* = 115) is highly emphasised (Figure 4.2) in the specific objectives and learning outcomes of the curriculum in comparison to all other emphases. The emphases Science Technology Decisions and Correct Explanations are ignored in the specific objectives with no representation of Self as Explainer in the Grade VII JSSC.

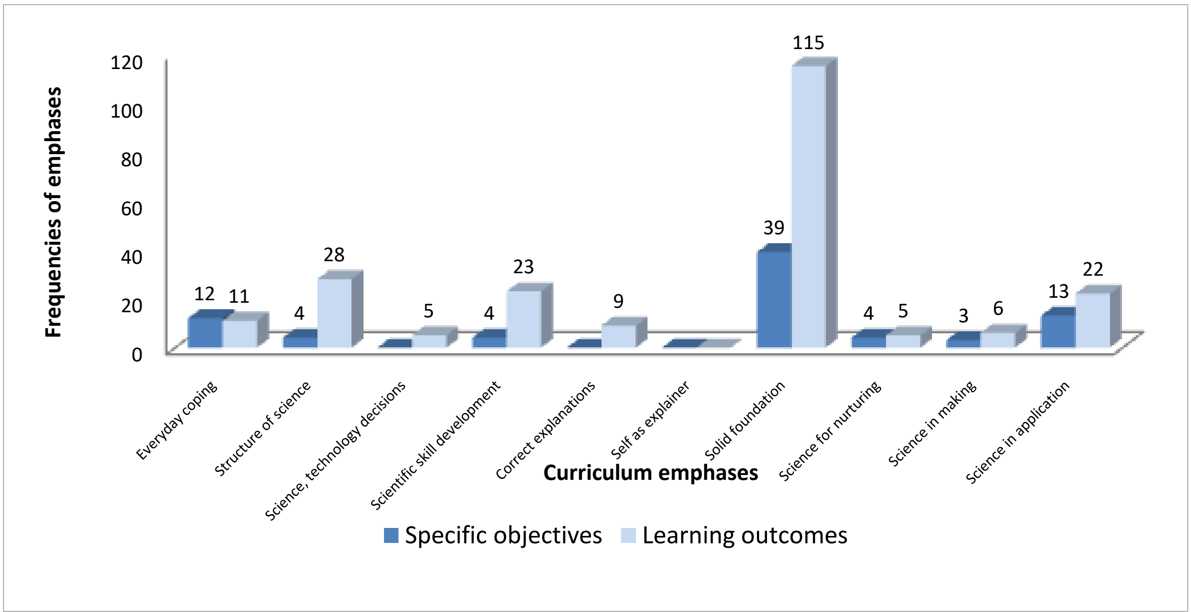

Figure 4.2: Frequencies of Curriculum Emphases in the Specific Objectives and Learning outcomes

Comparing the specific objectives and learning outcomes of the Grade VII JSSC in relation to the frequencies in the real-life and non-real-life aspects of emphases (see

Table 4.5) demonstrates that non-real-life emphases are addressed more frequently in the specific objectives (*f* = 47) and learning outcomes (*f* = 175) of the curriculum than real-life emphases in the specific objectives (*f* = 32) and learning outcomes (*f* = 49). Moreover, the differences in frequencies between the non-real-life emphases and real-life emphases for specific objectives and learning outcomes are half as great and more than three times respectively. Subsequently, the Grade VII JSSC indicates an excessive concentration on non-real-life emphases over real-life aspects.

Table 4.5: Frequencies of Non-Real-Life vs. Real-life Aspects of Curriculum Emphases

Emphases	Specific objectives (*f*)	Learning outcomes (*f*)
Non-real-life aspects	47	175
Real-life related aspects	32	49

In summary, the outcomes of the Grade VII JSSC mapping highlights greater emphasis on pure science content (i.e. "Solid Foundation”) in the specific objectives and learning outcomes of the curriculum. Even though the curriculum states the importance of the real-life emphases, the data demonstrate that the degree of articulation of these emphases in the specific objectives and learning outcomes is minimal and inconsistent on the basis of real-life curriculum emphases. Mapping of the Grade VII curriculum suggests that real-life aspects are addressed more readily in Physics topics than other subject areas of science.

4.3.3 Mapping Grade VIII.

There are twenty-five topics in Grade VIII JSSC. The summary of the frequencies of the curriculum emphases in the specific objectives and learning outcomes for these topics is presented in Table 4.6. As in Grades VI and VII the same process is applied to map the curriculum.

Table 4.6: Emphases in Grade VIII Curriculum

Curriculum emphases	**Chapter →**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
Everyday Coping (EC)	SOs				2*		1					1					1	1						1	1	1
	LOs				1*		1					1			1			1					2	5	1	2
Structure of Science (SS)	SOs							1	1	1									1							
	LOs					1		3	1	2				2	1		1	1	3	1	5					
Science, Technology, and Discisions (STD)	SOs																									1
	LOs																								3	1
Scientific Skill Development (SSD)	SOs			1	3					1			1	1	1	1	1			1	1				1	
	LOs			3	3								1	3	1	3				1					1	
Correct Explantation (CE)	SOs																									
	LOs	1	1					1	1						2	1	2	1	1				1	1		
Self as Explainer (SE)	SOs																									
	LOs																									
Solid Foundation (SF)	SOs	3	2	2	2	1	2	2	1	2	2	1	1	1	2		2	4	1	3	2	1	3	1	1	1
	LOs	6	8	7	1	3	2	5	1	2	3	1	5	7	5		6	9	2	7	2	3	21	6	1	2
Science for Nurturing (SN)	SOs										1	2											2	1	2	
	LOs							2		1	2	3			1								4	3	1	1
Science in Making (SM)	SOs				1																					
	LOs						1									1	1			1						1
Science in Application (SA)	SOs				2		1	1				1		1			1	1	1	1		1				1
	LOs				2		5	1				2	2	1	2		3	1		4	1					5
Topic names	→	Structure of Matter- Atom and Molecule	Symbol, Formula and Valency	Chemical Reaction and Equation	Measurement	Gravitation and Gravity	Simple Machines	Plant Morphology: Fruit, Seed and Germination of Seed	Flowering Plant: Chili Plant	Living Organisms and their Environment	Forest and Environment	Energy, Living being and Natural Resources	Earth' s Motion: Time and Season Change	Acids, bases and Salts	Hardness of Water	Common Laboratory Process	Heat	Sound	Refraction of Light	Electricity	Vertebrate Animal - Fowl	Cell Division	Human Body:- Blood Circulation, Respiration and Nervous system	Some Common Diseases	Population and Environment	Science and Technology in Everyday Life

*Frequency of corresponding curriculum emphasis

The shadings in Table 4.6 demonstrate that twenty-four out of twenty-five topics address the Solid Foundation emphasis in the specific objectives and learning outcomes. With this exception, the majority of the topics comprised different combinations of curriculum emphases in the specific objectives and learning outcomes. For example, two Biology topics (i.e., *Some Common Diseases*, and *Population and Environment*) incorporated Everyday Coping and Science for Nurturing, and in addition to these emphases another Biology topic (*i.e., Energy Living Being and Natural Resources*) included Science in Application in the specific objectives and learning outcomes. The Chemistry topic, *Hardness of Water* addresses Everyday Coping, Science for Nurturing, and Science in Application only in the learning outcomes. Three Physics topics (i.e., *Measurement*, *Simple Machines*, and *Sound*) encompassed the emphases Everyday Coping and Science in Application in the specific objectives and learning outcomes. Interestingly, of all these topics Science in Making is incorporated only in the specific objectives of *Measurement*, and in the learning outcomes of *Simple Machines*.

Mapping topics indicate that Everyday Coping is addressed in the specific objectives and learning outcomes for three Physics topics, three Biology topics, and in a single Technology topic. Science in Application is focused in the specific objectives and learning outcomes for five Physics topics, two Biology topics and in a single Chemistry and Technology topic. However, this emphasis is present only in the learning outcomes of a single Geography, Chemistry, and Biology topic and only in the specific objectives for a Biology topic. Science for Nurturing is identified in the specific objectives and learning outcomes of five (out of the ten) Biology topics and in the learning outcomes of two Biology, one Chemistry, and one Technology topic. In contrast, a limited and inconsistent emphasis is on Science in Making, in the specific objectives or in the learning outcomes of four Physics and one Chemistry topic with narrow representation of Science, Technology, and Decisions.

Out of the twenty-five topics, real-life emphases are absent in the specific objectives and learning outcomes of five topics. These include three Chemistry topics (*Structure of Matter- Atom and Molecule, and Symbol*, *Formula and Valence*, and *Chemical Reaction and Equation*), one Physics topic (*Gravitation and Gravity*), and one Biology topic (*Flowering Plant: Chili Plant*). Within these topics there is a concentration upon Solid Foundation.

In terms of the overall pattern, real-life emphases of Everyday Coping, Science in Application, and Science for Nurturing are targeted in the specific objectives and learning outcomes of the curriculum. The Everyday Coping and Science in Application are addressed more readily with Physics and Biology topics. Science for Nurturing is focused mainly in Biology topics. It is a matter of concern that in five topics real-life emphases are completely absent in the Grade VIII curriculum.

As with the JSSC for younger students, the curriculum emphases in the specific objectives should be represented in the learning outcomes for the same topic. However, data in Table 4.6 suggests that only three out of the twenty-five topics represented curriculum emphases in the specific objectives and learning outcomes. These topics include *Chemical Reaction and Equation* (two emphases), *Forest and Environment* (two emphases), and *Energy, Living Being and Natural Resources* (four emphases) (see Table 4.6).

Inconsistency in the curriculum emphases between the specific objectives and learning outcomes occurred in the remaining twenty-two topics (i.e. out of the twenty five) with two types of gaps apparent. For instance, both gaps exist for *Heat*, where Everyday Coping and Scientific Skill Development are present in the specific objectives but absent in the learning outcomes. In contrast, the emphases Structure of Science, Correct Explanations, and Science in Making are evident in the learning outcomes but are lacking in the specific objectives. In another topic *Plant Morphology*, Correct

Explanations and Science for Nurturing are present in the learning outcomes but absent in the specific objectives.

The total number of inclusions of each of the curriculum emphases in the specific objectives and learning outcomes are calculated from Table 4.6 (see Figure 4.3) These data reveal that Solid Foundation is highly emphasised in the specific objectives (f = 43) and learning outcomes (f = 115) of the curriculum more than all other real-life and non-real-life emphases. No emphasis has been given for Correct Explanations in the specific objectives, and Self as Explainer is totally neglected both in the specific objectives and learning outcomes. Among the real-life curriculum emphases, more emphasis has given on Science in Application in the specific objectives and learning outcomes than other real-life curriculum emphases.

the specific objectives and learning outcomes than other real-life curriculum emphases.

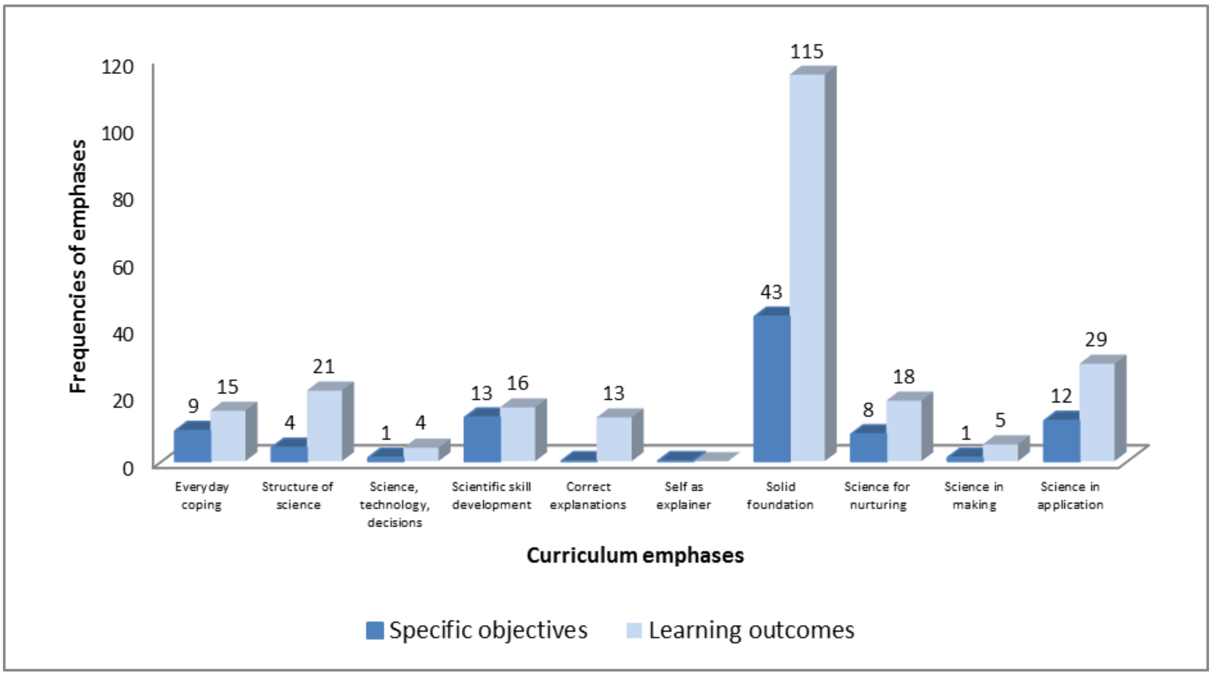

Figure 4.3: Frequencies of Curriculum Emphases in the Specific Objectives and Learning Outcomes

In order to consider the alignment of the specific objectives and learning outcomes of the curriculum in relation to non-real-life and real-life emphases, the frequencies of emphases, as identified in Figure 4.3, were used to generate the data in Table 4.7.

Table 4.7: Frequencies of Non-Real-Life versus Real-Life Aspects of Curriculum Emphases

Emphases	Specific objectives (*f*)	Learning outcomes (*f*)
Non-real-life aspects	60	165
Real-life related aspects	31	71

These data illustrate that the differences in frequencies between the non- real-life aspects and real-life aspects are nearly double for specific objectives and more than double for the learning outcomes. Representation of these incidences demonstrates an obvious concentration in the Grade VIII JSSC on non-real-life aspects in comparison to real-life aspects of the curriculum.

Results for the Grade VIII curriculum demonstrate greater focus on the pure science content (i.e. Solid Foundation) across the specific objectives and learning outcomes of the curriculum. As with the other year levels, this curriculum claims real-life emphases are supposedly important in the curriculum but a high degree of inconsistency is evident. Results of the analysis of the Grade VIII JSSC suggest that real-life aspects are addressed more readily in Biology and Physics topics than other areas of science.

4.4 Summary

In this chapter an analysis of the Grades VI to VIII JSSC Bangladesh is conducted thereby addressing:

RQ 1. To what extent is the junior secondary science curriculum in Bangladesh real-life oriented?

Mapping of the Grades VI, VII, and VIII curricula suggest that greater emphasis is placed around pure science content in both the specific objectives and learning outcomes for all grades with limited connections evident to real-life. A mismatch between the curriculum emphases is identified across the specific objectives and learning outcomes in topic areas in all grades. Real-life aspects are addressed more readily in Biology topics in Grades VI, Physics topics in Grade VII, and Physics and Biology topics in Grade VIII. Real-life curriculum emphases are absent in the specific objectives and learning outcomes of some topics in all three curricula for each grade level. These results serve as a basis to explore the curriculum emphases in the junior secondary science textbooks published by NCTB in 1997.

Chapter 5
Analysis of Textbook Content

5.1 Introduction

The previous chapter explored the relationship between junior secondary science curriculum (JSSC) and real-life situations by analyzing the curriculum emphases of the specific objectives and learning outcomes. This chapter presents a content analysis of the junior secondary science textbooks (Grades VI to VIII, Bangladesh). It was mentioned earlier in Chapter 2 that in Bangladesh, both the JSSC and science textbooks are developed by the National Curriculum and Textbook Board. Science textbooks are prepared based on the specific objectives and learning outcomes of the JSSC. Therefore, the same analytical framework as explained previously in Chapter 3 has been used for identifying the curriculum emphases in the textbooks. The purpose of textbook analysis is to address the following research question:

> RQ 2. To what extent are the science textbooks in Bangladesh real-life oriented?

In the first section of this chapter, an overview of the curriculum emphases in the General Science textbooks is highlighted. The following sections present the process of determining the frequency of emphases around content of the textbook topics and mapping of curriculum emphases in the textbook topics for each grade. At the completion of analyzing the topics of each textbook, a comparison between the intended curriculum and implemented curriculum - which is the textbook, is provided in terms of the curriculum emphases. These comparative analyses will indicate how the science textbooks are orientated and how the textbooks realize the outcomes of the intended JSSC as represented by the specific objectives and learning outcomes.

5.2 Overview of Curriculum Emphases in the General Science Textbooks

In this section a summary of the mapping of the curriculum emphases across the content of Grade VI to VIII General Science textbooks is presented, as exhibited in Table 5.1.

Table 5.1: Mapping of Curricular Emphases across Textbooks Grades VI to VIII

Curriculum emphases	Grade VI	Grade VII	Grade VIII
Everyday Coping (EC)	✓	✓	✓
Structure of Science (SS)	✓	✓	✓
Science, Technology, and Decisions (STD)	✓	✓	✓
Scientific Skill Development (SSD)	✓	✓	✓
Correct Explanations (CE)	-	✓	✓
Self as Explainer (SE)	-	-	-
Solid Foundation (SF)	✓	✓	✓
Science for Nurturing (SN)	✓	✓	✓
Science in Making (SM)	✓	✓	✓
Science in Application (SA)	✓	✓	✓

Table 5.1 indicates that, with two exceptions, most emphases were addressed in the content of the textbooks. It is noted that the curriculum emphases Correct Explanations is missing in the content of Grade VI textbook while Self as Explainer is not represented in any of the textbook content.

With this overview of the curriculum emphases in the textbooks, the next section presents an example of the process of determining frequencies of the curriculum emphases from the topics of textbook content.

5.3 Determining Frequencies of the Emphases around Content

This section uses examples of text passages to explain how the curriculum emphases were assigned to create the frequencies for the textbook content. Following the definitions of the curriculum emphases in the analytical framework and, by reading the content of the topic *Measurement* in the Grade VI textbook, the frequency for Everyday Coping emphasis was assigned as three. This indicates that three occurrences of Everyday Coping emphases were identified for the *Measurement* topic in the textbook. These three examples are discussed below.

Example 1: Units of measurement

> *Measure the length of a bench in your school by your forearm. Suppose the length is equal to four forearms. What does this mean? It means that the length of the bench is four times the length of your forearm. The length of your forearm is known. Hence the unit of length in comparison to which an unknown length is measured is called a unit of length. ... A convenient fixed length is taken as a standard to measure length; a convenient fixed mass is taken as a standard to measure mass, and a convenient fixed time is taken as a standard to measure time* (Shamsudduha, Miah, Wahab, & Khan, 1997, p. 2).

In explaining the units of *Measurement* in the textbook, instruction is given to the students to measure the length of a bench with their forearm even though meters are recognised and used as a standard unit of length in science. Certainly, this instruction may give the idea that anything of a suitable fixed length (e.g., a stick, or forearm), can be used as a standard unit for measuring the length of an unknown object as an alternative to the meter scale to serve the purpose for measuring in everyday life. Although the above excerpt is not scientifically accurate according to conventions of science it was coded as an example of Everyday Coping, as the general principle of a standard unit of length is being applied. Therefore, this excerpt represents first of the three occurrences of Everyday Coping emphasis for the topic *Measurement* in the Grade VI textbook (refer to Table 5.2, page no. 157).

Example 2: Historical background

> *Various units of measurement were used in different countries in different ages. About 5000 years ago the Egyptians used to measure length by [the] forearm. The length of the arm from elbow to the tip of the middle finger was taken as one cubit. This procedure is still in practice in some places. Occasionally this is used in our country also. …The Romans or the English used breadth of a thumb of an adult as one inch and the length of a foot as one foot (which is nearly equal to 12 inches)… the length of the tip of the nose to the tip of the middle finger was taken as one yard. But this kind of human body measurement based on some specific parts of a human body cannot be accurate because lengths of all human bodies are not equal. ... For measuring rice, paddy etc., cane bowls of a certain size are sometimes used in our country. Again coins of various denominations are used to weigh gold and silver. Such as a coin of one taka is taken as weight of one tola* [one kind of unit used in some places in Bangladesh]*… an approximate calculation of time can be made from the observation of the position and length of a shadow. But this is not very accurate especially during night and cloudy days. ... Therefore for accurate measurement, [a] unit should be such that it does not depend upon any particular person or time. Its value should be the same in all times.* (Shamsudduha, Miah, Wahab, & Khan, 1997, p. 3)

It is important to note that the textbook passage above illustrates how different kinds of units of measurement based on some parts of the human body, certain size and mass of objects, and position and length of a shadow for measuring length, mass, and time respectively are still in practice in many countries, including Bangladesh. Therefore, it might be expected that in some places like Bangladesh people have experience in using these measurement processes while in other places, especially in big cities, they use more scientific methods for measurement. However, it could be argued that sometimes it is not necessary to measure things accurately allowing an opportunity for other methods of measurement to be used. For example, if one kilogram of sugar is required for cooking, usually a weighing machine can be used. If the weighing machine is not readily available, any container equivalent to holding one kilogram can be used to measure approximately one-kilogram sugar. In this case, the mass of sugar might not be exactly one kilogram. It can be a little more or less than one kilogram, but the purpose of measurement can be fulfilled with this container allowing individuals to measure sugar using an alternative method. But, to buy one kilogram of sugar, money has to be paid. In this case a weighing machine for accurate measurement will be needed, because slight variations in the mass of sugar results in variations in the amount of money to be paid. Therefore, depending on the situation one has to decide what measurement system is most appropriate to meet the purpose. The above text passage encourages the use of accurate systems of measurement, which are acceptable across the globe. However, the examples of measuring processes described in Example 2 are still in practice in some parts of Bangladesh consequently, understanding approximate measurements is also useful for the students to appreciate diverse measuring processes. Considering this, the entire text was coded as Everyday Coping resulting in second occurrences of Everyday Coping for the topic, *Measurement* (see Table 5.2, page 157)

Example 3

> *In measurement [the] use of various systems of units causes inconvenience. As for example, you go to a shop and ask for 10 kilograms of rice and another person asks for 20 pounds of rice. In this situation the shopkeeper has to have two sets of weights. The prices have to be set in two ways. The shopkeeper should know the relation between a kilogram and a pound. Again say a businessman wants to import cloth from a foreign country. He wants to buy in yards. The foreigners say that they do not know yard[s]. They sell cloth in meters. If only a single system of units is used in all countries, there will be no such inconvenience. All the scientists of the world who met in a session in the city of Paris, in France in 1968, agreed to introduce a single system for all countries. It is known as system international or briefly S.I. … In S.I. … units resemble MKS [meter, kilogram, second units]…. Now-a-days … [S.I. units in science are] used all over the world. It is specifically used in scientific works. This system has also been introduced in Bangladesh.* (Shamsudduha, Miah, Wahab, & Khan, 1997, p. 4)

The above paragraph provides examples of the disadvantages of using various systems of units and the advantage of using a single metric system of units or S.I. units for measurement. This explanation helps students to learn and deal with S.I. units and measuring processes that can be applied in science anywhere in the world. However, knowing different kinds of measuring systems for different places can help in coping with buying, selling or measuring things. Therefore, this whole text was coded as Everyday Coping and contributed third occurrence of three frequencies (in total) in Table 5.2.

Thus, from these excerpts three occurrences for Everyday Coping were allocated for the topic *Measurement* in Table 5.2. The data in Table 5.2 for other curriculum emphases were derived in the same way. The following sections describe the mapping of ten curriculum emphases with their frequencies for each topic in the science textbooks for Grades VI to VIII.

5.4 Curriculum Emphases in the Topics of General Science Textbooks

Mapping of the ten curriculum emphases with their frequencies for each topic of the textbooks of Grades VI to VIII are presented in the following subsections.

5.4.1 Mapping of Grade VI.

The Grade VI General Science textbook included twenty topics covering a range of areas, i.e., Physics, Chemistry, Biology, and Geography (Shamsudduha, Miah, Wahab, & Khan, 1997). The frequencies in relation to the curriculum emphases in the content of each topic are presented in Table 5.2. As in Chapter 4, different colours are used to highlight the pattern of curriculum emphasis within the textbook content associated with the curriculum emphases. The real-life emphases in the left column are

Table 5.2: Emphases in Grade VI Textbook

Chapter → / Emphases ↓	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Everyday Coping (EC)	3*		1	3	4				2			1			1		1	4		1
Structure of Science (SS)			1	3	1	10	4	11	9	6	8	5	3	4	4	2		1	2	
Science, Technology, and Decisions (STD)											1								5	
Scientific Skill Development (SSD)	3	3	2		1		1	1		1	1	3	3						2	
Correct Explantation (CE)																				
Self as Explainer (SE)																				
Solid Foundation (SF)	4	3	1	5	1	2	4	3	6	3	1	3	2	7	3	9	5	3	3	3
Science for Nurturing (SN)			3		5			2							1	1	3	5	1	2
Science in Making (SM)	1								1			1	1							
Science in Application (SA)	3		2	5	1			2	2			1	1		1		2	1		
Topic name →	Measurement	Matters	Air	Metal and Non-metal	Water	Living World	Cell	Plant Kingdom	Morphology of Plants	Force, Pressure and Motion	Work, Power and Energy	Electric Energy	Magnetic Energy	Surface of the Earth	Features of Inverteb-rate Animals: Shrimp	Human Body: Skin, Muscle and Bones (Skeleton)	Health Rules: Skin Diseases	Food and Nutrition	Population and Natural Environment	An Introduction to AIDS

*Frequency of corresponding curriculum emphasis

shaded in grey with particular colours used to highlight each curriculum emphasis across the textbook content for a topic. As such, the gaps of curriculum emphases are evident clearly in the topics. The numbers in the table indicate the frequency for each emphasis for the topics identified in the textbook.

It appears in Table 5.2 that all of the topics in the textbook content addressed the emphasis of Solid Foundation while the Structure of Science was identified in sixteen of the twenty topics. The real-life emphases of Everyday Coping were represented in ten topics, Science for Nurturing in nine topics, and Science in Application in eleven topics. In contrast, limited emphases were evident for Science, Technology, and Decisions and Science in Making in Grade VI curriculum. It is interesting to note that the emphases Correct Explanations and Self as Explainer were not addressed in any topic in the textbook.

In focusing on the actual topics in the textbook, it is evident that the content addresses different combinations of curriculum emphases related to real-life. Such combinations can be linked to different subject areas. For example, Everyday Coping, Science for Nurturing, and Science in Application appeared in the textbook content for two Chemistry topics (i.e., *Air*, *Water*) and three Biology topics (i.e., *Features of Invertebrate Animals: Shrimp*, *Health Rules: Skin Diseases*, *Food and Nutrition*). Everyday Coping, Science in Making, and Science in Application were addressed in two Physics topics (i.e. *Measurement*, and *Electric Energy*) and one Biology topic (i.e. *Morphology of Plants*).

Looking at the pink, green and yellow shadings in Table 5.2, it appears that Everyday Coping, Science for Nurturing, and Science in Application were given more prominence in the content of Biology topics than in other areas of science. Out of the ten topics in Biology, Everyday Coping were addressed in the content of five, Science for Nurturing in seven, and Science in Application in five topics. On the other hand, out of the four Chemistry topics, Everyday Coping appeared in the content of three topics, Science for Nurturing in two topics and Science in Application in three topics. Of the six Physics topics, Everyday Coping was featured in two topics, Science in Application in two topics, and Science in Making in three topics. Of the twenty topics in the textbook, real-life emphases were absent in the content of five topics: *Matters* (related to Chemistry), *Living World*, and *Cell* (related to Biology), *Force, Pressure and Motion* (related to Physics) and *Surface of the Earth* (related to Geography).

It was noted earlier that Solid Foundation was addressed in every topic. However, the calculated values of the total number of occurrences (Figure 5.1) for each of the curriculum emphases in the textbook topics (determined from Table 5.2) illustrates that in the textbook content, key emphasis was given to the Structure of Science (*f* = 74) followed by Solid Foundation (*f* = 71). A similar emphasis occurred for Everyday Coping (*f* = 21), Scientific Skill Development (*f* = 21), Science for Nurturing (*f* = 23), and Science in Application (*f* = 21). In contrast, limited emphasis was identified for Science, Technology, and Decisions (*f* = 6) and Science in Making (*f* = 4).

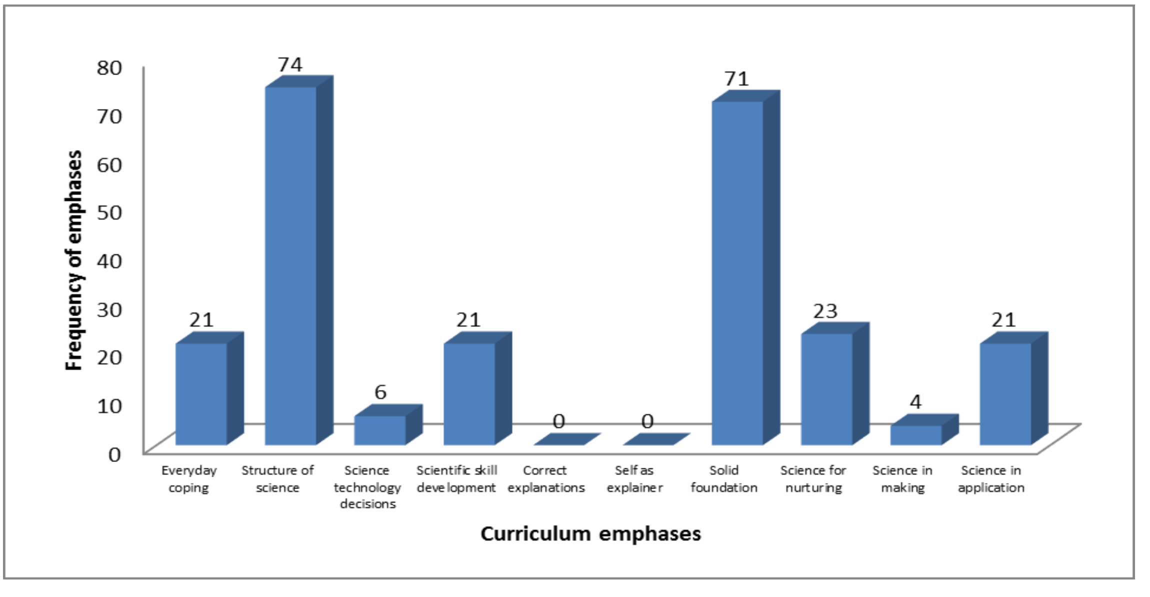

Figure 5.1: Curriculum Emphases in Grade VI Textbook Content

The frequencies in Figure 5.1 in relation to real-life and non-real-life emphases (see Table 5.3) highlight that the non-real-life emphases (*f* = 166) got more preference in the textbook content with more than double the frequency of real-life emphases (*f* = 75). This result suggests that in Grade VI textbook, a greater preference was placed on pure science content over their connection with real-life aspects.

Table 5.3: Frequencies of Non-Real-Life vs. Real-Life Aspects of Curriculum Emphases

Emphases	Textbook content (*f*)
Non-real-life aspects	166
Real-life related aspects	75

5.4.2 Comparison of intended and implemented curriculum: Grade VI.

Mapping of the Grade VI textbook topics in Table 5.2 provides the overall picture of how the curriculum emphases are focused in the content. Given that the textbook is the pseudo-curriculum for teachers, i.e. the guide for teachers about what they will actually teach. It was important to explore the emphases among the topics of the intended curriculum, and the textbook content to consider the similarities and differences in emphases between the intended and the implemented curriculum. Table 5.4 shows the existence of curriculum emphases in the specific objectives, learning outcomes, and in the textbook content with frequencies following the same method of counting frequencies as followed in Table 5.2. It has been mentioned earlier in Chapter 2 (Section 2.3) that after publishing the 1995 JSSC the corresponding textbooks of Grades VI to VIII were revised from time to time but the curriculum was not revised. As a result, one new topic, namely, *An Introduction to AIDS,* was included in the revised textbook (reprinted in 2010) of Grade VI; this topic was not in the Grade VI JSSC published in 1995. Therefore, the number of frequencies of the curriculum emphases in the specific objectives and learning outcomes for this topic could not be added into Table 5.4.

Table 5.4 illustrates that in terms of curriculum emphases a number of similar features were evident between the specific objectives and learning outcomes of the Grade VI JSSC and content of the textbook topics:

1. The specific objectives and learning outcomes of the curriculum along with the majority of the topics in the textbook had a focus on the Solid Foundation emphasis.
2. Self as Explainer was absent in the textbook content and in the curriculum.
3. The content of some of the textbook topics addressed a similar combination of curriculum emphases as in the specific objectives and/or learning outcomes. For example, the textbook content addressed Everyday Coping, Scientific Skill Development, Solid Foundation, Science in Making, and Science in Application in the topic *Measurement.* Similarly, in the topic *Health Rules* Everyday Coping, Solid Foundation, Science for Nurturing, and Science in Application were focused in the textbook content as were the specific objectives and learning outcomes.
4. In both the curriculum and textbook, Biology topics addressed real-life emphases more than the topics of other science subject areas.
5. Real-life emphases were not addressed in the curriculum and in the textbook content for the topics *Matters; Living World; Cell; Force, Pressure and Motion; and Surface of the Earth*.
6. The specific objectives and learning outcomes of the curriculum, and textbook content demonstrate that in both documents greater emphasis was given to non-real-life emphases (i.e. pure science content) rather than linking science to real-life emphases (see Table 5.5).

Table 5.4: Emphases in Grade VI Curriculum and Textbook Content

Curriculum emphases	**Chapter →**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Everyday Coping (EC)	SOs	1*		1		1			1	1			1	1		1		1	1	1	
	LOs	1*		1	4	4			1	2			1	1		1		2	3		
	Textbook	3*		1	3	4				2			1			1		1	4		1
Structure of Science (SS)	SOs			1		1	2	1	1			1									
	LOs				3	2	2	2	11	3	2	5	2	1	2		2				
	Textbook			1	3	1	10	4	11	9	6	8	5	3	4	4	2		1	2	
Science, Technology, and Decisions (STD)	SOs																				
	LOs																			5	
	Textbook											1								5	
Scientific Skill Development (SSD)	SOs	1			1		1	1											1	1	
	LOs	3	3	2	1		3	1		1	1			2					1	3	
	Textbook	3	3	2		1		1	1		1	1	3	3						2	
Correct Explanation (CE)	SOs						1														
	LOs			1			1			2							1		3	1	
	Textbook																				
Self as Explainer (SE)	SOs																				
	LOs																				
	Textbook																				
Solid Foundation (SF)	SOs	1	1		1	1		1	1	1	2	1	2	1	2	1	2	1	1		
	LOs	5	3	2	3	1	6	4	8	6	5	2	4	4	8	4	7	2	2	3	
	Textbook	4	3	1	5	1	2	4	3	6	3	1	3	2	7	3	9	5	3	3	3
Science for Nurturing (SN)	SOs			2		1			1	1						1		1	1	2	
	LOs			2		5			1	1						1		3	3	1	
	Textbook			3		5			2							1	1	3	5	1	2
Science in Making (SM)	SOs													1							
	LOs	1			1					1			1	1							
	Textbook	1								1			1	1							
Science in Application (SA)	SOs	1		1		1			1	1				1		1		1	1		
	LOs	1		2	5	2			2	2			2	1		1		1	2		
	Textbook	3		2	5	1			2	2			1	1		1		2	1		
	Topic names →	Measurement	Matters	Air	Metal and Non-metal	Water	Living World	Cell	Plant Kingdom	Morphology of Plants	Force, Pressure and Motion	Work, Power and Energy	Electric Energy	Magnetic Energy	Surface of the Earth	Features of Invertebrate Animals: Shrimp	Human Body: Skin, Muscle and Bones (Skeleton)	Health Rules: Skin Diseases	Food and Nutrition	Population and Natural Environment	An Introduction to AIDS

* Frequency of corresponding curriculum emphasis

In addition to the above similarities, some dissimilarity was identified between the curriculum and textbook topics.

First, given that the textbook is the vehicle for teaching and learning to implement the curriculum, so might be expected that the textbook authors developed the content based upon the specific objectives and learning outcomes of the curriculum. However, gaps in the curriculum emphases between the specific objectives and learning outcomes of the Grade VI curriculum, and textbook content, were identified in twelve topics. For example, in the topics *Magnetic Energy,* and *Plant Kingdom,* Everyday Coping was present in the specific objectives and learning outcomes but absent in the textbook content. On the other hand, some textbook topics addressed additional curriculum emphases that were missing for the same topics in the specific objectives and learning outcomes of the curriculum. For example, Science, Technology, and Decisions is addressed in the textbook topic of *Work, Power and Energy,* while absent in the specific objectives and learning outcomes of the curriculum. Similarly, Science for Nurturing is addressed in the textbook topics of *Human Body* but it was absent in the specific objectives and learning outcomes of the same topic in the curriculum.

Second, the difference in frequencies for a particular curriculum emphasis was evident in some topics in the curriculum and textbook. For example, in the topic *Measurement* the emphases Everyday Coping and Science in Application appeared once each in the specific objectives, and in the learning outcomes, while, in the textbook content both emphases appeared three times.

Third, the degree of alignment between the specific objectives and learning outcomes and textbook content in terms of frequencies for each of the curriculum emphases are plotted in Figure 5.2. These data indicate that the total frequency of the

Structure of Science (*f* = 74) was much higher in the textbook topics in comparison to the specific objectives (*f* = 7) and learning outcomes (*f* = 37) of the curriculum. Among

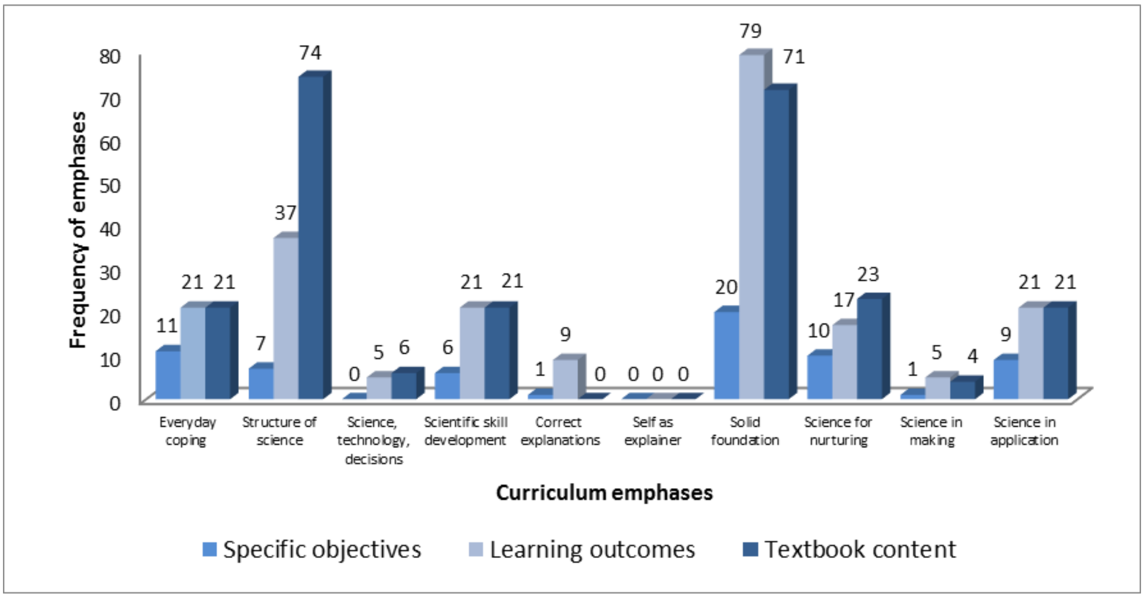

Figure 5.2: Curriculum Emphases in the Grade VI Curriculum and Textbook

the real-life emphases Science for Nurturing was emphasised more in the textbook content (*f* = 23) than in the specific objectives (*f* = 10) and learning outcomes (*f* = 17) of the curriculum. Much less emphasis was given to Science, Technology, and Decisions and Science in Making with no emphasis on Correct Explanations and Self as Explainer in the textbook content. Importantly, these emphases were absent in the curriculum.

Finally, the alignment of the two documents, curriculum and textbooks, with the real-life and non-real-life emphases (see Table 5.5) in terms of frequencies in the specific objectives and learning outcomes of the curriculum and, in the textbook content, are calculated from Figure 5.2. This figure identifies differences in emphases between the curriculum and content of the textbook topics.

Table 5.5: Frequencies of Non-real-life vs. Real-life Aspects of Curriculum Emphases

Emphases	Specific objectives (*f*)	Learning outcome (*f*)	Textbook content (*f*)
Non-real-life aspects	34	146	166
Real-life aspects	31	68	75

These data reveal that for the real-life and non-real-life emphases greater emphasis was given in the textbook topics than in the specific objectives of the curriculum. The total frequencies of these curriculum emphases in the textbook content indicate that the Grade VI textbook emphasised non-real-life aspects (f =166) more than twice as much as real-life emphases (f = 75). This result was also found in the learning outcomes of the curriculum in non-real-life (f = 146) and in real-life (f = 68) curriculum emphases.

Overall, the mapping of the Grade VI textbook topics showed greater concentration on the pure science content than real-life aspects. Real-life emphases were addressed more readily in the Biology topics than other subject areas of science. In seven topics, real-life emphases were absent (example, *Cell*). A comparison of the curriculum emphases between the topics of the specific objectives and learning outcomes of the curriculum and textbook illustrates that some features of curriculum emphases were common between these two documents (Example, in the topic *Health Rules*). This finding suggests that the Grade VI JSSC curriculum had some influence in the development of the textbook topics with respect to curriculum emphases. Conversely, some topics in the textbook concentrated on some emphases that were not addressed by the specific objectives and learning outcomes (for example in the topic: *Work, Power, and Energy*) of the curriculum. The emphases towards non-real-life and real-life emphases were greater in the textbook content than in the specific objectives and learning outcomes of the curriculum (Table 5.5).

5.4.3 Mapping Grade VII.

In the Grade VII General Science textbook there were twenty-five topics (Shamsudduha, Miah, Wahab, Khan, & Chowdhury, 1997). Using the same process as applied in the analysis of the Grade VI textbook, the frequencies of curriculum emphases in Grade VII textbook topics were determined and are summarised in Table 5.6.

The data in Table 5.6 indicate that the majority of the textbook topics (i.e. twenty three out of the twenty-five) addressed the emphasis Solid Foundation followed by the Structure of Science in twenty one topics. The real-life emphases of Science in Application were focused in the content of fourteen, Everyday Coping in seven, and Science for Nurturing in seven topics. On the other hand, limited emphasis was given to Correct Explanations and Science in Making, while Self as Explainer was not identified at all in the textbook topics.

Looking at the highlighted colours in Table 5.6 it appears that fewer topics picked up a combination of curriculum emphases. For example, Everyday Coping, Science in Making, and Science in Application appeared only in a single Physics (i.e. *Heat*), and Chemistry (i.e. *Atmosphere*) topic. Another Chemistry topic (i.e. *Oxygen*) picked up Science for Nurturing and Science in Application. In a Biology topic (i.e. *Microbial World*) preferences were in Everyday Coping, Science for Nurturing and Science in Application.

The highlighted colours in Table 5.6 clearly illustrate that Science in Application was addressed in the content of all Physics topics and five out of the seven Chemistry topics. Everyday Coping and Science for Nurturing were emphasised in Biology topics (i.e. each in four topics out of the ten) in the Grade VII textbook. Everyday Coping was emphasised only in a single Physics and two Chemistry topics. However, out of the twenty-five topics in the textbook real-life emphases were absent in the content of seven topics: Morphology of Plants, Animal Kingdom, Tissue, and Human Body (related to Biology), Common Laboratory Process, Production of

Table 5.6: Emphases in Grade VII Textbook Topic

Chapter → / Emphases ↓	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Everyday Coping (EC)	3*		1				1		4			1											4		1
Structure of Science (SS)	7	2	3	2	1		1	7	3	5	1	1	8	2	1	1	2	1			1	2	5	1	
Science, Technology, and decisions (STD)																							7	4	
Scientific skill development (SSD)	3	4	1	4	4	3	4				1		1	3	1				7	1			1		
Correct Explanation (CE							1	1																	1
Self as Explainer (SE)																									
Solid Foundation (SF)	8	1	5	2	2	2	4	6	7	2	9	3	4		2	4	5	11		3	2	7	5	7	4
Science for Nurturing (SN)				1			1		1		1	1						1					2		
Science in Making (SM)	2		1												2										
Science in Application (SA)	4	2	3	3	1	1	1		3			1	2	1	2	1		1							
Topic name →	Heat	Pressure of a Liquid	Atmosphere	Oxygen	Hydrogen	Carbon dioxide	Solution	Morphology of Plants [Leaf, Stem, Flower and Fruit]	Microbial World	Animal Kingdom	Interdependency of Plants and Animals	The Vertebrates	Light	Magnetism	Electricity	Earth Crust and Rock	Sea and Ocean	Weather and Climate	Common Laboratory Processes	Production of Essential Goods from Discarded Raw Materials	Tissue	Human Body: Digestive and Excretory System	Population Growth and Environmental Pollution	Flood, River erosion and Drought in Bangladesh	AIDS

*Frequency of corresponding curriculum emphasis

Essential Goods from Discarded Raw Materials (i.e. Chemistry topics), and *Sea and* Ocean (related to Geography).

It is evident in Table 5.6 that the majority of the textbook topics addressed Solid Foundation. The calculated values of the frequencies of each of the curriculum emphases determined from Table 5.6 (see Figure 5.3) also indicate that Solid Foundation (*f* = 105) was the key emphasis in the content of Grade VII textbook topics.

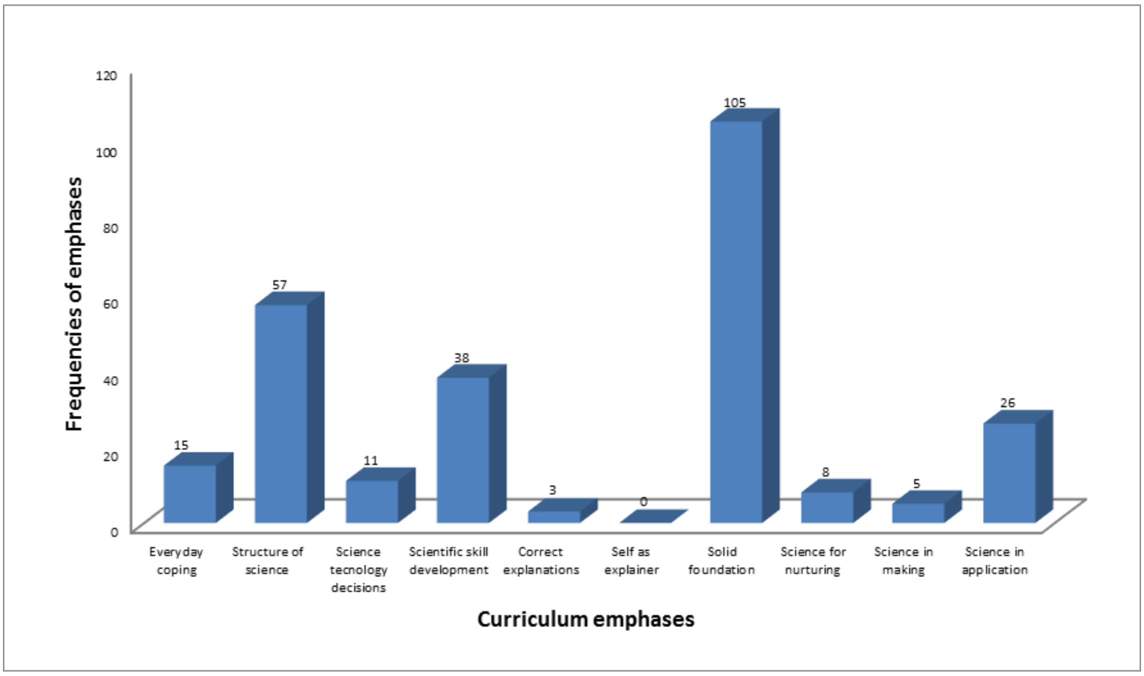

Figure 5.3: Frequencies of Curriculum Emphases in Grade VII Textbook Content

Among the real-life emphases Science in Application received more attention (*f* = 26) in the content of textbook topics compared to other real-life emphases, i.e., Everyday Coping (*f* = 15), Science, Technology, and Decisions (*f* = 11), Science for Nurturing (*f* = 8), and Science in Making (*f* = 5).

The alignments of the textbook content towards non-real-life and real-life emphases were calculated in terms of frequencies from Figure 5.3 (see in Table 5.7).

Table 5.7: Frequencies of Non-real-life versus Real-life Aspects of Curriculum Emphases

Emphases	Textbook content (*f*)
Non-real-life aspects	203
Real-life related aspects	65

These data demonstrate that the frequency of non-real-life emphases was three times more than that of real-life emphases. This finding suggests a higher concentration of Grade VII textbook topics on the pure science content than on aspects related to real-life.

5.4.4 Comparison of intended and implemented curriculum: Grade VII.

Table 5.8 shows the overall picture of the existence of curriculum emphases in the specific objectives and learning outcomes of the curriculum and in the textbook topics in terms of frequencies. The purpose of this table was to identify the similarities and differences in the features of the curriculum emphases between the topics of the curriculum and textbook. It should be mentioned that two topics, namely, *Flood, River Erosion and Drought in Bangladesh*, and *AIDS* were added to the Grade VII revised textbook (reprinted in 2010). These two topics were not included in the 1995 curriculum. For this reason, in Table 5.8, curriculum emphases for these two topics could not be provided for absence of the specific objectives and learning outcomes in the curriculum. Hence, only textbook content emphases were presented in Table 5.8.

Table 5.8: Emphases in Grade VII Curriculum and Textbook Content

Curriculum emphases	Chapter →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Everyday Coping (EC)	SOs	2*	1	1	1					2				1	1	2								1		
	LOs	1*		1	1					3									1					4		
	Textbook	3*		1				1		4			1											4		1
Structure of Science (SS)	SOs		1		1	1	1																			
	LOs	7	2	1	1			1	6		3			1	1	1	1	2		1						
	Textbook	7	2	3	2	1		1	7	3	5	1	1	8	2	1	1	2	1			1	2	5	1	
Science, Technology, and Decisions (STD)	SOs																									
	LOs																							5		
	Textbook																							7	4	
Scientific Skill Development (SSD)	SOs	1																		1	1			1		
	LOs	2	2	1	2	2	4	1	1					1						4	1			2		
	Textbook	3	4	1	4	4	3	4				1		1	3	1				7	1			1		
Correct Explantation (CE)	SOs																									
	LOs					1		3	1	1		1	1											1		
	Textbook							1	1																	1
Self as Explainer (SE)	SOs																									
	LOs																									
	Textbook																									
Solid Foundation (SF)	SOs	3	1	2	1	1	1	1	3	4	2	1	1	4	2	2	1	3	1	1	1	1	1	1		
	LOs	7	3	5	3	3	2	4	12	7	2	9	3	8	3	3	4	5	10	4	3	2	7	6		
	Textbook	8	1	5	2	2	2	4	6	7	2	9	3	4		2	4	5	11		3	2	7	5	7	4
Science for Nurturing (SN)	SOs				1							1												2		
	LOs				1					1			1	1				1								
	Textbook				1			1		1		1	1						1					2		
Science in Making (SM)	SOs	1														2										
	LOs	2		2												2										
	Textbook	2		1												2										
Science in Application (SA)	SOs	1	2	1	1	1	1			2				1	1	2										
	LOs	5	1	2	2	1	1	1		3				2	1	2			1							
	Textbook	4	2	3	3	1	1	1		3			1	2	1	2	1		1							
	Topic name →	Heat	Pressure of a Liquid	Atmosphere	Oxygen	Hydrogen	Carbon dioxide	Solution	Morphology of Plants [Leaf, Stem, Flower and Fruit]	Microbial World	Animal Kingdom	Interdependency of Plants and Animals	The Vertebrates	Light	Magnetism	Electricity	Earth Crust and Rock	Sea and Ocean	Weather and Climate	Common Laboratory Processes	Production of Essential Goods from Discarded Raw Materials	Tissue	Human Body: Digestive and Excretory System	Population Growth and Environmental Pollution	Flood, River Erosion and Drought in Bangladesh	AIDS

*Frequency of corresponding curriculum emphasis

The following similarities in the curriculum emphases appeared in the specific objectives and learning outcomes of the curriculum and textbook topics:

1. Solid foundation was the key emphasis in the majority of topics.
2. Limited importance was given to Correct Explanations, Science in Making, and Science, Technology, and Decisions with no representation of Self as Explainer.
3. Science in Application was addressed in all Physics and most of the Chemistry topics.
4. Real-life emphases were absent in seven topics.
5. In both curriculum and textbook topics similar combinations of curriculum emphases, i.e., Scientific Skill Development, and Solid Foundation were addressed for the topic *Production of Essential Goods from Discarded Raw Materials*.
6. Greater emphasis was given to non-real-life emphases (i.e. pure science content) than real-life emphases.

The following differences were identified between the specific objectives and learning outcomes of the curriculum and textbook topics in terms of curriculum emphases.

First, gaps in the curriculum emphases in twenty-two topics, e.g., in the topic *The Vertebrates*, Everyday Coping, Structure of Science, and Science in Application occurred in the textbook content while these emphases were absent in the specific objectives and learning outcomes of the curriculum. In contrast, in the same topic, Correct Explanations was present in the learning outcome of the curriculum but not evident in the textbook content.

Second, specific curriculum emphasis, namely, Everyday Coping in the topic of *Heat*, appeared two times in the specific objectives and in learning outcomes it appeared once. The textbook content Everyday Coping appeared three times (Table 5.8).

Third, the curriculum emphases in terms of frequencies (see Figure 5.4) demonstrates that Structure of Science and Scientific Skill Development were given more importance in the textbook content than in the specific objectives and learning outcomes of the curriculum. Real-life emphases Everyday Coping, Science, Technology, and Decisions, Science for Nurturing, and Science in Application were given much less importance both in the curriculum and content of textbook topics in comparison to Solid Foundation and Structure of Science. However, data presented in Figure 5.4 indicates that all of these emphases were given greater emphasis in the textbook content.

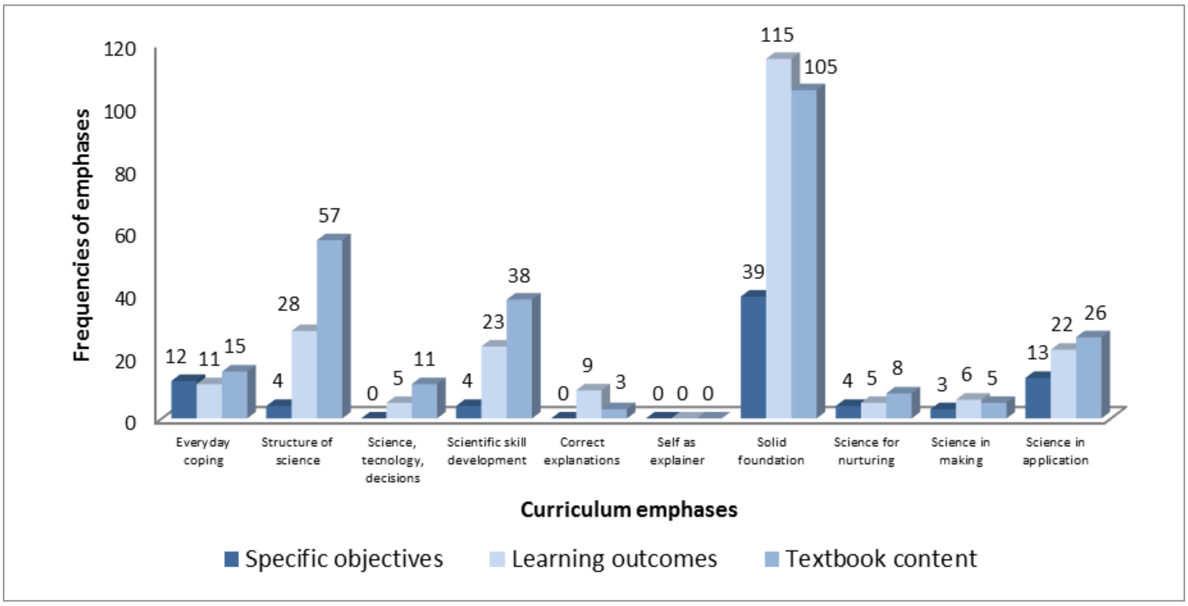

Figure 5.4: Frequencies of the Emphases in Grade VII of Curriculum and Textbook Content

Fourth, the real-life and non-real-life emphases were determined from curriculum emphases of the specific objectives and learning outcomes of the curriculum and textbook content. The total number of frequencies for real-life and non-real-life emphases was calculated from Figure 5.4 and is presented in Table 5.9.

In reference to Table 5.9 there is a greater concentration on non-real-life (f = 203) and real-life emphases (f = 65) in the textbook topics than in the specific objectives in non-real-life (*f* = 47) and real-life (*f* = 32). Learning outcomes of the curriculum in non-real-life was *f* = 175, and in real-life it was *f* = 49. The total numbers of frequencies of these emphases in the textbook content and learning outcomes also demonstrate that Grade VII textbook content and learning outcomes emphasised non-real-life aspects more than three times than that of the real-life emphases. These results suggest a greater emphasis on pure science content in both documents with non-real-life emphasis being comparatively higher in the textbook content.

Table 5.9: Frequencies of Non-real-life versus Real-life Aspects of Curriculum Emphases

Emphases	Specific objectives (*f*)	Learning outcome (*f*)	Textbook content (*f*)
Non-real-life aspects	47	175	203
Real-life aspects	32	49	65

In summary, the mapping of the Grade VII textbook topics indicated a greater concentration around pure science content than real-life emphases. Real-life emphases were addressed more frequently in the Physics and Chemistry topics than other subject areas of science. These emphases were absent in the content of seven topics, namely: *Morphology of Plants, Animal Kingdom, Sea and Ocean, Common Laboratory Process, Production of Essential Goods from Discarded Raw Materials, Tissue, and Human Body: Digestive and Excretory System*. Similar findings as above were identified in the curriculum when the curriculum emphases associated with the specific objectives and learning outcomes of the same topics were compared with the curriculum emphases in the textbook content. However, inconsistency in the curriculum emphases appeared between the specific objectives and learning outcomes of the curriculum and in the content of some textbook topics, such as *Light*. Alternatively, a number of textbook topics emphasised on certain curriculum emphases that were not addressed by the specific objectives and learning outcomes of the curriculum, for instance *The Vertebrates*. The emphases with non-real-life and real-life emphases were comparatively greater in the textbook content than in the specific objectives and learning outcomes of the curriculum.

5.4.5 Mapping Grade VIII

In the Grade VIII textbook, reprinted in 2010, there were twenty-six topics (Shamsudduha, Miah, Wahab, khan, & Morshed, 1997). As in Grades VI and VII, the same process was used to map the frequencies of the curriculum emphases for the Grade VIII textbook topics as shown in Table 5.10.

Table 5.10 demonstrates that the majority of the content of textbook topics (i.e. twenty-five out of the twenty-six) addressed the Solid Foundation emphasis. The Structure of Science was emphasised in seventeen topics. The real-life emphasis Everyday Coping was identified in the content of textbook in eleven topics, Science in Application in twelve, and Science for Nurturing in nine topics. Limited emphasis was given in Science, Technology and Decisions, Correct Explanations and Science in Making with no emphasis on *Self as Explainer* in the content of textbook topics.

It was also noted that some topics associated with different subject areas of science addressed different combinations of real-life curriculum emphases. For instance, Everyday Coping, and Science in Application were identified in the content of three Physics topics (i.e. *Measurement*, *Simple Machines*, *Sound*), and in a single Technology related topic (i.e. *Science and Technology in Everyday Life*). Everyday Coping, Science for Nurturing and Science in Application were focused on in the content of a single Biology topic (i.e. *Energy, Living Being and Natural Resources*). Another Biology topic (i.e. *Some Common Diseases*) addressed *Everyday Coping* and Science for Nurturing.

Table 5.10: Curriculum Emphases in Grade VIII Textbook Topics

Chapter → / Emphases ↓	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Everyday Coping (EC)				1*		1					1			2		1	1			1		4	8		3	4
Structure of Science (SS)	5	2	1		2	1	6	2	2			2	2			4	3	4	1	4		4				1
Science, Technology, and Decisions (STD)																								2	1	
Scientific Skill Development (SSD)		2	2	4			1		1			1	7	2	3	2	1	1						1		
Correct Explantation (CE)															1										1	
Self as Explainer (SE)																										
Solid Foundation (SF)	5	6	7	1	3	2	5	1	1	3	3	4	4	5		3	6	1	7	5	3	17	9	1	2	10
Science for Nurturing (SN)							2		1	2	2			1						1		6	7		1	
Science in Making (SM)															1				1						1	
Science in Application (SA)				1		6					1	2	2	1		3	2	1	5	1					5	
Topic names →	Structure of Matter-Atom and Molecule	Symbol, Formula and Valency	Chemical Reaction and Equation	Measurement	Gravitation and Gravity	Simple Machines	Plant Morphology: Fruit, Seed and Germination of Seed	Flowering Plant: Chili Plant	Living Organisms and their Environment	Forest and Environment	Energy, Living being and Natural Resources	Earth' s Motion: Time and Season Change	Acids, Bases and Salts	Hardness of Water	Common Laboratory Process	Heat	Sound	Refraction of Light	Electricity	Vertebrate Animal - Fowl	Cell Division	Human Body:- Blood Circulation, Respiration and Nervous system	Some Common Diseases	Population and Environment	Science and Technology in Everyday Life	Natural Disaster: Cyclone and Tidal Wave

*Frequency of corresponding curriculum emphasis

As observed in Table 5.10, the real-life emphases of Everyday Coping and Science in Application were addressed more prominently in the Physics topics. Everyday Coping with Science for Nurturing was given more prominence in Biology topics compared to other science subject areas. However, real-life emphases were absent in the content of six topics: *Structure of Matter- Atom and Molecule, Symbol, Formula and Valence, Chemical Reaction and Equation* (Chemistry related topics), *Gravitation and Gravity* (Physics related topic), and *Flowering Plant: Chili Plant, and Cell Division* (Biology topics).

Alignment of the content of Grade VIII textbook topics with curriculum emphases was determined by the number of frequencies from Table 5.10 (see Figure 5.5). These data reveal that greater emphasis was given to Solid Foundation (f = 114) in the content of the topics. On the other hand, Everyday Coping, Science, Technology and Decisions, Science for Nurturing, Science in Making, and Science in Application received less attention than Solid Foundation. Self as Explainer was not emphasised in the content.

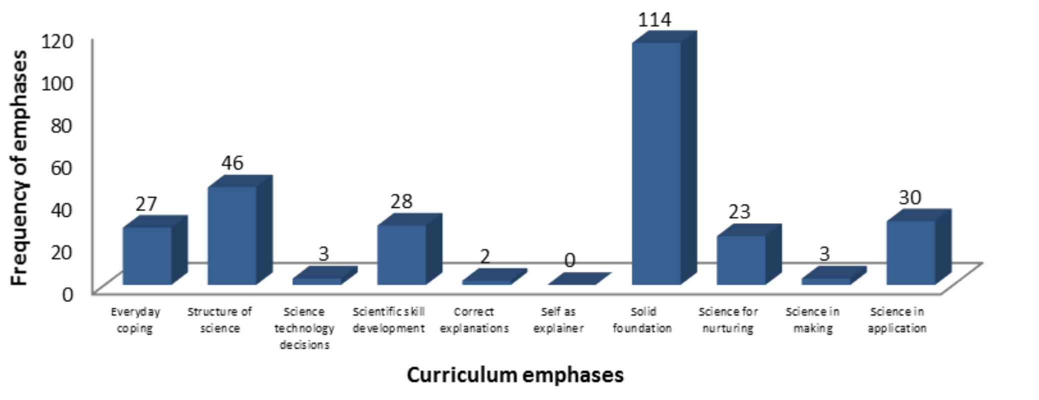

Figure 5.5: Frequency of Curriculum Emphases in Grade VIII Textbook Content

The total numbers of frequencies of the non-real-life and real-life curriculum emphases were calculated from Figure 5.5 and are shown in Table 5.11. These data illustrate that in the textbook topics non-real-life emphases (f = 190) were given twice as much importance as that of real-life emphases (f = 86). This result suggests more emphasis on pure science content in the Grade VIII textbook topics compared to real-life emphases.

Table 5.11: Frequencies of Non-real-life versus Real-life Aspects of Curriculum Emphases

Emphases	Textbook content (f)
Non-real-life aspects	190
Real-life related aspects	86

5.4.6 Comparison of intended and implemented curriculum: Grade VIII.

Table 5.12 shows the total mapping of the frequencies of curriculum emphases in the specific objectives, learning outcomes and in the textbook content for each topic of Grade VIII. As in Grades VI and VII textbooks, one new topic, namely, *Natural Disaster: Cyclone and Tidal Wave* was included in the Grade VIII revised textbook. This topic was not included in the 1995 curriculum. Therefore, in Table 5.12 frequencies of curriculum emphases for this newly added topic were absent in the specific objectives and learning outcomes of the curriculum.

Comparison of the curriculum emphases between the specific objectives and learning outcomes of Grade VIII JSSC and the textbook topics indicates a number of similar features (see Table 5.12):

Table 5.12: Emphases in Grade VIII Textbook Topics

Curriculum emphases	**Chapter →**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
Everyday Coping (EC)	SOs				2*		1					1					1	1						1	1	1	
	LOs				1		1					1			1			1					2	5	1	2	
	Textbook				1		1					1			2		1	1			1		4	8		3	4
Structure of Science (SS)	SOs							1	1	1									1								
	LOs					1		3	1	2				2	1		1	1	3	1	5						
	Textbook	5	2	1		2	1	6	2	2			2	2			4	3	4	1	4		4				1
Science, Technology, and Decisions (STD)	SOs																									1	
	LOs																								3	1	
	Textbook																								2	1	
Scientific Skill Development (SSD)	SOs			1	3					1			1	1	1	1	1			1	1				1		
	LOs			3	3								1	3	1	3				1					1		
	Textbook		2	2	4			1		1			1	7	2	3	2	1	1						1		
Correct Explanation (CE)	SOs																										
	LOs	1	1					1	1						2	1	2	1	1				1	1			
	Textbook															1										1	
Self as Explainer (SE)	SOs																										
	LOs																										
	Textbook																										
Solid Foundation (SF)	SOs	3	2	2	2	1	2	2	1	2	2	1	1	1	2		2	4	1	3	2	1	3	1	1	1	
	LOs	6	8	7	1	3	2	5	1	2	3	1	5	7	5		6	9	2	7	2	3	21	6	1	2	
	Textbook	5	6	7	1	3	2	5	1	1	3	3	4	4	5		3	6	1	7	5	3	17	9	1	2	10
Science for Nurturing (SN)	SOs										1	2											2	1	2		
	LOs							2		1	2	3			1								4	3	1	1	
	Textbook							2		1	2	2			1						1		6	7		1	
Science in Making (SM)	SOs				1																						
	LOs						1									1	1			1						1	
	Textbook															1				1						1	
Science in Application (SA)	SOs				2		1	1				1		1			1	1	1	1		1				1	
	LOs				2		5	1				2	2	1	2		3	1		4	1					5	
	Textbook				1		6					1	2	2	1		3	2	1	5	1					5	
Topic names →		Structure of Matter-Atom and Molecule	Symbol, Formula and Valency	Chemical Reaction and Equation	Measurement	Gravitation and Gravity	Simple Machines	Plant Morphology: Fruit, Seed and Germination of Seed	Flowering Plant: Chili Plant	Living Organisms and their Environment	Forest and Environment	Energy, Living being and Natural Resources	Earth' s Motion: Time and Season Change	Acids, Bases and Salts	Hardness of Water	Common Laboratory Process	Heat	Sound	Refraction of Light	Electricity	Vertebrate Animal-Fowl	Cell Division	Human Body:- Blood Circulation, Respiration and Nervous system	Some Common Diseases	Population and Environment	Science and Technology in Everyday Life	Natural Disaster: Cyclone and Tidal Wave

*Frequency of corresponding curriculum emphasis

1. Solid Foundation was the key emphasis in the specific objectives and learning outcomes of the curriculum, and in the textbook content of all the topics except Chapter 15, i.e. *Common Laboratory Process*.
2. The emphasis Self as Explainer was absent in both the curriculum and textbook content.
3. A smaller number of topics in the textbook content addressed the same combinations of curriculum emphases as in the specific objectives and learning outcomes of the curriculum. For example, Everyday Coping, and Science in Application were addressed in three Physics topics (i.e. *Measurement*, *Simple Machines*, *Sound*), and a single Technology related topic (i.e. *Science and Technology in Everyday Life*).
4. Real-life emphases were absent in the six topics of both documents. These were *Structure of Matter- Atom and Molecule*, *Symbol, Formula and Valence, Chemical Reaction and Equation Gravitation and Gravity*, *Flowering Plant: Chili Plant* and *Cell Division.* However, there was an exception for the topic *Cell Division* where Science in Application was addressed only in the specific objectives of the curriculum.
5. In the curriculum and textbook real-life emphases were focused more in Physics and Biology topics than other science areas.
6. In both Grade VIII curriculum and textbook, greater emphasis was placed on non-real-life emphases (i.e. pure science content) than real-life emphases.

However, a number of differences were identified between the specific objectives and learning outcomes of the Grade VIII JSSC curriculum and content of the textbook topics in terms of the curriculum emphases. First, inconsistency of the curriculum emphases were found in the majority of topics (i.e., twenty four of the twenty six topics) between the curriculum and textbooks. For instance, in the topic *Population and Environment*, Everyday Coping and Science for Nurturing existed in the specific objectives and learning outcomes but were absent in the textbook content. Science, Technology, and Decisions was absent in the specific objectives but emphasised in the learning outcomes and textbook content. In contrast, in topic *Science and Technology in Everyday Life*, Correct Explanations appears in the textbook content but is not included in the specific objectives and learning outcomes. Moreover, in this topic Science for Nurturing and Science in Making were emphasised in the learning outcomes and textbook content but excluded from the specific objectives.

Second, Figure 5.6 demonstrates that limited focus was given to Everyday Coping, Structure of Science, Scientific Skill Development, Science for Nurturing, and Science in Application in the curriculum and textbook content in comparison to Solid Foundation. Importantly, very little emphasis was placed upon Science, Technology, and Decisions, Correct Explanations and Science in Making in both textbook content, and in the specific objectives and learning outcomes of the curriculum.

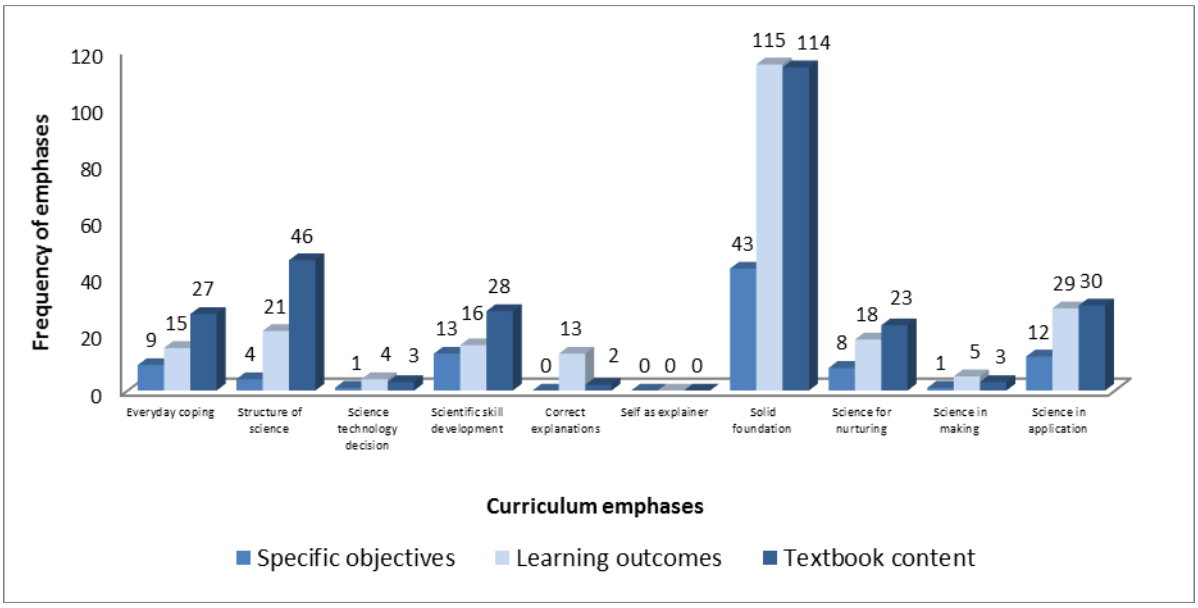

Figure 5.6: Frequencies of Emphases in Grade VIII Curriculum and Textbook Content

Third, in order to compare the relationship between the real-life and non-real-life emphases in the specific objectives and learning outcomes of the curriculum and in textbook content, the total numbers of frequencies for each of these emphases are presented in Table 5.13.

Table 5.13: Frequencies of Non-real-life versus Real-life Aspects of Curriculum Emphases

Emphases	Specific objectives (*f*)	Learning outcomes (*f*)	Textbook content (*f*)
Non-real-life aspects	60	165	190
Real-life aspects	31	71	86

Table 5.13 illustrates that non-real-life and real-life emphases were focused on to a greater extent in the textbook content than in the specific objectives and learning outcomes of the curriculum. Data also show that the frequencies of non-real-life emphases in the learning outcomes (f = 165), and in the textbook content (f = 190), were more than twice than that of the real-life emphases. In the later the frequency in learning outcome was 71 and in textbook content it was 86. These findings indicate that more importance has been placed on the pure science content both in the specific objectives and learning outcomes of the curriculum, and in textbook content. However, higher emphasis on pure science content was evident in the content of textbook topics than in the curriculum.

Overall, the mapping of the Grade VIII textbook topics indicates that pure Gravitation and Gravity, science content was given more emphasis compared to real-life emphases in the topics. The Self as Explainer did not appear in the topics. Real-life emphases were focused more readily in Physics and Biology topics than in other areas of science. Real-life emphases were not addressed in the content of six textbook topics, namely: *Structure of Matter- Atom and Molecule*, *Symbol*, *Formula and Valency*, *Chemical reaction and Equation*, *Gravitation and Gravity*, *Flowering Plant: Chili Plant*, and *Cell Division*. Reflection of the curriculum emphases in the specific objectives and learning outcomes were inconsistent in the content of textbook topics. Some topics in the textbook addressed some curriculum emphases that were not focused in the specific objectives and learning outcomes of the curriculum (for example, in the topic *Science and Technology in Everyday Life)*. A comparison of the alignment of the emphasis towards non-real-life and real-life aspects of curriculum emphases demonstrated that non-real-life emphases were greater in the textbook content than in the specific objectives and learning outcomes of the curriculum.

5.5 Summary

This chapter presents content analysis of Grades VI to VIII General Science textbooks used at the junior secondary level in Bangladesh addressing the research question:

> RQ 2. To what extent are the science textbooks in Bangladesh
>
> real-life oriented?

Findings suggest that in the content of Grades VI to VIII textbook topics, greater emphasis has been given to the pure science content with limited connections provided to real-life aspects for the students. Real-life emphases were incorporated to a greater extent in Biology topics for Grade VI, Physics and Chemistry topics for Grade VII, and Physics and Biology topics for Grade VIII than other subject areas of science. Real-life emphases were absent in the content of some topics in all grades.

Comparison of the curriculum emphases between the specific objectives and learning outcomes of the JSSC and textbook content in all grades also showed similarities to the above findings in the curriculum. This outcome suggests that the intended curriculum had some influence in developing the content of textbook topics. A mismatch between the curriculum emphases was also found in the textbook topics and in the curriculum. Articulation of the curriculum emphases in the specific objectives and learning outcomes appeared inconsistent in the textbook content for the majority of topics across the three grades. On the other hand, the textbook content of some topics addressed some of the curriculum emphases that were ignored in the specific objectives and learning outcomes for the associated topics in the JSSC. These findings suggest that uniformity or a degree of consistency was not evident in terms of curriculum emphases in developing the specific objectives and learning outcomes of the curriculum as well as in developing the textbook content for all grades.

Chapter 6
Teachers’ Perspectives of Implementing the Curriculum

6.1 Introduction

The previous chapter explored the extent of the real-life orientation of the General Science textbooks (Grades VI to VIII), in Bangladesh, with respect to curriculum emphases. This chapter investigates teachers’ perspectives around implementing the curriculum in relation to its alignment with real-life situations. Initial data were collected through questionnaires administered to teachers (N = 194) who taught General Science at the junior secondary level in Bangladesh. Using these data, six participants were selected for the qualitative part of the study, which is presented in this chapter. The procedure used to select these participants is described in Chapter 3. The purpose of selecting these teachers was to understand how they applied their views of teaching real-life science in classroom practices. Data were collected from pre and post-lesson interviews with the six teachers, lesson observations, and focus group discussions conducted with their students. The intent of this data collection was to address the following research question:

> RQ 3. What are the perspectives of teachers of implementing this curriculum with a real-life emphasis?

In the first section of this chapter, teachers’ background information from the questionnaires is provided. This information is relevant to understanding how teachers’ backgrounds influence their outlook on teaching science with a focus on real-life. The next section presents teachers’ views about implementing the curriculum with their students. It includes a discussion of the major goals of science education, teaching techniques and methods used in class, assessment processes, and teachers’ self-reflection on their teaching. These teaching aspects are important because meaningful learning for students depends on the teaching practices of the teachers. Lastly, teachers' challenges in teaching science, along with their suggestions about initiatives to be taken to make science learning relevant to students' lives, are presented. Pseudonyms are used throughout this chapter in the presentation of the data from teachers and students.

6.2 Teachers' Background Information

In this section information about the educational qualifications and teaching experience of the teacher participants is presented. This information includes details of their professional development activities, teaching loads, and class sizes.

6.2.1 Educational qualification and teaching experience

In many countries, science classes in secondary schools are taught by science teachers who have completed professional teacher training courses (Dow, 1971). This training provides teachers with a comprehensive understanding of content knowledge and pedagogical knowledge to teach science, which cannot be achieved otherwise. Marquis (2013) pointed out that this kind of training course ensures teachers to understand 'what to teach' and 'how to teach'. To explore these aspects teachers were asked to identify their general and professional qualifications in the questionnaire.

As shown in Figure 6.1a, 90% of the teacher participants in this study held a science degree (e.g., Bachelor of Science-3 years, Bachelor of Science with Honours-4 years and/or 1-2 years Masters of Science) while 10% of teachers were non-science graduates or undergraduates.

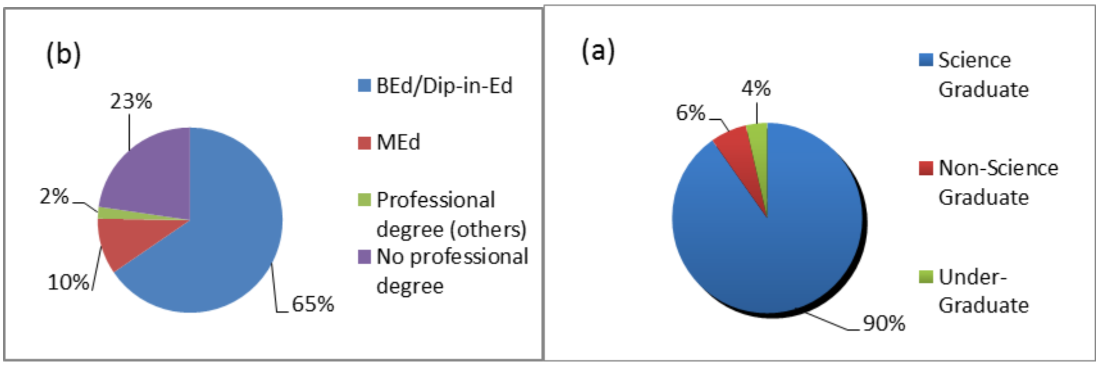

Figure 6.1. Participants' Academic Qualifications (a) and Teaching Qualifications (b)

The results indicate that the non-science and undergraduate teachers (Higher Secondary Certificate holders) were teaching General Science at the junior secondary level in Bangladeshi schools. Among the science teachers in this study, 65% had either a Bachelor of Education (BEd) degree or a Diploma in Education, with 10% holding a Master of Education (MEd) degree (see Figure 6.1b). Given these data, 75% of the teachers in this study would be considered fully qualified to teach science at the junior secondary level having both the necessary science content background, and teaching qualification. Osborne and Simon (1996) argue that science content knowledge is an important aspect for teaching science. However, the remaining 25% either lacked the science content knowledge (4% of teachers having undergraduate certificates and 6% with non-science degree backgrounds) or did not hold teaching qualifications in the sciences. Among the remaining 25%, 2% held other professional degrees (e.g., Bachelor of Physical Education) while 23% did not have any professional degree. These findings raise questions about the effectiveness of teachers without science backgrounds and professional degrees teaching science. This issue is addressed in Section 6.2.2 of this chapter.

Teaching experience (i.e., years of teaching) is one of the important factors for effective science teaching that may influence students' achievement (Gawlik, Kearney, Addonizio, & LaPlante-Sosnowky, 2012). In the questionnaire, participants were asked to identify their teaching experience. As reflected in Figure 6.2, 76% of the teachers had more than five years of teaching experience while 58% had more than 10 years. As such, the majority of teachers in this study were experienced in teaching science at the junior secondary level in Bangladesh.

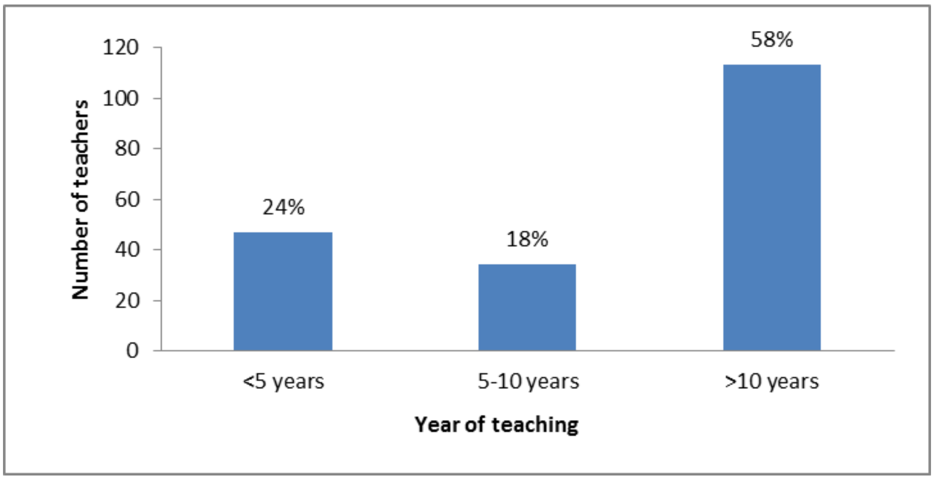

Figure 6.2: Teaching Experience of the Teachers

6.2.2 Professional development opportunities

Professional development activities provide opportunities for teachers to improve their pedagogical knowledge and skills (Goodrum, Hackling, & Rennie, 2001) for teaching science. Considering this, participant teachers were asked to provide information about their participation in professional development training programs in recent years. Figure 6.3a demonstrates that 76% of participants attended training programs in recent years, but for different school subjects, as shown in Figure 6.3b. Among the science teachers, 15% actually participated in the training program for teaching a General Science course at the junior secondary level, whereas the other 85% were trained for secondary level, including 39% who were trained in individual science subjects (10% in Physics, 15% in Chemistry and 14% in Biology) and 22% who received training in non-science subjects, such as Mathematics, Computer Science, Social Science, Bengali and English.

This finding indicates that in-service training for teachers to teach General Science at the junior secondary level may be inadequate in Bangladesh. It was also identified from the questionnaire and interview data that not one of the six teachers, in

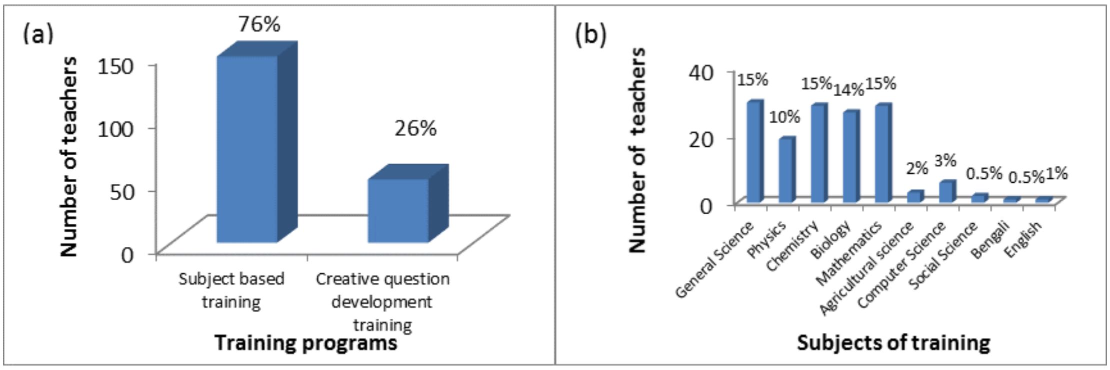

Figure 6.3. Science Teachers' Participation in Professional Development Activities

this study, participated in the training program for teaching General Science, but had completed in-service training in different science subject areas.

It could be argued that although the teachers participated in training programs for specific science subject areas (e.g., Chemistry) for teaching at secondary level (Grades IX to X), they may not have sufficient knowledge and skills to teach General Science at the junior secondary level. The reason for this is that General Science is not just about teaching a specialised science subject - it is an integrated course, combining a number of different science subject areas. Consequently, teachers with knowledge and skills of particular subject matter (Cohen & Hill, 1998; Supovitz & Turner, 2000) may not be equipped to teach other subject areas (i.e., Biology or Chemistry) in General Science effectively, at junior secondary level. Integrated science teaching requires in-service training where teachers need to understand how to develop new conceptual structures to teach the science topics (Lang & Olson, 2000). For this purpose, they need to analyse the content knowledge of General Science to identify the main themes and their socially relevant connections that are linked to different subject areas of science

(Lang & Olson, 2000). Therefore, it is essential that teachers who teach General Science should have opportunities to upgrade both content knowledge and pedagogical knowledge for teaching integrated science at the junior secondary level.

As mentioned in Chapter 2, in the Bangladeshi education system, the government introduced creative types of questions from 2010 to assess students' learning. These types of questions help students to demonstrate their scientific understanding rather than recalling answers based on rote learning. However, Figure 6.3a illustrates that only 26% of the science teachers participated in creative question development training. This finding suggests that there may be an inability amongst the teachers to assess students' learning using alternative methods and tasks due to a lack of training. These types of techniques to assess students learning help students to increase their thinking ability particularly in relating scientific knowledge to real-life situations. Therefore, it is crucial for the General Science teachers to participate in training for creative question development, to be able to assess students' learning effectively so that they can relate and apply their scientific knowledge in real-life.

6.2.3 Teacher load

To gauge information about teacher load, teachers were asked to identify the number of lessons they taught per week. Figure 6.4 demonstrates that 61% of the participants conducted 24 to 30 lessons per week, with 14% of teachers conducting more than 31 to 37 lessons per week. The average teaching load for teachers in a week was 27 lessons, which represented a teaching load of 6 lessons per day. Sarkar and Corrigan (2013) identified that teachers in Bangladesh usually conduct seven lessons per day. In the National Education Policy (Ministry of Education, 2010) of Bangladesh the recommended teaching load for Grades VI to VIII is 24 lessons per week. Thus, 76% of the teachers participating in this study were significantly over the recommended teaching load. Specifically, five of the six participant teachers' had a weekly teaching load from 25 to 36 (Jalil 26, Khushi 25, Shyamol 28, Sabrina 36, Nabila 26, Bishnu 28) lessons per week. It is worth mentioning that the class time period was on average 35-40 minutes at the time of data collection. During interviews, teachers stated that they could not prepare detailed lesson plans, due to excessive teaching loads.

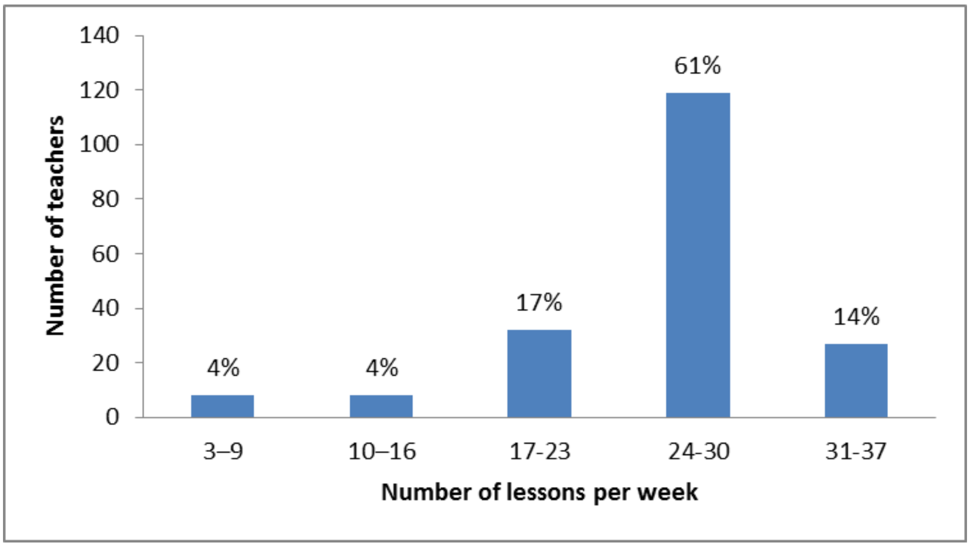

Figure 6.4: Participant Teachers' Weekly Teaching Load

6.2.4 Class size

The recommended teacher to student ratio in the National Education Policy 2000 (Ministry of Education, 2000) of Bangladesh is 1:40 at the secondary level. To collect data about this aspect, one item in the questionnaire requested teachers to identify their class sizes. Figure 6.5 illustrates the teacher to student ratios for science classes. Only 6% of classes had a maximum of 40 students with 23% of classes comprising 41 to 60 students. Moreover, 44% of classes had 61 to 120 students and 24% of classes had more than 120 students, which is significantly above the recommended class size according to National Education policy 2000.

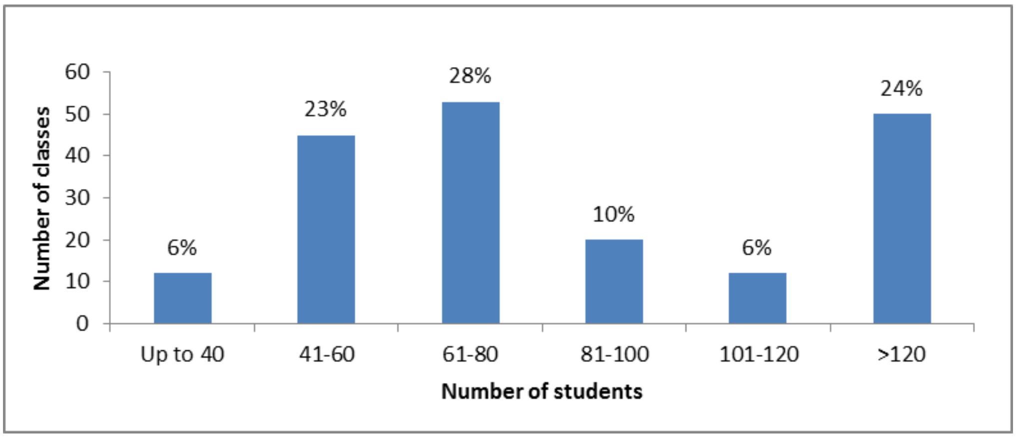

Figure 6.5: Average Class Size of the Participant Teachers

Furthermore, lesson observations revealed that five of the six teachers had significantly high numbers of students (50, 58, 70, 116 and 117 respectively) in their classes.

6.3 Resources Available to Support Teaching and Learning

This section explores teachers' responses regarding the printed resource materials available in their schools to support teaching. Figure 6.6 indicates that textbooks were available at all participating teachers' schools. Most of the schools had training manuals, teachers' guides (NCTB publications), and the junior secondary science curriculum. A question booklet containing creative types of sample questions was available at some of the schools.

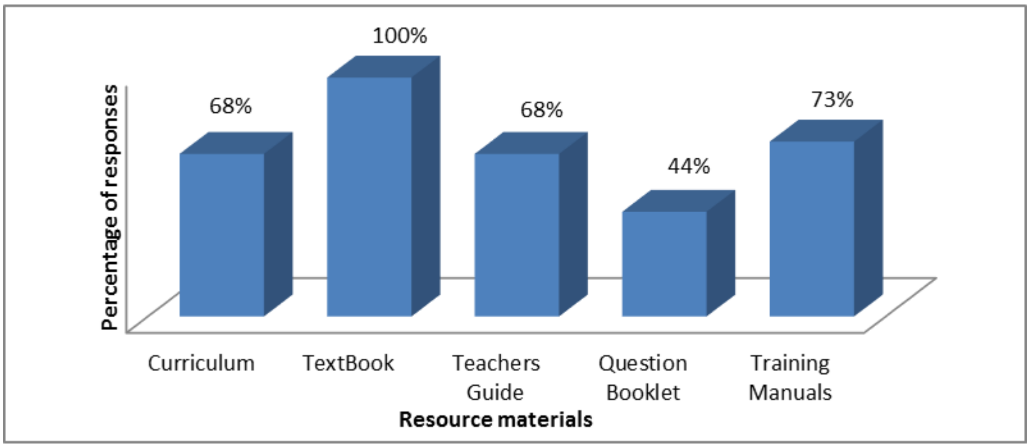

Figure 6.6. Availability of Printed Materials at Participants' Schools

These findings illustrate that textbooks were the main supportive materials available for teachers in teaching General Science courses at the junior secondary level in Bangladesh. In open-ended response items, very few teachers mentioned that they had sample copies of guidebooks, with questions and answers, supplied by commercial publishers, as well as teaching aids in their schools.

6.4 Teachers' and Students' Views of Implementing the Curriculum with a Real-life Emphasis

Teachers' views of implementing the curriculum with a real-life emphasis were obtained from the teacher questionnaires, interviewing teachers, observing their teaching approaches, and from student focus group discussions. For this purpose, it was essential to identify the teachers' views regarding the major goal of science education at the junior secondary level. These data were then compared with the six teachers' actual classroom practices along with data from the student focus group discussions. An analysis of these data is presented below.

6.4.1 Major goal of science education at the junior secondary level

There are two aims of science education at the junior secondary level in Bangladesh: (1) building a solid foundation to prepare students for further studies in science, and (2) preparing students to be able to apply scientific knowledge and skills in solving daily life problems (NCTB, 1995). As shown in Figure 6.7, teachers were given two alternative statements in the questionnaire to express their responses about the main goal of science education.

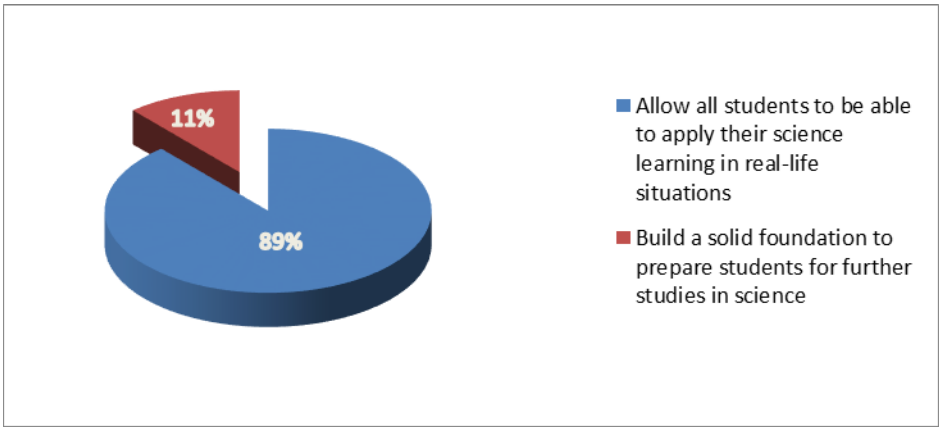

Figure 6.7: Teachers' Views about Major Purposes of Teaching Science

Figure 6.7 shows that 11% of teachers considered that a solid foundation for future study in science was the major goal of science education with 89% perceiving that the real-life application of scientific knowledge was the primary goal of science education. During their pre-lesson interviews, similar views were expressed by the six teachers about the goals of science education:

> *The goal of science education must be to enable students to apply their science knowledge in real-life.* (Nabila)

> *It seems to me that the goal of our present curriculum is that this acts as the pillar for achieving higher education and also aims to apply the science knowledge in real-life for solving different types of problems.* (Khushi)

> *The aim is to prepare students for higher education and make their lives meaningful by utilizing acquired knowledge in their lives…in personal, family, social, and national life.* (Bishnu)

> *They [students] will learn practically and will apply it in real-life. (Sabrina)*

> *It should be realistic. The students should learn by doing and practical activities by which they can understand what science is and how science can be related with life.* (Jalil)

At first, Shyamol was unable to articulate the goal of science education stated in the curriculum, however with some probing he said:

> *The main goal is to prepare future citizens based on science knowledge so that they can work for the development of the country … .The goal of science education should focus on preparing self-dependent learners through working with by different experiences. Because of traditional education, unemployment is increasing in our country, so, is possible to include work experience in science education from the primary level, then the path of life will be easier. If they gain some work experience skills from the school, then they will practice these at their*

home and they will be better equipped to use these in their practical life compared with students who do not have work experience.

It seems from the above comments that all six teachers appreciated using science in everyday life as a goal of science education. Shyamol particularly emphasised students' work experience, through science education, that will make students' far more employable in the future. Khushi and Bishnu's comments also acknowledge the need to prepare students for further education in science, as another goal of science education as stated in the curriculum (NCTB, 1995).

In the focus group discussions, when students were asked why they wanted to learn science, all students' responses included both goals of science education. For example, Jalil's students' comments were:

Akash*: We would like to learn the type of science knowledge that we can use in our daily lives; also, for helping others to understand the use of scientific knowledge, when we are in higher positions [professions], such as teaching, or as a physician. Moreover, if we want to study science in Grades IX and X then there will be separate subjects such as Physics, Chemistry, and Biology -- what we have learnt before, in junior classes will be useful for understanding these subjects …. if we study Medical Science we will be able to detect human diseases for treatment. All of this we can do by learning science.*

Ibrahim*: Learning science will help us to be an engineer, doctor or scientist.*

Shoma*: We can use the knowledge of science in our everyday lives. From our science class I have learnt how to use a thermometer to measure room temperature. Now I can measure body temperature, in the Celsius scale, using a thermometer.*

The students' responses indicated that they understood that learning science will help them to utilize scientific knowledge in everyday life, for instance, in being able to identify diseases and to provide treatment. It will also help them with further studies in scientific fields or in gaining employment in science-related professions. Similarly, Mamun (Shyamol's student) and Rafia (Khushi's student) said that:

Mamun: *I want a bright future … I want to educate* people about science*. I want to learn about humans, animals, and the earth from science. I want to be a scientist.*

Rafia: *Learning science will help us to become a doctor, a scientist… we can invent a lot of things through science*.

One of Nabila's students said:

> Sadia: *The present world is very advanced in science and technology. Our country is poor and we need to improve in science and technology. So, I think it is essential for us to gain scientific knowledge. In our daily lives we need science for various purposes like communicating with others through the internet.*

Sadia clearly recognised that science and technology were important for a country's development. She stressed the importance of science and technology in everyday life with an example of communicating through the internet. Furthermore, she emphasised the need for a country's citizens to acquire higher levels of scientific and technological knowledge and skills. Bishnu's students' responses were:

> Asif: *Mam, we can use our knowledge of science in our practical life. Likewise, today we have learnt about acid and the process of preparing salt … We will be able to teach our next generation. We want to implement science knowledge practically. Sodium chloride salt is necessary for our body.*
>
> Hira: *We can gain knowledge to cultivate our land in a scientific way and to improve production. We can learn about all types of inventions, including agricultural tools that are beneficial to agricultural production.*
>
> Rony: *We used knowledge of first aid treatment from our science classes in our daily life. In our area a boy was drowned. We placed him on the ground, and then created pressure upon the belly. We emitted water from the belly and then took him to the hospital.*

Asif, Hira and Rony demonstrated their understanding of utilizing knowledge of science in real-life situations. For example, Asif wanted to teach others about the practical implementation of scientific knowledge; Hira recognised that agricultural production benefits from science and technology, and Rony with his friends utilized their knowledge of science to apply first aid to a drowning boy.

The above discussion indicates that the majority of teachers and students identified the real-life application of scientific knowledge as the primary goal of science education. In addition, some of the students stated that they would like to undertake further studies and/or professional occupations in scientific fields.

6.4.2 Teachers' views of teaching aspects to consider in teaching science

A number of teaching aspects, given their importance for helping students to develop an orientation to real-life (Goodrum, 2004; Millar & Osborne, 1998), were provided in the questionnaire (see Table 6.1). The purpose was to explore teachers' beliefs and whether they felt these teaching aspects could contribute to linking school science with the students' lives. These teaching aspects are presented as statements in the table along with the frequency of their representations. These frequencies are also presented as percentages determined by dividing the frequency of responses by the total number of occurrences (N=1158 responses) to these statements.

Table 6.1: Teachers' Beliefs about Teaching Aspects for Students' Real-Life Orientations

Aspects in teaching science to link with real-life	Frequency of responses	Percentage of responses
Link the topic or lesson with students' prior knowledge and experiences	176	15
Link topic with real-life examples	176	15
Explain application of science in everyday life situations	180	16
Present up-to-date knowledge regarding real-life related topic	142	12
Present science related themes/problems/issues that require awareness	142	12
Involve students in hands-on activities	171	15
Encourage students to learn science using different sources other than textbooks, for example, newspaper, radio, TV, the internet, etc.	171	15

What is interesting about these results is that there is not much variation in teachers' responses to the statements presented in the first column of Table 6.1. This finding indicates that teachers perceived that linking science with students' lives in different ways was helpful in supporting the real-life orientations for the students.

However, lesson observation illustrated that in actual classroom teaching these aspects were rarely addressed. Regarding students' prior knowledge and experiences, researchers consider that students do not come into the class with blank ideas around the content (Leach & Scott, 1995). According to constructivist point of view it is the prior knowledge that shapes the way in which students build new ideas beyond their experiences (Fensham, Gunstone, & White, 1994). Therefore, students' preconceived ideas, values, and beliefs should be elicited, addressed and linked to their classroom experiences at the beginning of the lessons (Hipkins et al., 2002; Goodrum, Hackling, & Rennie, 2000). However, the lesson observations revealed that none of the teachers retrieved students' preconceived ideas from the previous lesson to link with real-life, at the beginning of the lesson, and then linked these with their classroom experiences.

The common feature identified during lesson observations was that not one of the six teachers explained teaching objectives or learning outcomes to the students to link the topic with real-life. This component was important for the students to know why they were learning particular science topics or what the benefits of learning these topics might be in future. Rather, teachers' announced the topic name as an objective of their teaching science, e.g., "today we will learn about aquatic plants" (Nabila). Nabila could relate planting trees to the need for the classification of plants or uses of aquatic plants using examples (such as, to make organic fertilizer) but she missed the opportunity by not explaining this to her students.

Lesson observations showed that among the six teachers, Khushi and Bishnu used some real-life examples related to lessons that were not provided in the content of textbook topics. For example, Khushi discussed the use of solar cells and the way these addressed the problem of electricity supply. This had an impact on her students, as articulated by the focus group discussion, as follows:

> Faria: *Our teacher makes our classes very interesting day by day. Her presentation varies from chapter to chapter. She provides various kinds of examples for our lessons for the different chapters. She gives us lots of information out of books. We think this technique is helpful for us to understand the lessons. She gave us an example of the atomic bomb that was used in the Second World War, when we were learning about atoms. In our last class she used a quiz, which was very interesting.*

This response reveals Khushi’s popularity as a science teacher as she used various real-life related examples that were useful for students’ understanding of science concepts. On the other hand, Sabrina used examples from the textbook topic (e.g., uses of sweet and hot chili). The other three teachers, Jalil, Nabila, and Shyamol did not use real-life examples in any of the observed lessons.

Regarding awareness of science related themes, problems or issues, Bishnu warned his students about ‘acid violence’ when he taught about acids. In Bangladesh there is an abusive practice of throwing acid at the face or body of a victim for vindictive reasons. This practice is often termed acid violence and is a social problem.

When Shyamol taught his students about the digestive system of chickens he explained the function of the pebbles that they take with food or grains. He advised his students that these pebbles carry out the function of teeth in grinding food during muscular contractions in the gizzard of chickens. At the same time, he warned them not to mix pebbles with chicken food to increase the chickens’ mass before selling them to make a profit in business. This is an important value for the students to learn, i.e., to abstain from the misuse of scientific knowledge and to be honest.

Lesson observations illustrated that not one of the interviewed teachers involved students in hands-on activities related to the lessons or encouraged them to apply their knowledge in appropriate situations. Neither were they urged to learn science using different sources other than textbooks, e.g., newspaper, radio, TV, or the internet.

However, during focus group discussions, Khushi's students observed that Khushi insisted they use the internet, and other sources of information, for preparing assignments related to their earlier science lessons.

> Nujhat: *I collected lots of information and pictures from the internet when I prepared my assignment on anthrax. The teacher provided us with guidelines for getting information about different viruses which cause contemporary animal diseases. This information was absent from the textbooks for Grades VI to VIII.*
>
> Shifat: *Mam I have collected information on anthrax from the newspaper.*

Hence, data from lesson observations and students' focus group discussions suggested that teachers' positive views in the questionnaire, regarding various aspects of teaching science, contradicted their actual classroom practices that often lacked a real-life orientation for the students. There was little evidence in their teaching practices that teachers linked a topic or lesson with students' prior knowledge and experiences, or they seldom explained how science is applied in everyday life situations.

6.4.3 Teacher' views of using teaching aids for real-life emphasis

Use of teaching aids is considered an integral component in drawing students' attention to a lesson, and in comprehending abstract and difficult ideas of science for effective learning (ÇİMER, 2007). Students' best understand and remember the ideas and concepts of scientific knowledge that are presented through audio-visual, pictorial or multimedia presentations (Nayar and Pushpam, 2000).

In the questionnaire, teachers were provided with a list of teaching aids and asked to select those they used in teaching science with a real-life orientation. They were also encouraged to mention other types of teaching aids they used in teaching. Teacher use of teaching aids is presented in Figure 6.8.

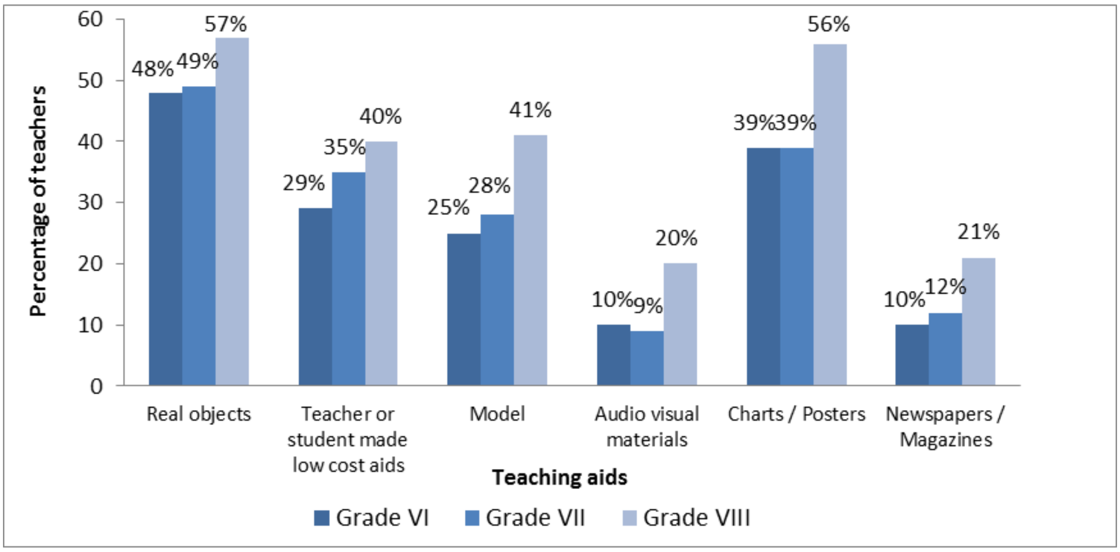

Figure 6.8: Teachers' Extent of Using Teaching Aids

These data demonstrate that teachers identified as using mostly real objects (e.g., chilli plant, thermometer, and magnet) in all grades, followed by charts/posters, then teacher or student-made teaching aids, and after these, models. However, the extent to which teachers used a range of teaching aids was greatest in Grade VIII compared with Grades VI and VII. Audio-visual resources and newspapers/magazines were less frequently used, as teaching aids, although these teaching aids have the potential to increase students' levels of understanding of contemporary science-related real-life problems and issues. Furthermore, their levels of understanding could be enhanced through the use of social media including radio, television, and the internet.

Lesson observations illustrated that teachers did incorporate real objects, such as chemicals or pictures in their teaching. For example, Jalil, Nabila, Sabrina and Bishnu incorporated magnets, aquatic plants, sour fruits, and chemicals, like sulphuric acid, and hand-drawn pictures to demonstrate lesson/topic-related scientific concepts. Sabrina provided chilli plants for her students and explained the external morphology of a chilli plant with a picture drawn by her students. Like Sabrina, Shyamol also used pictures drawn by his students during his lessons. In both cases, the size of the picture was too small (A4 size paper) to be noticed and observed by all the students of the class. Four of the six teachers (Khushi, Nabila, Jalil and Bishnu) used a chalk-board to draw pictures or for writing scientific terms, equations or solving mathematical problems.

During focus group discussions, students were probed about the teaching aids that teachers used in their science classes. One of Khushi's students commented:

> Jinat: *Our teacher sometimes uses charts or draws pictures on the board. Sometimes our teacher uses pictures drawn by us* [students]. *Book pictures are not always easy to understand or interesting. If the teacher only uses a book then she writes or draws pictures on the board again and again. This is very difficult and time consuming for her … the students also feels sleepy. If the teacher uses a projector then nobody will be sleepy and we can learn attentively. We don't like to learn by heart ... we want to see something more science-related through a projector.*

This comment illustrates that Khushi either used charts or drew pictures on the board. However, students wanted to learn from images shown by the teachers using projectors because pictures in books are not clear enough for students to understand the concepts of science. Jinat's response also illustrates that students would be more attentive if their teacher displayed pictures using a projector. The other positive outcome is that use of projected pictures might be more time efficient. Puspo's comment in this regard was:

> Puspo: *Mam, science is an important and interesting subject. So we want to learn in more interesting ways. We took a real onion, opened it and saw its different parts. If we learn using real or artificial objects then we learn easily. Supposing the teacher is teaching about the food cycle, if she comes to class with a model or chart of the food cycle then we can get a clear idea of it.*

Puspo went on further to provide an example of an audio-visual aid for a science lesson that was used in an Indian school, which she thought was effective for their learning.

> *It is basically used in Indian schools to teach science. At first it shows a tree. Then rain is falling on the tree. After that we learnt about chlorophyll, and finally … it shows us how the tree gives us food … Mam, we really want to learn science in this way.*

Puspo's response suggests that the students want to understand abstract concepts of science taught in an interesting manner by teachers using various types of teaching aids such as models, charts and audio-visual aids.

Responses from Nabila's students indicated that besides drawing and using real objects, Nabila involved each student in the actual practice of using a slide calliper to understand its measurement function. In addition, Nabila set practical activities for her students, such as collecting flowering and non-flowering plants, which she then used as a teaching aid for classroom studies. Nabila's focus on practical teaching activities is illustrated in the following examples:

> Sadia: *The teacher draws the figure on the blackboard and shows us teaching aids, if she has them. Recently she taught us about measurement. She brought slide callipers to class to help us understand measurement. Each of us used a slide calliper and understood how it works.*

> Mehjabin: *Our teacher told us to collect flowering and non-flowering plants. We collected the plants and stuck them onto art paper. We displayed them in the classroom and everyone saw them. During the teaching of the chapter, our teacher showed us the group tasks so that we could see these clearly and understand them easily.*

Like Nabila's students, Sabrina's students wanted to learn about science by doing it in the class, and through group discussion. For instance:

> Masud: *Our teacher often uses charts, for example, the oxygen cycle, as well as real objects, for example, a chilli plant, and pictures drawn by us.*

> Mahmud*: It's very important to learn science by hands on activities. It gives real experience and helps us to remember. We also want to learn science through drawing pictures, and wall magazines. We can remember our learning much more by seeing than listening. We can learn by discussion in groups too. Madam gives us group work. We discuss this amongst ourselves. This helps us to recognise our wrong conceptions.*

The focus group discussions with Shyamol's and Jalil's students revealed that Shyamol taught lessons without teaching aids, while Jalil sometimes incorporated teaching aids. Here are two examples given by their students respectively.

> Tania: *Our teacher teaches us with pleasure, sometimes drawing pictures on board, sometimes orally, sometimes we have to write.*

> *Maruf: In the former lessons our teacher taught us orally to make sure we understood the ideas but, today he showed us a thermometer*.

Hence, findings from the teacher questionnaire, lesson observations and students' focus group discussions illustrated that participating teachers generally used pictures or real objects in their teaching of science in all grades. Importantly, not one of the teachers used resources, such as audio-visual aids, models and other sources for teaching science. This was consistent with the questionnaire responses that demonstrated that teachers' used these types of teaching aids less frequently. Conversely, student focus group discussions indicated that in most cases teachers taught without the use of teaching aids.

6.4.4 Teaching methods to orient students to real-life

Researchers have advised teachers to consider a range of teaching strategies to enhance students' learning (Millar & Osborne, 1998) in science. Goodrum (2004) commented that the extent to which students will be able to use science in their everyday lives depends on 'what' and 'how' teachers teach. The junior secondary science curriculum (NCTB, 1995) instructs teachers to avoid a lecture method as much as possible with the emphasis on 'learning by doing' in teaching science. Therefore, in the questionnaire, science teachers were asked to indicate their teaching methods for exploring real-life orientations of students. Figure 6.9 presents the extent of the methods used in Grades VI to VIII.

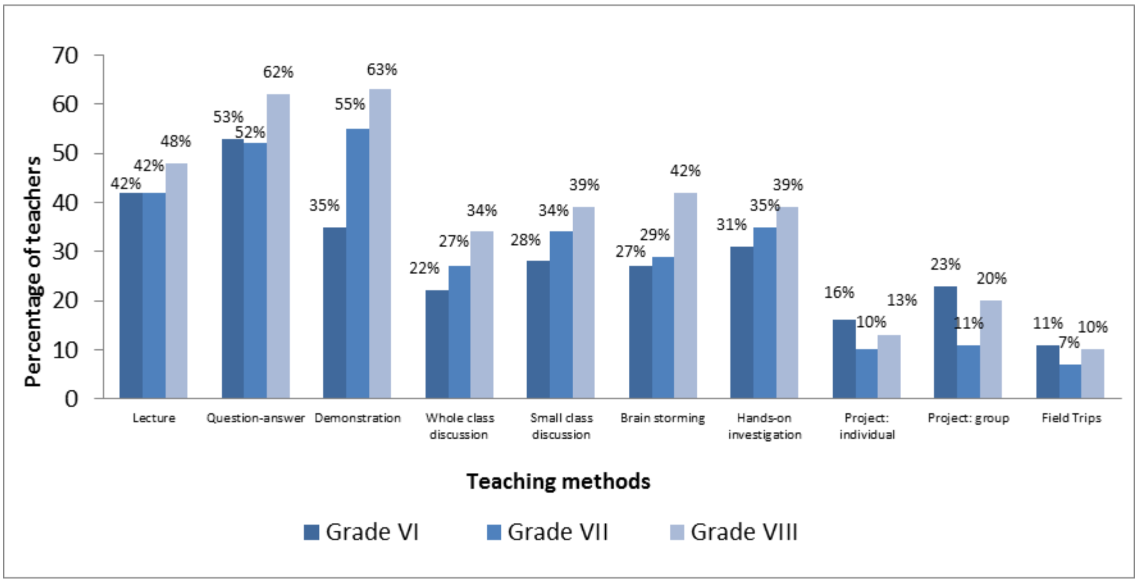

Figure 6.9: Teachers' Views of their Uses of Teaching Strategies in Teaching Science

It would be reasonable to infer from the questionnaire data that participant teachers mainly used lectures, question-answer strategies, and demonstration methods during their science teaching. Lesson observations illustrated that all six teachers followed the lecture method in conducting classes while, in addition to formally instructing Khushi, Nabila, and Bishnu incorporated demonstrations to clarify concepts. Students' in focus group discussions were asked to identify any differences in their teachers' teaching approaches between the lessons observed by the researcher and prior lessons. Their responses too revealed that teachers mostly followed the lecture method using demonstrations occasionally. The students gave the impression that, except for Shyamol, all of the six teachers involved them in simple practical activities either at school or instructed them to do those activities at home.

Here is a comment from one of Jalil's students when Jalil conducted a lesson using a lecture approach:

> *Sudipto: Sir explains the content. Then he draws the figures nicely on the board to help our understanding ... I understand how to prepare oxygen. He drew this picture on the board. I memorised it by rote. During the examination I wrote the answer nicely along with drawing the picture.*

Moreover, lesson observations demonstrated that Khushi conducted a quiz competition in her teaching along with question-answer activities and whole class discussion. This, allowed students to express their ideas and thoughts freely, and stimulated their participation (Harlen, 1999). Also, Khushi discussed a number of real-life examples related to the lessons. For example, the use of a magnetic compass to indicate geographical directions, such as sailors identifying directions in the open ocean; baking shik (thick iron rod used to bake kebab) kebab by burning coal where chemical energy stored in coals is transformed into heat energy. Her students related that Khushi conducted lessons using different methods:

> *Rosy: Most of the previous classes were theoretical. Some classes were based on practical. We did practical to observe the characteristics of acids and bases; we*

> *separated salt, water, and sand by filtering and vaporisation processes. Today she conducted quiz competition in our class.*

As with Khushi, Nabila used question and answer sessions during lesson observations whereas Jalil, Shyamol, Bishnu, and Sabrina barely used this teaching technique. Student focus group discussions revealed that their teachers sometimes used demonstrations to engage and motivate them to perform simple experiments. For example, Nabila's students said:

> Sadia: *We do not see any difference; our teacher explains lessons in the same way every day. She draws figures on the board. When teaching about plants, she demonstrates the different parts. She demonstrated the inner structure of a flower by cutting it. We also cut a flower at home. In the first chapter [i.e., Heat], our teacher showed us a thermometer so that we could measure the room temperature.*
>
> Mohua: *Our teacher did an experiment about the pressure of liquid. She used a container made of tin with three holes one above the other. We put wax in the holes to seal. Then we put tap water into the tin. We opened all of the holes at the same time. We saw the water come out at different pressures and it fell at different distances from the tin. We learnt that the speed of the flow of water from the holes was different because it is controlled by the depth of the water. In this way we did the experiment of the pressure of liquid.*
>
> Mehjabin: *Our teacher wrote a topic about biology on the board and told us to write our concept on that topic in groups … she gave us slide callipers to observe for two to three minutes. Then she told us to measure the diameter of the chalk … She demonstrated how to identify acid or bases with the help of litmus paper. We used lemon as acid and lime water as base*

It was observed that Bishnu in his class demonstrated the characteristics of acids and bases, and presence of acid in sour fruits through experimentation. His students' responses also illustrate that he inspired them to do experiments in groups at home instead of in the school laboratory or in the classroom. The following is a response from one of Bishnu's student:

> Farzana: *Today, our teacher demonstrated the characteristics of acids and bases and explained the preparation process of salt. He demonstrated that sour fruits like lemon contain acid … Another day he demonstrated that a lighted candle goes out when covered by a glass. We did it by ourselves at home. Sir also directed us to do some experiments at home in a group.*

Lesson observations revealed that among the six teachers, only Jalil, took the initiative to engage students in practical activities in the laboratory by inspiring them to make a temporary magnet. However, he did not discuss or provide opportunities for the students to think about its importance or use their learning in everyday life situations. For other parts of the lesson, which were abstract in nature (for example, magnetic field and magnetic lines of force) for the students, he read the experimental part from the textbook aloud instead of explaining the concepts by demonstration or by engaging the students in experiments. These observations were consistent with his students' comments in the focus group discussion. For example,

> Maruf: *The difference is in our former classes teacher only explained the content but, today, he gave us ideas about the content through hands-on activities. He gave us a thermometer. We were able to measure the room temperature in the laboratory. In another lesson he gave us a magnet. We did an experiment in the laboratory about preparing an artificial magnet by an induction process. There were other experiments in the book, which he described, but were difficult to understand.*

Teachers' responses in the questionnaire demonstrate that whole class discussion, small group discussion, brain-storming and hands-on activities were used less frequently by the participant teachers (see Figure 6.9). This finding was consistent with lesson observations. Only two out of six teachers, Sabrina and Shyamol, conducted small group discussions after completing lectures. The discussions were based on the content knowledge of the lessons. The following conversations with students illustrated Sabrina's methods of teaching.

> Mahbub: *The teacher explains with figures and tells us to draw a picture at home.*
>
> I: *What did you learn through hands-on activities in science lessons?*
>
> Mahbub: *We made a paper weight.*
>
> Khodeza: *No Mam, we did it at home but the teacher explained the process of making it in the class.*
>
> I: *What are the practical activities you have done in science classes?*
>
> Sujon: *No Mam, it is not possible in the class [cramped room]. It is possible only in the lab. We haven't got the chance to do those kinds of activities in the lab.*
>
> I: *How do you discuss topics in the class?*
>
> Mishu: *Mam, the teacher organises us in discussion groups. She also makes one person the group leader. Then we present what we discussed. After group work if*

the teacher ask questions and if we can provide the answers then we are very pleased.

I: *Are there any other ways you learn science, individual work?*

Mishu: *The teacher instructs us to read the topic at home before the lesson. Next day, she explains the topic more vividly so that we can understand the lesson.*

Titon: *Mam, the teacher tells us to memorise the answers from the guide books. We do that.*

I: *Your teacher supplied chili plants to the groups?*

Titon: *Yes Mam, if we observe demonstrations and do the practical work on our own, instead of just listening, then we can remember the lesson and it lasts longer in our heads.*

Sujon: *Mam, we want to learn by doing in the lab.*

The preceding conversation demonstrates that after conducting group discussions, Sabrina gave the students opportunities to present their group tasks ensuring that the answers were correct. She also encouraged her students to prepare for the next lesson by reading the topic beforehand. Sabrina provided tasks for the students that required observation or doing simple activities at home instead of in the classroom or in the laboratory.

Lesson observations illustrated that Shyamol's instructions to students, for small group discussion, were for each student to describe in writing at least two characteristics of each of the six organs of a chicken. Then they were to discuss these characteristics in their small groups. In another lesson Shyamol taught about the rearing processes of different breeds of chickens using a lecture method instead of organising a field visit to a poultry farm for students' to have a direct experience of the chicken rearing processes. Shyamol's students' indicated that he always used lecture and discussion methods in conducting lessons.

Hosna: *Sir teaches us by drawing figures. He discusses these with us. It helps us to remember the lesson.*

I: *What have you learnt through experiment or hands-on activities?*

> Tamim: *Mam, we haven't that kind of arrangement. We don't do hands-on activities. There's nothing in practical work. But, our teacher explains the content. We want to learn by doing.*
>
> Obayed: *Our teacher teaches us with care. Whenever we ask question he answers them with explanations.*

However, lesson observations revealed that the students did not have opportunities to participate in discussions, or to ask questions.

Teachers' responses to the questionnaire indicated their limited use of projects and field trips (see Figure 6.9) for teaching science. This finding was consistent with Sabrina and Shyamol's teaching practices, as previously described. In the comment section of the questionnaire, only two teachers mentioned that they used role play to help students understand abstract scientific knowledge (e.g., existence of atoms and molecules in three states of matter).

The findings of the questionnaire results, lesson observations and students' focus group discussions indicated that besides lecture, question-answer, and demonstration methods, teachers rarely involved students in group activities either at school or at home. Not one of the six teachers involved students in hands-on activities in the observed lessons, nor did they involve students in thinking about how they could use their learning in their everyday lives. Hence, the common goal for the six teachers was to ensure students clearly understood the science curriculum content using traditional practices, i.e., by the "pervasive use of transmissive pedagogies", rather than considering how students might learn to apply their scientific knowledge in their everyday lives.

6.4.5 Teachers' views on assessing students learning for real-life emphasis

Considering that assessment is an important part of teaching to identify students' meaningful learning, four statements derived from Goodrum (2004) and Hackling's (2004) studies about processes for assessing students' learning were included in the questionnaire. Teachers were asked to consider whether they agreed that the statements (presented in Table 6.2) contributed to building science learning that was relevant to the students' lives. These statements are presented in the table along with the frequency of their representations. These frequencies are also represented as percentages determined by dividing the frequency of responses by the total number of occurrences (N=606 responses) to these statements.

Table 6.2: Aspects of Assessment in Teaching Science Relevant to Students' Real-Life

Aspects of assessment	Frequency of responses	Percentage of responses
Emphasis on memorising scientific terms and facts	88	15
Ask students a range of open questions to assess students' understanding of applying science knowledge in real-life	154	25
Provide with appropriate assignment/activities related to real-life to assess students' ability to apply science learning in real-life	171	28
Provide feedback after assessment	193	32

The data in Table 6.2 indicate that the majority of teachers (i.e., 32%), suggested feedback after assessment as the most preferred way to assess science relevant to students' real-life. According to Black (1993), quality feedback after assessment helps their students to fill-in their learning gaps. The percentage of frequency of teachers' responses (28%) regarding assessing students' learning through life-related assignments and activities was the second favoured aspect of assessment. The third favoured aspect, represented by 25% of frequencies of teachers' responses, was asking open-ended questions that contribute to developing students' understanding to apply science in real-life. Teachers' responses on memorising scientific terms and facts were (15%) the least favoured aspect of assessment. These results demonstrate that the teachers' responses to the questionnaire statements gave least emphasis on memorisation of scientific terms and facts as being important for learning.

However, there was a clear mismatch between these findings and the outcomes of the observations of teachers' teaching practices. During lesson observations, it was identified that one teacher, Jalil did not assess students' learning. The other four teachers (Nabila, Bishnu, Shyamol, and Sabrina) assessed students' learning by asking questions around the content of the textbook topics that required correct answers reflecting the accuracy of students' rote memorisation. One example observed was when a teacher asked students to '*define acid*'. Rather than requiring the students to use their reasoning and interpretation skills to describe factors, such as the composition or uses of acid, the teacher wanted students to reproduce the textbook definition. Nabila and Shyamol repeated the questions and answers from the textbook content several times for the students to lock the answers into their memories. Moreover, they directed questions to specific students, rather than the whole class. Sabrina and Shyamol also assessed students' content knowledge through small group discussions in which students shared and wrote answers to the questions provided by the teachers. However, not one of the questions gave the students an opportunity to demonstrate their thinking ability to reason and discuss in answering the questions.

On the other hand, Khushi assessed students' learning in groups through a quiz competition. She divided students into five groups, drew pictures on the board and asked questions. For example, after drawing two boats on the blackboard, one with a "goon" *(Bangla term for a rope or chain by which a boat is pulled)* pulled by a man and another with a sail and a man, Khushi then asked students what type of energy was being used to move each boat (for the first boat mechanical energy, and for the second one air energy). If one group was unable to provide the correct answer, other groups took the opportunity. For each correct answer each group received one star mark. At the end, the group with the highest number of stars won the competition. In this way, Khushi encouraged the students to ascertain the correct answers about different types of energy, the transformation of one type of energy into other forms of energy, and the linking of those energies with everyday life examples.

Hence, teachers' views of asking open-ended questions, providing assignments or activities, and feedback after assessment to identify students learning gaps, and to take measures to close the gaps for applying science knowledge in real-life, were absent in most of the teachers teaching practices observed in the classroom. Rather they emphasised assessing students based on rote memorisation. This kind of assessment did not elicit the students' understandings regarding the application of scientific concepts in everyday life, but determined to what extent transmitted knowledge was remembered. In the focus group discussions, students were not asked about the ways in which teachers assessed them so there was no data with which to compare with the view of teachers.

6.4.6 Teachers' self-reflection about their own teaching

As part of post-lesson interviews, participant teachers were asked to explain their feelings after teaching various science topics. They were asked what benefit students received from their science learning that could be applied in their everyday lives, and how they could have taught the lessons to achieve this goal. Many similarities were found in their responses. The following quotes from the teachers' self-reflections are examples of their justifications of the way they taught saying that students understood the content.

> *I believe that students have learned about magnets, magnetic induction, poles 100% and they will have benefitted. I taught them practically. It's better than lectures … I hope they have learned better this way.* (Jalil)

> *I feel I am satisfied, because when I drew the pictures for their understanding of different kinds of sources of energies on the blackboard, my students were able to tell me the names of the energies, and their uses, in real-life, and they were very thrilled. I believe that from these examples they understand how they could apply their knowledge in real-life. I am optimistic, because they understood the theoretical part through pictures. They understood renewable and non-renewable sources of energies, too. I think these examples will help the students to make use of this learning in their real-life. When they enter into their working life they will remember these uses and apply their knowledge and skills.* (Khushi)

> *The aim of the lesson was to give a clear idea about aquatic plants. After assessing the students learning through questions I feel I'm successful in completing the aim.* (Nabila)

> *I would say that the outcome is satisfactory. I used the demonstration method using real aids which was perfect for this class. So, they understood the lessons and they answered all questions correctly. I am optimistic that this process will help them to improve their quality of learning.* (Bishnu)

> *I told them beforehand to read the chapter. During teaching I try to make them understand the lesson. They find it easy that way. I do it in each class.* (Sabrina)

However, Shyamol's comment reflects that he was not sure that his students fully understood the lesson although he tried his best to make the subjects and their content clear.

> *I try to give my level best. It is true that I cannot give 100%, but I try to give at least 50-60%.* (Shyamol)

It is clear from teachers' responses that they emphasised students' understandings of theoretical knowledge about the science content. It has been mentioned in the former section that participant teachers assessed students' content knowledge based on memorisation. There was no opportunity for the students to apply their reasoning in answering the questions or their knowledge in their everyday lives. Lesson observations and teachers' responses in post-interviews suggest that most of the teacher participants' (e.g., Jalil, Khushi, Nabila, Bishnu, and Sabrina) levels of teaching satisfaction were determined by assessing students' content knowledge. As previously mentioned, this was because the teachers felt a great responsibility in order to support student achievement in the examinations. This is because examination designers develop questions covering the textbook content. In Bangladesh teachers' performance is determined by students' results (Holbrook, 2005; Sarkar, 2012a). Students were well-aware of the importance of obtaining good marks in examinations. For example, during a focus group discussion, students were probed about their reasons for memorising content. Here is an example of the response to this question from one of Nabila's students:

> Tamanna: *We try to understand. If we do not understand the content from the description then we memorise it, because we have to do well in the examination. We have to get good marks. So, to get good marks in an examination you have to memorise the answers.*

Regarding students' learning from the topics and their ability to apply knowledge in real-life, the six teachers pointed out a number of ideas from the lessons they taught. However, it was interesting that many of the ideas they discussed were not used during their teaching practice. This means that, although theoretically teachers understood how they could teach the lessons more effectively for real-life application, they do not implement it in practice. For example, Jalil said:

> *Students can use a magnet in many ways. Suppose a needle is lost then they can find it with a magnet. They will be able to make an artificial magnet to use for many purposes. For example, a magnet is used in a fan. They can use the magnet to determine direction ... I could use very small iron filings, drop them on the floor and tell the students to find them using a magnet. Moreover, I explained the magnetic lines of force and magnetic field. In that case, it would be better if I could demonstrate those using iron filings, bar magnet and compass, but I could not show them because there was no time left.*

The focus group discussion with his students indicated that they had difficulty in articulating the immediate uses of magnetic properties in their daily lives. Here are some examples of their responses,

> Ibrahim: *I have learned to prepare a temporary (artificial) magnet. I want to use this knowledge in future.*

> Maruf: *For different purposes we can use a magnet. I know artificial magnets are used in making fans.*

> Sudipto: *I have learned from today's class how a temporary magnet is prepared; the opposite poles of two magnets attract each other and similar poles repel each other. This knowledge may be useful but, for me, it is not used much in my life ... I*

> *have learned about AIDS and I have shared my knowledge with those who do not know about this disease. In this way we can use our knowledge. Also, from chapter about heat I have learned about the rail line, that is, the cause of the gap between two consecutive rails; I could not use that learning. I get heat from the sun. The heat we get from the sun is useful to me. I can dry my clothes but expansion of matter due to heat- I could not use this knowledge. If we understand we will be able to use this [knowledge] in future. If we don't understand we will not be able to use this [knowledge] in future, for example, if we choose science in grade 9-10 then zoology, botany, chemistry and physics will be available. To study these subjects the science we have learned here will be needed. If we cannot learn by hands-on activities and cannot demonstrate anything we have learned, then we will not understand future science. If we go to study medical science then we will need to conduct examinations to detect diseases. In this case, we can use our learning gained from doing experiments.*

Despite having understood content of the lesson through experiments with magnets, neither Maruf or Ibrahim, nor Sudipto could articulate the immediate uses of their learning. Sudipto thought that learning was useful for understanding future science. Students' comments and lesson observations indicate Jalil's inability to link science content with everyday life in his teaching.

In contrast to Jalil, Nabila could not articulate her ideas as to how students could use their knowledge of the classification of aquatic plants:

> *Students will be curious about nature and environment. I don't think these lessons can help the students much in everyday life. But water hyacinth is used to make organic fertilizer; I forgot to share that.* (Nabila)

However, Nabila's students were advanced in this particular case. During focus group discussions with her students, when they were asked how they could apply their science learning in real-life, they came up with a number of ideas about the uses of different types of plants. For example, Tamanna proposed that knowledge of the habitat of different types of plants would be helpful for the careful plantation of trees while Mehnaj recognised that some aquatic plants, such as *Kalmi* [Botanical name: Ipomoea] spinach can be used as sources of nutritious food. Here are some examples of actual responses:

> Tamanna: *Plants help to balance the natural atmosphere… if we know the exact habitat of all types of plants, we could be more careful in planting different types of plants.*

> Mehnaj: *"Kalmi spinach"* [Botanical name: Ipomoea] *can be grown on both land and water. This spinach helps to provide the nutrition that we need.*
>
> Mehjabin: *Well, water hyacinth is a great example of aquatic plants. It can be used in making paper; organic fertilizer ... Chemical fertilizer is harmful whereas organic fertilizer is very effective for nurturing the land to grow crops. Water lily, Kalmi spinach* [Botanical name: Ipomoea] *and Helencha* [Family name: Asteraceae] *can be used as food meeting our nutrition needs. Beside this "water hyacinth", "khudipana"* [Duckweed, Family name: Lemnaceae], *"topa moss"* [water lettuce] Scientific name: Bryophyta] *can be used as fertilizer.*

These responses suggest that the students were drawing on their previous experiential knowledge. Nabila did not ask the students about this type of knowledge during the observed lessons. Regarding teaching methods Nabila felt that:

> "*If I could arrange a video clip it would be more effective. For example: about the uses of water hyacinth or water lily, I couldn't arrange a field trip for the students because it is too tough to organise a field trip.*"

Nabila demonstrated the characteristics of aquatic plants through different types of plants. She also used a plant classification chart by drawing it on the blackboard. Her self-evaluation illustrated her feeling that her teaching could have been more effective if she were able to include direct experiences, for the students.

Khushi had a number of ideas about what she could do in her teaching stating that:

> *I could show the students one compass that was fixed in my "jaynamaj" [mat used for praying]. By taking them to a new place I could ask them to show me the west direction. It might happen that they could not answer but then I could tell them to stand on the "jaynamaj" and see the compass on it; you can understand in which direction one has to pray. I could also take them into a science laboratory or our atomic energy centre or into a science museum to show them the function of a solar cooker and solar cell ... or a coal mine or any gas field to show them how these products are being extracted and burned, then they would understand that these resources will be finished one day. We have lots of gas but we do misuse this gas. I could not tell them about being conscious of using non-renewable energies properly, especially use of gas because the students were keen to take their tiffins. Madam, I do not know if you can remember my class was before tiffin (lunch) period. The students wanted to take tiffins ... If I could show them any videos of our houses ... or could discuss how housekeepers dry our clothes by keeping them over the gas cooker then they could understand how we are misusing gas.*

Khushi's self-evaluation indicated that she was aware of a number of teaching methods and resources she could use to teach her students about the relationship between science and everyday life. In the focus group discussion, Khushi's students also expressed a desire to learn science in different ways that incorporated models and audio visual aids, as discussed in Section 6.4.3.

Shyamol's self-reflection about teaching, *Vertebrate animal: Fowl*, demonstrated that he was aware of local resources he could use for teaching.

> *If I could take the students to a poultry farm while teaching them about the different types of fowl, their features and rearing processes, they could get practical knowledge and their learning could be better. Actually I have not got that time. It takes a long time if I want to show anything practically. But, I believe that sometimes the village students are more advanced in learning science. Fowls are available in villages and the students have them in their houses, so they know how to rear them and what sorts of diseases they might have and what the treatments are. I could ask students in the previous class, who have poultry in their villages, to observe and investigate the different types of improved breeds of fowls, their rearing processes, and other things like diseases and treatments. Then, in the next class I could ask them to tell me about all of these and other related things.*

Like Khushi, Shyamol also did not plan the lesson in advance although he had an opportunity to visit a poultry farm to support students' learning within a local context. But, according to Shyamol, time constraints prevented such planning.

Sabrina articulated the usefulness of curriculum-based lesson knowledge for the students in various ways. She said:

> *Students who were in the class had known many things about chilli especially its types, sweet and hot chilli, uses and its importance. Chilli contains vitamin C; this will help them to cure dental problems. They have known the scientific name of chilli and about the life cycle of the chilli plant. They have known that germination isn't possible without sufficient air and light. I told them that the chilli plant is a cash crop of our country. Students could suggest that their fathers, who are farmers, cultivate the chilli plant. In this way the students will get vitamin C and will benefit financially. But I missed it. It would be better if I told them during class-time.*

Sabrina realised that she could fill this knowledge gap by inviting village students to share their experiences regarding the cultivation of chilli plants and their benefits. What Sabrina perceived from her self-reflection regarding linking lesson knowledge with real-life is exhibited in the following extract from a student focus group discussion:

Sabrina's village students talk about how they could utilize their knowledge from the topic in everyday life situations.

> Faisal: *We can use the knowledge of chilli plants in cultivating chilli. Now we have the knowledge to cultivate sweet and hot-- both types of chillies. We can keep it in our memory for cultivation ... I know that a chilli plant gives many fruits. It continues fruiting for 5 to 6 months. We have many uses of hot chillies. Hot chillies are used to prepare spices, and sweet chillies are used to prepare salad, sauce etc. Chillies are very useful. Money could be earned by selling it.*

Bishnu was aware of the teaching methods he needed to use in his lessons; he was familiar with the instructions in the teachers' guide and he was keen to incorporate teaching practices from his training programs into his classroom. Nevertheless, the physical limitations of his classroom, time factors, and the absence of partitioning walls between the classes did not permit him to implement the ideas in the teachers' guide or the skills acquired in the training programs. Also, he was not able to conduct experiments and demonstrate various science-related processes in the classroom. Bishnu said that:

> *I used a demonstration method to show them the properties of acids and bases. I also showed them that sour fruits contain acid. The demonstration method was perfect for this class. It would be better to have more time to let them participate in doing experiments in groups. The process could be more effective if I could bring more equipment, demonstrate the tests more clearly by using both litmus paper and natural indicators. But for some problem it is not possible. More apparatus, chemicals, natural indicators should have been brought. But this method could disturb the other classes. There is no partition between the classes.*

Focus group discussions with all groups of students expressed the view that they preferred to learn science practically in the laboratory. But, as previously contended, due to a shortage of laboratories for the junior secondary students and insufficient class time, students are generally deprived of the opportunity to learn science practically. The following comments from two of Nabila's students support these observations.

> Mehjabin: *If each student did the practical work in the laboratory, then it would be better. But we are not getting this chance. If you are in Grade IX or X then you will be taken into the laboratory.*

> Sadia: *We are now in Grade VIII, and there are many chemical reactions in the book that we cannot do practically but our seniors can see those. So if we could see them practically from Grade VIII, it would be more helpful. If each student can do*

practical work by herself it would work better ... it helps with remembering ... But, the class duration should be more than 35 minutes ... Teachers should be given more time to prepare for classes. They shouldn't do classes one after another. There must be a break between two classes. If the teacher takes two classes one after another his/her patience can decrease. As science is so difficult the teachers need to be patient.

In summary, the self-reflection about their own teaching identified gaps in the teaching practices of this group of teachers as well as an awareness of factors, such as time and resource limitations that impacted their teaching. They were conscious of alternative teaching methods and techniques that would allow them to teach science with a real-life orientation. The gaps identified by the teachers included the absence of practical activities in the classroom; the teachers' preparation of lessons plans was restricted by factors, such as time and resources; and the implementation of alternative teaching methods, including experiments, constrained the teachers' capacity to shift the learning focus from rote memorisation to a real-life application of science. The findings of the student discussion groups supported these factors contending that, ultimately, the delivery of lessons was compromised. The barriers teachers' encountered in teaching science are discussed in Section 6.6. Before proceeding to that section, the following section provides the curriculum emphases that teachers focussed on, while implementing the curriculum.

6.5 Curriculum Emphases in Teaching Practice

Regarding curriculum emphases, the lesson observations illustrate that all six teachers mostly emphasised Solid Foundation, and the Structure of Science. All of them gave little importance to real-life curriculum emphases throughout their teaching. For example, by engaging students in making an artificial magnet Jalil highlighted the Structure of Science and Science in Making. He taught the students about magnetic poles, and their attractive and repulsive properties for Solid Foundation to understand how the Earth acts as a magnet. But Jalil did not discuss or encourage students to share their experiences about using the attraction property of magnets in their daily lives; neither did he engage students in relevant activities in the classroom. Hence, he did not give importance to Science in Application. From the focus group discussion with his students, it appeared that students could not connect magnetic properties with their immediate use in real-life (see Section 6.4.6). Jalil's teaching method demonstrated little initiative in engaging students by doing experiments, while requiring them to learn science content which was not connected to their everyday lives.

In addition to Solid Foundation and/or Structure of Science, three of the six participating teachers, Khushi, Sabrina, and Shyamol, linked science learning to the real-life curriculum emphases during their teaching. Sabrina focussed on Science in Application by explaining that the amount of capsicum present in chilli causes both hot and sweet tastes. This knowledge is useful for the students; they can make use of chilli in their everyday lives by preparing different tasty food items, such as curries, or salads. Khushi addressed Science, Technology, and Decisions by discussing how a solar cell might be used in coastal areas where electricity is not available. He also explained how solar cells could be used on house-roofs in big cities, including those in Bangladesh, to solve some of the electricity supply problems, e.g., load shedding. Shyamol linked the rearing of improved chicken breeds with real-life and motivated students by explaining how they could benefit from the knowledge gained during the lesson thereby emphasising Science for Nurturing. The focus group discussion with Shyamol's students, after the lesson observation, suggested that they perceived the usefulness of learning science about chickens.

> Obayed*: Today we have learned about fowls, the placements of the organs and their functions. We can rear fowls, we can take care of them, and we can also eat them.*
>
> Tania: *We get nutrition from fowls from the eggs and meat. This* [rearing fowls] *will come into use when we are able to run a poultry farm. We will sell the eggs and fowls and then we can earn money.*

Obayed referred to learning about the rearing of chickens for the purpose of eating while Tania considered eggs and meat as nutritious foods that were a useful source of protein that is crucial for maintaining health. As a result of the lesson, Tania understood the utility of her knowledge, i.e., Science for Nurturing, and perceived the possible use of her learning for business, as in the building of a poultry farm.

As previously stated, Shyamol advised his students to use their scientific knowledge honestly. Student focus group discussions confirmed this value as useful in learning science, as identified by one of Shyamol's students:

> Mamun*: I learnt that fowls' digestive systems are different from human digestive systems. Fowls eat small grains, uncooked rice and paddy etc. They eat small stones with their food to digest it well in the gizzard. If stones are fed to fowls it increases their weight. Sir* [teacher] *also said that you shouldn't feed them stones while selling them. This knowledge is useful for us; we need to be honest. In our society there are dishonest sellers.*

Mamun understood how dishonest chicken sellers profited in their business. He valued his teacher's explanations of the importance of being honest in using scientific knowledge. Thus, through explanation, Shyamol emphasised values in his teaching that were a part of the everyday life of students.

Bishnu linked scientific content about acids, bases and salts and their characteristics with some real-life examples. By demonstrating the characteristics of acids and bases he emphasised Structure of Science. For example, he demonstrated that acid turns red litmus blue, and it is sour in taste. By connecting to these properties of acid he demonstrated the presence of natural organic acid (i.e., citric acid) in sour tasting fruits using red litmus paper, such as in lemon. He said that sour fruits are "*good for health*", and provided examples of yoghurt and cold drinks that contain (organic) acid. To teach the burning property (harmful effects) of inorganic acids (concentrated) he drew students' attention to the issue of acid violence in Bangladesh. By using the example of acid violence he emphasised morals that eventually may prevent students from misusing acid. The teacher asked the students to be cautious when handling acid. He showed how a soap solution acts as an alkali and turns blue litmus red, and is slippery in nature. He mentioned that soap acts as a cleansing agent and sodium chloride is used as table salt or for cooking and thereby linked science knowledge with Science in Application. Bishnu made links between science and students' lives, which were perceived as worth knowing by the students. However, it may be argued that Bishnu could have emphasised Science in Application and Everyday Coping by sharing additional information with students during his lesson. For example, he could have mentioned the reasons for using salt, yoghurt and lemon in food preparation and their necessity for health (i.e., salt makes electrolytic balance in our body, iodised salt is used for goitre disease, sour fruits contain vitamin C).

Hence, regarding curriculum emphases, it was observed that most teachers emphasised Solid Foundation and Structure of Science when teaching. The other non-real-life aspects of curriculum emphases, such as Scientific Skill Development, Correct Explanations, and Self as Explainer were not addressed during teaching. However, in relation to real-life curriculum emphases, Jalil highlighted Science in Making; Bishnu, Sabrina, and Shyamol focussed on Science in Application; and Khushi addressed Science, Technology, and Decisions. Nevertheless, in most cases the teachers were unable to move away from the textbooks when preparing and delivering their lessons. I support the teachers, as they faced many challenges in teaching science that placed constraints on their teaching practices. These challenges are discussed in the next section.

6.6 Challenges in Teaching Science

This section presents teachers' views about the barriers they encountered in promoting students' learning focussing on applying science in everyday life. Data are be presented from the questionnaire and teacher interviews. Six types of barriers to science teaching were given in the questionnaire. The teachers were asked to rank the barriers or challenges using numbers, i.e., 1=first choice, 2=second choice etc. (Figure 6.10). They were also asked to add other barriers they encountered in teaching science, in a given space, on the questionnaire. It should be mentioned here that teachers' ranks were scored inversely in order to calculate the average rating of the scores. For example, if a teacher put rank "1" for the challenge 'lack of resources', then this was scored as "6" and considered as the most dominant challenge.

As seen in Figure 6.10, participating teachers viewed the heavy teaching load as the most challenging issue in their science teaching. This finding supports earlier results presented in Section 6.2.3. Similar findings were obtained from the six teachers. During interviews, teachers identified that they had weekly teaching loads of 25 to 36 lessons. Teachers ranked "lack of resources" and "large class size" as the second and third challenges in teaching science.

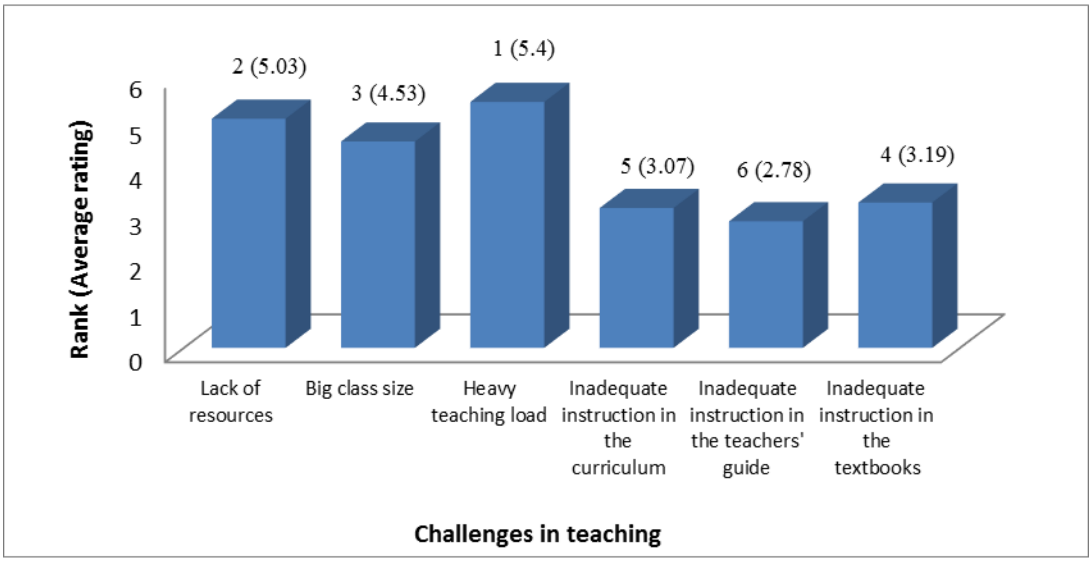

Figure 6.10: Teachers' Challenges to Enhance Science Learning

While Jalil had only 27 students in his class, Khushi, Sabrina, Nabila, Shyamol, and Bishnu had large numbers of students (Section 6.2.3) in their classes, which were beyond the standard size ratio of 1:40. This situation, together with congested classrooms, compelled Khushi and Nabila to follow the lecture method. As previously observed, Bishnu argued that it was impossible for him to conduct practical work in groups with a large number of students, in cramped class room, with no partition between classes. Figure 6.10 also demonstrates that inadequate instructions in the textbooks, teachers' guides, and in the curriculum were viewed as lesser challenges. Findings from teachers' interview indicated that although textbooks gave no explicit instructions for teaching, teachers got some direct and indirect teaching hints by reading the content of these guides. Here are two examples:

> *There are many pictures in textbooks which indirectly tell us that students should be taught by using those pictures. There are also some instructions on experiments, for example, how to make soap and sodium chloride salt. Such types of direct and indirect instructions are in the textbooks. In addition, by reading textbooks I can make my decisions about when to explain and discuss, when to demonstrate, and when to prepare charts although teaching instructions are not explicitly expressed in them. Furthermore, I also tell my students that if they can't continue their studies they can survive by rearing fowls, cultivating fish and catering (from the textbook content). In this way, textbooks are really helpful to my teaching.* (Khushi)

> *The pictures in the textbooks are useful for teaching. For example, there are two pictures of chilli plants in the book: one with different parts of the chilli plant and another one with the life cycle of this plant. I get ideas from these pictures that I can use the picture to teach my students about the chilli plant. For instance, I can ask students to draw a chilli plant and label the parts of the plant. I also get the idea that I can use the real chilli plant to demonstrate the different parts of this plant to students.* (Sabrina)

The above responses indicate that the textbooks supported teachers in teaching science as they gained ideas about particular methods and techniques to use including demonstrations, experimental instructions, and the use of charts, pictures and real objects.

During interviews, teachers commented that they usually did not have access to the curriculum. Consequently, not one of the six participants could explain the science teaching strategies suggested in the curriculum. Shyamol and Sabrina did not see the curriculum at all as this was a special document held by head teachers in their offices. As expressed by one of the participants:

> *I cannot remember the curriculum. It would be good to look at the curriculum in my leisure time but we cannot get it as our head teacher keeps it to himself. We never get it*. (Shyamol)

From this statement it is evident that the curriculum is not readily available to the teachers, hence the reason why the government produced textbooks have become the de-facto curriculum. From the above comment, it is also conceivable that the teacher considers the curriculum is only for the head teacher and it is not accessible to him. It could be argued that the curriculum should be available to all teachers irrespective of their positions in the hierarchy.

Regarding teachers' guides, Jalil, Nabila, Khushi and Bishnu mentioned that they had read the older versions of teachers' guides, and acquired some ideas about teaching methods and techniques from these documents. For instance, Jalil described how teachers' guides help teachers to teach.

> *This* [teachers' guide] *is a milestone: it helps us to decide what to teach, how to teach and how much to teach. Learning outcomes, teaching objectives, and teaching methods are presented there. It instructs the teachers to be realistic, to use teaching aids in the classrooms and to use laboratories to engage the students with practical experiments and hands-on activities. Teachers' guides ask us to manage the teaching aids. Students can be even asked to make and bring teaching aids if those are not available at schools. For example, students can bring thermometers from home and use them to learn about using them or they can draw pictures and charts to use for their learning.*

Khushi articulated how she benefitted from teachers' guides:

> *It seems to me that teachers' guides are very helpful for innovative thinking and especially for the novice teachers. Mostly, for novice teachers it is hard to teach properly. So they can seek help from the instructions in teachers' guides for thinking about innovative activities for the classroom, applying new strategies and proper teaching aids, and eventually improving their teaching quality. When I started teaching I found the teaching aids to be very expensive and time consuming to prepare and collect. But later on, thanks to the teachers' guides, I learnt how to prepare cost effective teaching aids within a short time. I also found out that I can ask my students to prepare such teaching aids which can help me a lot with teaching.*

It is clear from these responses that specific objectives, learning outcomes and teaching instructions are provided in the teachers' guides. However, as has been mentioned in Section 6.3, most of the teachers reported that the teachers' guides were not available to them. For example, Shyamol and Sabrina had no idea about the teaching strategies presented in the teachers' guides as they had never seen one.

In addition to the above challenges, participating teachers in the open-ended question identified other barriers that produced 407 data occurrences. These are categorised and summarised in Table 6.3 under the heading *Frequency of responses* and *Percentage of responses*. The percentages were determined by dividing the frequency of responses by the total number of occurrences (N=407) of these challenges.

Table 6.3: Additional Challenges Faced by the Teachers

Additional challenges	Frequency of responses	Percentage of responses
Teacher related:		
Lack of in-service training	28	7
Lack of subject teacher	21	5
Poor knowledge	21	5
Lack of helping teacher or lab assistant	2	0.5
Science teachers are engaged in other activities	1	0.2
Resources:		
Lack of teaching aids (chart, model, chemicals, microscope and scientific equipment	119	29
Lack of technology (computer, laptop, multimedia etc.)	15	4
Unavailability of curriculum, teacher guides, reference books	12	3
Infrastructural problems:		
Lack of furniture/sitting arrangement/spacious class room	48	12
Lack of science lab	14	3

Lack of storeroom to preserve teaching aids	6	1
Others:		
Shortage of class time	81	20
Big syllabus	11	3
Financial crisis	21	5
Students poor knowledge	7	2

The data presented in Table 6.3 indicate that resources, e.g., insufficient teaching aids (29%), allocated class time (20%), lack of furniture, seating arrangements and inadequate classroom space (12%) presented significant challenges to the teachers as they attempted to engage students in activity-based learning. The unavailability of the curriculum and teachers' guides as an issue accounted for a lower percentage of response rate (3%).

These findings were consistent with interview findings. All six teachers reported a lack of resources, such as teaching aids, equipment and consumables like chemicals, inaccessibility of curriculum and up to date teachers' guides. In addition to the above constraints Bishnu, mentioned the financial issue at his school regarding buying teaching aids. Nabila, Sabrina, and Shyamol also talked about insufficient time allocated for science classes. Here are two examples:

> *I do not think that the methods I follow are completely suitable for the students. They need more practical tasks and more life related approaches. But I can't do this because of the lack of time, long syllabus, and many students*. (Nabila)
>
> *The prime problem is time constraint. It's not possible to explain and engage students practically in a 35 minute class; it should be at least 45 minutes. Moreover, I have to take 8 to 9 classes daily. So, it is not possible for me to prepare or collect teaching aids, I can't do many things because of limited time.* (Sabrina)

Both Nabila and Sabrina were conscious of the students' lack of engagement in activities due to big class sizes and restricted teaching times for science classes. Moreover, Nabila was anxious about the overloaded curriculum that had to be completed within a limited time. Sabrina on the other hand wanted to increase the allocated class time up to 45 minutes so that she could conduct classes properly using teaching aids. Shyamol found group work impossible due to lack of time as there were too many groups formed (e.g., 11 groups) given the large number of students in his classes (e.g., 117 students); Therefore, he struggled with his time management, particularly when he was supervising students' group work.

> *If we try to teach in groups, many groups are formed and it is very difficult to conduct group work properly with the huge student numbers as well as to provide them with feedback within a limited time*. (Shyamol)

Lesson observations indicated that Shyamol could not monitor, or provide feedback to all groups, during the allocated class time.

Four of the six participants mentioned that since there was no break between classes, they had to run from one class to another, so faced difficulties in collecting teaching aids.

> *I have many materials ready to use in science classes but when I go from one class to another it is really difficult to take them.* (Nabila)

> *Some teaching equipment is kept in the head teacher's room because of the small space in the lab. These are under his control. It is difficult to collect the equipment before a science class.* (Jalil)

In this situation, Jalil, Khushi and Nabila felt the need for an assistant or support teacher for conducting science lessons if they were to implement different methods. For instance:

> *I have 5 classes every day. I do not have extra time. It is hard to organise the teaching aids as I run from one class to another and try to maintain each class. Due to the large number of students and limited time I cannot demonstrate experiments and use teaching aids though these are available in school. If someone assigned to assisted me to bring the teaching aids in the classroom then I could teach them properly keeping in connection with real-life*. (Khushi)

In addition, Khushi and Sabrina reported time table issues in teaching science.

> *I teach science in Grade VIII in two sections. The timing of these two classes is in the last periods. The students are in a hurry to go home and they also do not have the energy to grasp the science lessons properly. Similarly, in Grade VI the period of the science class is before tiffin (lunch) time. The students become restless. They want to eat their tiffin. I think this is also a problem for me. So, if*

> *the science classes are placed on the roster earlier in the day, well before the tiffin period, then we can teach the students properly.* (Khushi)

> *It would be better for us if the science classes were held before all of the other classes.* (Sabrina)

From these comments, it is clear that the timetabling of science classes at a different time of the day could help Sabrina and Khushi maintain the students' attention. However, in the centralised curriculum system of Bangladesh, individual schools do not have the authority to change the timetable for science classes.

Regarding infrastructural problems, all six teachers reported problems of congested classrooms, inappropriate seating arrangements and inadequate space in classrooms, load shedding of electricity, and lack of room for storing teaching aids. During the lesson observation it was observed that Bishnu's classroom did not have a partition between it and the adjacent classroom resulting in excessive sound and noise during teaching. The teachers' comments, along with the observations made during their teaching practices, reveal that conditions suitable for creating a learning atmosphere were absent in these science classrooms:

> *The seating arrangements of the classroom are not good. Moreover, the furniture is not suitable. There are high benches and low benches, and these cannot be moved. At one bench five to six students sit instead of three. You will give them activities, but there is no space for me to go close to them to show the teaching materials or to place those. There is also the problem of electricity, and because of load shedding all the students start sweating, so this is also a problem.* (Khushi)

After she was asked how she could face this problem, she said,

> *Still ... I could not solve this problem. I have informed administration about the teaching-learning methods of science, that is, that these should be application based but I am in a trouble, no action was taken. From administration* [i.e., policy makers as well as in national education policy] *they said to keep the ratio 1:40. If my institutional head wants to keep the proper ratio or divide the class into three sections, and keep the capacity normal, then the teachers can teach their lesson nicely. But the problem is we don't have spare classrooms. In a poor country like ours it takes time, and it is financially hard to construct the buildings and classrooms needed.*

It is obvious that a lower teacher-student ratio and a spacious classroom with appropriate seating arrangements might help teachers conduct life-related lessons satisfactorily. But these challenges will remain until the authorities take the initiative to divide classes into sections and infrastructure problems are solved.

Shyamol and Sabrina felt the lack of access to the laboratory was an issue. They believed that a laboratory in which students could conduct experiments played a significant role in encouraging students to develop their conceptual understanding of science while experiencing authentic science opportunities. For instance:

> *Students will learn practically and will apply their learning in real-life. At present they are just studying, they are not seeing everything. It's because there is no laboratory to do things like carbon dioxide preparation, and to observe its properties. They can see these in a lab and understand why this gas is used to extinguish fire. I have shown them the figures. But everything they need to learn properly is not available to them … there is no laboratory for them.* (Sabrina)

Most of the schools in Bangladesh have lack of facilities for teaching science, especially non-government rural schools (Tapan, 2010). However, this does not mean that these kinds of activities cannot be done without a laboratory. In such cases teachers can obtain help from teachers' guides, which provide instructions for low cost and no-cost teaching aids to use in conducting experiments when a laboratory is not available. Ultimately, it depends on the teachers' interests, motivation and proper training regarding their use of these types of low-cost materials in science classes (Tapan, 2010).

Another important finding from the interviews related to the teachers' concerns was about their professional development experiences and opportunities. In their response to the barriers of teaching science in the questionnaire, the percentage of frequency of teachers' responses to the issue of training was comparatively low (7%), suggesting that the teachers did not perceive it as being a significant challenge. However, in the interviews the six teachers strongly expressed their dissatisfaction with their professional development. Not one of them had received an opportunity to participate in a training program for General Science and one teacher, Khushi, did not get any professional development training at all. Furthermore, Jalil's comment demonstrates that he was not pleased about the professional development training he attended. Questionnaire data showed that Jalil attended a training program for teaching physics. He identified his limitations in teaching the content of General Science textbooks.

> *Over all science is reality based and of course there is something to learn in training but we are not fully satisfied with this training. It should be more extensive. We need intensive training based on content and hands-on activities of those experiments which are in the General Science textbooks. Then we will know how we can teach to help the students learn, which type of teaching aids we need to use, and how we will assess them.*

As discussed earlier, the General Science course is an integrated course of different science subject areas. In Bangladesh, the duration of short-term professional training for each course provided by TQI is usually two weeks. According to Jalil this is not enough to address all the aspects required to teach General Science courses. Jalil argued for intensive training focused on content knowledge, methods of teaching and assessment processes regarding General Science courses at the junior secondary level. During the interview he mentioned: "*some experiments with acid were hard to teach*". His words described his lack of knowledge regarding chemistry topics and might explain his apparent lack of confidence to teach different areas of General Science courses other than Physics. Studies revealed that the teachers' levels of subject matter knowledge, and related pedagogical skills, affected the quality of instruction and its outcomes.

Nabila's point of view was that the training program did not give directions for teaching a large number of students in a congested classroom:

> *There is no alternative to training. According to me training assists us in knowing how we can teach a lesson using materials. Through training we find out how we can motivate the students. If anyone can show us the way to perform in a classroom of 70 to 80 students, like the present situation with my class, with a difficult seating arrangement, and how to use teaching materials in this environment with the pressure of syllabus completion, then it would be invaluable.*

In this situation teachers cannot be, or should not be expected, to orient students towards for real-life science on their own, without any support from the authorities. Therefore, it is essential for the professional developers to take account of teacher feedback when developing and/or revising training programs for general science teachers.

On the other hand, Sabrina's problem was different. Being a social science teacher, she was teaching science at the junior secondary level and felt ignored by the school authority for not sending her for professional development training. To be prepared for teaching science she urged that the head teacher should encourage her to attend in-service professional development training.

> *The help of administration is needed for the betterment of teaching. As I am a social science teacher, training in science would be great as I have to take science classes also. I could learn many things practically. I told the principal about this, but he didn't do anything. Only Mr. Daulat from this school has training in science. I can't go to training because the principal says that there will be shortage of teachers.*

After being asked whether she discussed how to teach a particular topic with other teachers, she said: "*Yes I do discuss it with Mr. Daulat. He helps me a lot.*" In this instance discussion with colleague was useful for her to learn and remove her anxiety around the teaching science. Thus, barriers in teaching General Science identified in the questionnaire responses were consistent with responses indicated by the interviewed teachers.

Teachers were asked to make suggestions about initiatives that might make science learning relevant to real-life situations with 487 responses provided by the 183 participants. Table 6.4 provides a summary of those suggestions with the percentages determined by dividing the frequency of responses by the total number of frequencies of suggestions in their responses.

Table 6.4: Teachers' Suggestions to Make Science Teaching Relevant to Real-Life

Teachers' suggestions	Frequency of responses	Percentage of responses
Resources:		
Supply of updated teachers' guides	60	12
Supply of sufficient teaching aids (equipment, laptop, computer, chemicals)	58	11.9
Solving infrastructural problems through building more laboratories, creating environment for real-life teaching and learning, and making more rooms for classes and for storing teaching aids.	42	9
Appointing meritorious, trained and efficient subject teachers through fair selection	40	8
Organising field trips, study tours, science clubs, science fairs, and publishing science magazines	18	4
Reducing class size	7	1
Practical classes to be included in the timetable	1	0.6
Teachers:		
Need training (subject wise and also in using technology)	29	6
Class load needs to be reduced	7	1
Supervision of science classes by the Head Teacher	4	0.8
Cooperation between teachers and school authority	2	0.4
Curriculum, textbook and pedagogy:		
Teaching through nature/environment observation, hands-on activities, using ICT and real-life examples, and emphasis on practical application of science	162	33
Need more real-life related content and work oriented topics	40	8
Syllabus should be of reasonable length	7	1

Better timing for science class in the time table and increasing time allotment for science class	6	1
The list of references to be included in textbooks	2	0.4

Data in Table 6.4 demonstrates that the most important factors identified in teachers' responses, to make science learning relevant to real-life were: teachers' use of appropriate teaching methods and techniques including ICT (33%), supply of up-to-date teachers' guides (12%), sufficient teaching aids and equipment (11.9%), and solving infrastructural problems (9%).

During focus group discussions students identified factors they perceived impacted negatively on the teachers' ability to make science lessons more relevant to real-life situations. Some of these factors were similar to those nominated by the teachers (Table 6.4) including: teachers' limitations regarding resources, shortage of allocated time for teaching science, and no break time for the teachers to prepare for science lessons. For example, Shyamol and Nabila's students said that they had no arrangement for using a science laboratory. Sabrina and Bishnu's students stated that they do some experiments at home instead in the classroom or in the laboratory. Nabila's students argued for increasing the allocated class time, which they thought was insufficient for teaching science. They also pointed out that no break for teachers decreases their patience of teaching science using different methods.

Findings from questionnaire data, teacher interviews and focus group discussions outline the aspects that teachers and students consider might improve the conditions for teaching science in Bangladesh. Crucial for the teachers is that in minimising or solving these aspects it would help teachers to make science learning relevant to real-life.

6.7 Summary

This chapter presents teachers' and students' views of teaching science, and their reflections on their own teaching practices addressing the following research question:

> RQ 3. What are the perspectives of teachers of implementing this curriculum with a real-life emphasis?

The findings revealed that the majority of the participating teachers were science degree holders with teaching degrees. Also, they had undertaken professional development in-service training in science and non-science subject areas. Nonetheless, only 15% of the participating teachers attended professional development training for teaching the General Science course at junior secondary level. This type of professional development is critical for all teachers of the General Science course at junior secondary level. Heavy teaching loads and large class sizes provided teachers with challenges for classroom management, and in the use of a wide range of teaching techniques. In five of the six schools represented in the study, the preparation and delivery of lessons was hampered by the unavailability of a copy of the junior secondary curriculum and older versions of teachers' guides. Science textbooks were the only supportive resources that teachers could access readily in their schools.

Teachers and students generally agreed that the main goal of science education was to allow students to apply their science learning in real-life. In addition, the students acknowledged the importance of scientific knowledge for further study in science or in entering science-related professions. In the questionnaires, teachers' beliefs about teaching techniques demonstrated that they valued developing students' understanding of scientific knowledge, and linking it to the real-life orientations of their students. They nominated a number of teaching techniques for making these linkages, and for aspects of assessment, which made a significant contribution to science learning.

However, there was a mismatch between the questionnaire results and those of the lesson observations. With a small number of exceptions, lesson observations demonstrated that, there was minimal evidence of the teachers applying either the nominated teaching techniques or aspects of assessment in their classroom practices. Most of the teachers conducted lessons through oral communication in the form of lectures, question-answer, plus demonstration methods using a limited number of teaching aids, i.e., they used a transmissive pedagogy (Shirazi, 2017) to communicate content knowledge. Consequently, students acquired mostly knowledge of science rather than processes for learning to apply their scientific knowledge in real life. Real-life curriculum emphases were rarely incorporated in the lessons. The combining of all data sources indicated that implementing the curriculum in relation to real-life did not occur for a range of reasons.

The next chapter, Chapter 7, will address discussion and implications of the results identified in Chapters 4, 5, and 6.

Chapter 7
Discussion of results, implications and conclusion

7.1 Introduction

This chapter considers the overall findings of this study's investigation into the relationship to real-life of Bangladesh's junior secondary science curriculum (JSSC). The discussion focuses on the extent to which the JSSC, its corresponding textbooks and teachers' perspectives of teaching science enable students to apply their learning in real-life by examining the data with regard to these research questions:

1. To what extent is the junior secondary science curriculum of Bangladesh real-life oriented?
2. To what extent are the science textbooks in Bangladesh real-life oriented?
3. What are the perspectives of teachers of implementing this curriculum with a real-life emphasis?

A detailed analysis of the orientation of the JSSC to real-life was articulated in Chapter 4 while Chapter 5 elaborated on the orientation of the science textbooks to real-life. Teachers' and students' perceptions about the implementation of the curriculum regarding their real-life emphases were provided in Chapter 6.

Chapter 7 summarises the major findings, as they respond to the research questions, revealed in these preceding chapters and discusses them in the light of science education literature. Following this, the implications of the findings are identified along with some limitations of this study and directions for future research. The discussion commences with the key findings.

7.2 Addressing the Research Questions

7.2.1 Junior secondary science curriculum and its relationship to real-life.

The theme of the first research question was:

> To what extent is the junior secondary science curriculum of Bangladesh real-life oriented?

The findings of this study identified a number of relevant characteristics of the junior secondary science curriculum that indicate the curriculum is not strongly related to the real-life of the students.

1. Much emphasis was placed on pure science content: A review of the specific objectives and learning outcomes for each of the topics of JSSC (Grade VI to VIII) demonstrated that a heavy emphasis was placed upon the pure science content in the curriculum, with few connections evident to real-life (Table 4.2, 4.4 and 4.6). In all grades, Solid Foundations and/or the Structure of Science were the key emphases in the specific objectives and learning outcomes of the curriculum, which are characteristic of a traditional science curriculum (Roberts, 1988; van Driel & others, 2008). This type of curriculum cannot help students to learn science meaningfully (Roberts, 1995) to apply their knowledge in real life situations.

2.Real-life emphases are absent in some topics: In some of the topics, across all grade levels, real-life emphases were totally absent, both in the specific objectives and learning outcomes of the General Science curricula (Table 4.2, 4.4, 4.6). Consequently, these topics had no relevance to students' personal and social lives and the pure science content of the curricula was favoured over application of knowledge which tends towards a lack of real-life curriculum emphases. This result is indicative of a traditional science curriculum for preparing future scientists and science-related professionals

(Fensham, 1985) and inconsistent with the characteristics of a 'Science for All' curriculum. In these topics, students cannot see the importance of understanding of science and its products and processes. Sjøberg (2001) reported that science curricula in most countries were criticised for being traditional, overloaded with facts and information, and concentrated on 'big ideas', and key principles. It seldom treats the contemporary issues.

3. *Some emphases are neglected in the curriculum:* In the specific objectives and learning outcomes of the JSSC, limited emphasis has been placed on the areas of Science, Technology and Decisions; Scientific Skill Development, Correct Explanations, Science in Making, and Self as Explainer. It was identified that Correct Explanations was absent in the specific objectives for the topics in Grades VI (Table 4.2) and VII (Table 4.4), while the components of Science, Technology and Decisions were absent in those of the Grade VII (Table 4.4) and VIII (Table 4.6) curriculum. Moreover, Self as Explainer was not emphasised at all in any of the specific objectives and learning outcomes of the JSSC for Grades VI to VIII. These findings are inconsistent with Roberts (1988), who argued that curriculum emphases are genuine purposes for school science and all curriculum emphases can be considered equally important as they all have their role around enhancing students' learning. For example, sometimes students hold misconceptions regarding everyday phenomena due to personal experiences, social environment, religion and other contextual considerations. The emphasis Self as Explainer in the curriculum ensure students "active involvement in scientific reasoning" (Fensham, 1997) and helps teachers to identify students' alternative conceptions or misconceptions, and facilitate conceptual change. On the other hand, the presence of the Self as Explainer assist author to develop curriculum materials for students' active engagement in a process of knowledge restructuring. Involving students in activities regarding scientific reasoning, encourage questioning in

the classroom. The absence of Self as Explainer, in the objectives and students' outcomes of the curriculum was reported by Demircioğlu et al. (2005) who argued that many of the science curricula and textbooks do not address students' alternative conceptions. Hence, absence or neglect of related curriculum emphases in the curriculum will affect on student's conceptual development for fulfillment of their science knowledge to apply in everyday lives.

4. *Uniformity was not maintained in developing the specific objectives and learning outcomes of the curriculum*: Analysis of the curriculum across all grade levels demonstrated that, for the majority of topics, there were incompatibilities of curriculum emphases. Some curriculum emphases linked to specific objectives were not found in the learning outcomes. And, some emphases associated with the learning outcomes were absent in the specific objectives. This lack of uniformity of application of emphases is the second type of imbalance identified. Considering the significance of the curriculum emphases, specific objectives and learning outcomes for each topic of the junior secondary science curriculum need to be restructured to fill the gaps. Whatever topics are chosen in any areas of science, related curriculum emphases that are appropriate for the students at this level must be consistently developed. Otherwise, gaps or inconsistency of curriculum emphases in the specific objectives and learning outcomes of the related topics will affect authors to develop textbook content properly emphasising on both real-life and non-real-life curriculum emphases. In turn, it might influence teachers to teach students without engaging in any kind of activities to apply scientific knowledge in their real lives. This is because teachers view the textbooks as the content authority (Nargund-Joshi, Rogers, & Akerson, 2011). As presented in Section 6.5, in their lessons, teachers mostly taught the content knowledge of textbooks, emphasising non-real-life curriculum emphases through Solid Foundation and/or Structure of Science. Other non-real-life and real-life emphases were given little

consideration in comparison to Solid Foundation and/or Structure of Science. While the aim of the curriculum was to link science to students' everyday lives, textbook content did not reflect the intended specific objectives and/or learning outcomes of the curriculum. As a result, of the six teachers, Shafiq, Sabrina and Bishnu emphasised Solid Foundation and/or Structure of Science in their teaching, along with Science for Nurturing and Science in Application, using examples mentioned in the textbook. These teachers did not provide examples of their own outside of the textbooks' examples nor did they engage students in activities to apply scientific knowledge in their real lives. It was as if they viewed the textbooks as the content authority (Nargund-Joshi, Rogers, & Akerson, 2011). This type of teaching science without linking it to real-life situations is likely to be unhelpful for students' meaningful learning.

The discussion above suggests that the junior secondary science curriculum is not strongly related to real-life and provides minimal opportunity for students to apply their science learning in everyday life. While the goal of science education is about orienting students to real-life, this curriculum with key emphases in Solid Foundation and Structure of Science will create an issue here in Bangladesh. Students will not be interested in learning science. This may be the cause of decreasing science student's day by day in Bangladesh.

7.2.2 Junior secondary science textbooks and their relationship to real-life.

The second research question was:

> To what extent are the science textbooks in Bangladesh real-life oriented?

The major findings of this study showed the following features in the content of General Science textbooks that indicate that the textbooks are not orientated towards real- life of the students:

1. Textbook contents mostly based on pure science content: The analysis of the (Grades VI-VIII) textbook topics on the basis of the ten curriculum emphases demonstrated that, across all grades, excessive emphasis of Solid Foundation and Structure of Science in the specific objectives and learning outcomes of the junior secondary science curriculum, which are followed in developing the textbook topics, may cause an emphasis on pure science content in these books. The finding is consistent with Sarkar and Corrigan (2013) who reported that science textbooks at the junior secondary level of Bangladesh mostly emphasised science content that was academic in nature and not connected to students' lives (Sarkar, 2012a, 2012b; Sarkar & Corrigan, 2013). While teachers in Bangladesh see the textbooks as defacto curriculum, and follow only the textbook content to teach students, their emphasis will definitely be on pure science content during teaching. Consequently, teachers will not relate concepts of science with students' meaningful learning.

2. Real-life emphases are totally absent in the textbook content of some topics: In some of the textbook topics at all grade levels, real-life emphases were totally absent. Some of these topics (in different grades) include: *Cell; Surface of the Earth; Animal Kingdom; Sea and Ocean; Structure of Matter—Atom and Molecules*. By presenting their content in terms of scientific classifications and terminology, these topics characterized traditional textbooks that prepare students for future studies in science-related courses. Fensham (1985) suggested that the features of a 'Science for All' curriculum should include content that has immediate and obvious personal and social relevance to the learners. Otherwise, students will not be interested to learn science if they do not find any relationship of these content to their lives.

3. *Some emphases are neglected in the textbooks*: In the Grade VI textbook, Correct Explanations is not addressed in the content (see Table 5.2). Self as Explainer is not emphasised at all in text content of any topics at all grade levels (see Table 5.2, 5.6

and 5.10) while limited emphasis has been placed on Science, Technology and Decisions, Correct Explanations and Science in Making in all grade levels (see Table 5.2, 5.6 and 5.10). These findings identified in the textbook topics are contrary to Fensham's (1994a) ideas that all curriculum emphases are considered as equally important and should be emphasised in the topics according to students' needs and interests. Absence or inadequate curriculum emphases in any particular topic can negatively affect in teaching and students' learning, as mentioned previously.

4. *Intended curriculum had some influence in developing the content of textbook topics*: Following the curriculum, the textbook authors incorporated real-life curriculum emphases in the textbook content. For example, Everyday Coping, Science for Nurturing, Science in Applications and Science in Making were addressed in the topics *Features of Invertebrate Animals: Shrimp;* and *Health Rules: Skin Diseases* related to Biology in Grade VI, *Heat* (Physics topics in Grade VII), *Simple Machines;* and *Energy, Living being and Natural Resources* (Physics and Biology topics in Grade VIII respectively). These topics had relevance to the students' personal and social lives so they could apply their learning in their daily lives to solve problems. Not only that, according to Östman (1996), the emphases were also helpful for them to learn what knowledge was helpful in solving problems and how problems were to be perceived. For example, learning about causes, symptoms, treatments and prevention of contagious skin diseases helps students to be aware and take care of their skin.

5. *Mismatches of curriculum emphases within same topics between the textbooks and curriculum*: Inconsistencies of curriculum emphases between the curriculum and textbook topics were identified for the majority of topics across the three grade levels. Some of the curriculum emphases that were ignored in the specific objectives and/or learning outcomes were addressed in the associated topics in the textbooks. Uniformity was not maintained in terms of curriculum emphases in the textbook content following

the curriculum in all grades. However, in a number of topics, the textbook content filled some of the gaps around required emphases that were not addressed in the curriculum. For example, in the topic *Weather and Climate* in Grade VII, Everyday Coping was not emphasised in the curriculum but this emphasis was addressed in the textbook topic (see Table 5.8). It was possible because there has been revision of the textbooks but, clearly, there has not been corresponding revision of the curriculum.

Comparison of alignments of real-life and non-real-life aspects of curriculum emphases in terms of number of frequencies of occurrence in the curriculum and textbooks (see Table 5.5, 5.9, and 5.13) revealed that, in all grades, the textbooks featured non-real-life and real-life curriculum emphases more than the specific objectives and learning outcomes did in the curricula. But the alarming point is that the non-real-life aspects in textbooks were emphasised at more than double the rate in Grade VI and VIII, and triple in Grade VII, than the real-life aspects.

The same organization, NCTB, developed both the curriculum and textbooks, but huge differences regarding the rates of inclusion of non-real-life and real-life aspects are observed between the curriculum and textbooks. These different rates show that textbooks are shifting away from the real-life aspects of curriculum emphases. These findings in the textbook content will provide guidelines to develop the Bangladeshi curriculum and textbooks in such a way that will educate students in science in ways that can be meaningful for them.

7.2.3 Teachers' perspectives of implementing the intended curriculum.

The third research question of this study was:

> What are the perspectives of teachers of implementing this curriculum with a real-life emphasis?

Connecting school science with students' lives was considered in this research as an important aspect for promoting students learning to apply science knowledge in real-life situations. Insights into teachers' perspectives were gained through a questionnaire, interviews with six teachers, classroom observations and students' focus group discussions. The following discussion illustrates their views of teaching real-life science and of the way these views are translated into implementing the curriculum.

1. *Teachers' views of teaching aspects related to real-life science contradicted their classroom practices*: The majority of teachers in this study considered that students' applications of scientific knowledge in real-life should be the prime goal of science education. This result is consistent with 'Science for All' (Fensham, 1985) that is aimed at preparing informed citizens along with future science professionals. Teachers' responses were also positive regarding some aspects of teaching science that can promote students' meaningful learning. While most of the teachers' questionnaire responses were positive regarding some aspects of teaching science to enhance students' meaningful learning, in fact, in most instances, these teachers' views were not demonstrated in the classroom practices for the six teachers observed and interviewed for this study. Science teaching and learning was teacher-centered. Learning by doing, scientific inquiry, problem-solving, rational thinking, analysing cause-effect relationships, developing students' creativity and innovativeness were noticeably absent in the teaching practices. They did not encourage students to learn science from different sources other than textbooks. They presented the content to students in the same way as provided in the textbooks and did not even clarify the lesson objectives which could help students understand the reasons for learning science. As a result students cannot grasp the taught lessons relevance with real-life or non real-life topics. This is in line with Babu's (2010) finding that teachers mainly depended on a lecture

method for delivering lessons and is inconsistent with constructivists' approaches of teaching and learning science.

The study findings revealed that teachers' practices of teaching, where they emphasised science content knowledge and did not relate lessons to everyday life situations, were totally opposite to the majority of teachers' responses from the questionnaire about the prime purpose of science education. Morris (1986) argued that most teachers do not use officially recommended approaches to teaching science although their attitudes are favorable to those approaches. On the other hand, Babu (2010) commented that they had limited capacity to translate their ideas into their actual classroom teaching practice. Sjoberg (2001) pointed out that students perceive school science as lacking relevance.

The main reasons behind not using the scientific approaches for engaging students in activities was expressed by the interviewed teachers include: teachers' heavy class load, big class size, shortage of allocated time for teaching science and resource scarcity. Similar reasons were identified by Babu (2010), that teachers' huge workloads and lack of ingredients were the causes of not practicing the activities suggested in the textbook. Another reason is the importance of public examination, where the structure of the examination does not support an inquiry-based approach to learning science. These types of pedagogical approaches may fail to meet the needs of the majority of students and fail to fulfill the major goal of science education which is to apply students' learning in everyday life situations.

The above discussion regarding teaching approaches provided important insights into the widespread decline in students' interest in enrolling in science at the secondary and higher secondary levels in Bangladesh, as in many developed countries (Caillods, et al., 1996).

The findings above are important for the policy makers to create opportunities for the teachers of Bangladesh to conduct training program about constructivist teaching and students learning process to promote higher-order thinking skills such as problem solving and critical thinking (Li et al., 2013). Teachers' practices during professional development will open their insight about the benefits of the constructivist teaching and learning process, and how constructivist teaching differs from the traditional approach.

2. *Teachers' limited use of teaching aids for real-life orientation of the students*: Results of this study showed that participant teachers mostly used charts, pictures or real objects. Five out of the six teachers used real objects (Referring to Section 6.4.3) in their lessons for demonstration. Two teachers used pictures which were very small and not clearly and equally observed by the students. The use of inappropriate teaching aids is unlikely to draw students' attention and interest sufficiently and students were silent and passive learners. These findings were consistent with Babu (2016) that teachers did not use proper teaching aids and, in most cases, they did not know how to use them appropriately.

3. *Teacher-assessed students' learning based on science content*: The majority of the teachers' responses in the questionnaire indicated that asking open-ended questions, providing assignments, activities related to real-life and feedback after assessment contributes to students' understanding of applying science in real-life. However, these examples of appropriate practice were not observed in their lessons observed. Rather, teachers assessed students' ability to recall theoretical knowledge by testing the science content of their knowledge, which was the lowest level of learning domain according to Bloom's Taxonomy (Bloom, 1956).

Teachers' lack of training in creative question development may be the cause of assessment of students' learning through memorisation capability. For example, in this study, only 26% of the teachers who completed the questionnaire and one interviewed teacher had participated in creative question development training. Another cause identified during teachers' interviews was that, in most of the schools, subject teachers have no opportunity to develop questions for their students for the half-yearly and final examinations because school authorities buy questions from teachers' associations for cost effectiveness. Where most of the interviewed teachers did participate in assessing students learning since most of them had not been trained in formulating creative questions, none of their questions in the classroom reflected why, how and where students will apply their knowledge for a particular topic.

Assessing students' learning is a formidable task for teachers if they are to address real-life curriculum emphases to promote, and orient students towards, real-life applications of science. The textbook-driven examination system (Holbrook, 2005) in Bangladesh may be the cause of teachers' assessing students' learning through rote memorisation, where answers to the questions are provided in the textbooks. In this situation, students are not expected to learn and link science with everyday lives. Rather, they are prepared for getting high marks in the examination, which will help them to choose a science stream in Grades IX and X or choose a science-related profession.

As has been shown, implementing the curriculum to orient students to apply their learning in real-life is a challenge for teachers in Bangladesh. The following section discusses teachers' perspectives of other challenges in teaching science for implementing the desired aims of the curriculum.

4. *Teachers' Perceptions of Challenges in Teaching Science to Implement the Curriculum*: In the questionnaire, teachers were asked to rank barriers to teaching science for students' meaningful learning will be discussed individually.

Class Teaching Load: The average teaching load per week of the teachers was 27 (Section 6.2.3). This finding is consistent with Hossain (1994, 2000), Babu (2016, 2016), Tapan, (2010), Rahman (2011), and Sarkar and Corrigan (2013), who identified teachers' excessive class teaching loads in their studies in Bangladesh. This is because, in most cases, they were required to teach both mathematics and science classes at the junior secondary level (Rahman, 2011). In addition to this, subject teachers take classes in physics, chemistry and biology at the secondary and higher secondary level. On top of this, teachers engage in administrative work (Rahman, 2011). This situation impacts on teachers' capacity to appropriately prepare and teach the content and assessing students' learning using varieties of methods and techniques to meet students' need for meaningful learning.

Class Size: The findings showed that, in this study, 23% of classes comprised 41 to 60 students, 44% of classes included 61 to 120 students and 24% of classes had more than 120 students (Section 6.2.4), which were one and half to three times larger than the class size of 40 students per teacher recommended by the National Education Policy, 2000.

It should be mentioned here that in secondary education, to increase the access and equity among poor boys and girls, including those living in remote areas, the Secondary Education Quality and Access Enhancement Project (SEQAEP) provided stipends and tuition fees since2008. This measure has increased students' enrolment tremendously. On the other hand, the number of teachers was not increased in line with student enrolment. Under these class size conditions, teachers tend to deliver traditional, lecture-based instruction to complete the syllabus and students remain passive, non-participative and disengaged (Deveney, 2005; Vajyavutjamai & Clements, 2006). Moreover, except for the textbooks, teachers in this study had no other teaching materials, such as teachers' guides or worksheets. Importantly, this situation is found in other developing countries like India, China (Nargund-Joshi, et al., 2011; Zhang et al., 2003), and Thailand (Tolley, Johnson, & Koszalka, 2012), where teaching science as inquiry is hindered by large class sizes and limited materials.

Shortage of Class Duration and Lack of Teacher Assistance: As noted previously in Chapter 6, teachers understood, during self-reflection on their teaching, that they could teach students using varieties of teaching techniques and methods but, due to a shortage of class duration along with excessive teaching load, big class size and shortage of resources, they could not teach lessons meaningfully. They felt the allocated time of 35 to 40 minutes for teaching science did not allow the time required to implement different techniques and methods. For example, Shyamol reported that it was not possible to monitor and provide feedback to all groups due to a shortage of class time. Similarly, shortage of class time period did not permit Nabila and Shyamol to use different teaching approaches as they were anxious about the overloaded syllabus that had to be completed within a limited timeframe. On top of these time constraints, Jalil, Khushi and Nabila felt the need for supporting/helping teachers to enable them to conduct science lessons following different methods and techniques. This lack of helping teachers meant they could not collect the teaching aids due to no break time between classes, even when some aids were available and could be useful for students' meaningful learning of science. Except in pre primary level there is no provision in the 2010 education policy of Bangladesh for appointing supporting teachers in secondary schools.

Resource and infrastructure problems: This study identified resource and infrastructure obstacles (e.g., lack of teaching aids, lack of furniture, sitting arrangement and spacious class room) for teachers' as compromising their science teaching. They mentioned they could not plan their lesson for students' active engagement due to such problems restricting inclusion of group activities, video use or field visits, for instance, and being restricted to demonstrating experiments instead of the students conducting group experiments (as mentioned in Chapter 6). This result is consistent with the study by Caillods, et al. (1996), where they identified the lack of facilities and equipment, and inappropriate teaching and learning conditions as major reasons for the teaching methods used in developing countries.

Issues of Curriculum and Teachers' Guides: Unavailability of the junior secondary science curriculum and teachers' guides were another concern for the teachers interviewed in this study. Although, 68% of the respondent teachers indicated that the curriculum and teacher' guides were available in their schools, this was not the case for the teachers interviewed in this study. The interview data showed teachers do not study the curriculum for teaching purposes and that the teachers' guides referred to old versions of the textbooks. These issues are, understandably, perceived as challenges to the interviewed teachers, especially those who did not see the curriculum and teachers' guides at all (and it can be assumed the remaining 32% of questionnaire teachers feel similarly concerned). Overall, the teachers felt they were unable to articulate the goals of science education stated in the curriculum or the teaching strategies suggested in both curriculum and teachers' guides for teaching science at the junior secondary level.

Teacher Related Issues: Some teachers perceived the lack of in-service training, lack of subject teachers and teachers' poor knowledge as limitations to teaching science. In this study, only 15% of surveyed teachers were trained in teaching General Science courses and only one interviewed teacher had the opportunity for developing creative questions for assessing students' learning. These were also found by Caillods, et al (1996) in other developing countries like Bangladesh. Teacher's access to training opportunities to teach science can impact on teachers' confidence to teach General Science with pedagogical skills. Similarly, access to training to develop creative questions may influence teachers to assess students' learning with relevant questioning skills that can help students to apply their thinking ability in answering the questions.

The discussion above regarding teachers' perspectives of implementing the curriculum revealed that neither teachers' teaching practices nor teaching facilities provided teachers in their implementation of the junior secondary curriculum with a real-life emphasis. The ways students are learning science are helping them acquiring theoretical knowledge and in most of the cases without conceptual understanding of science that cannot help them to be scientifically literate citizen to use science in real life contexts. Another tension is between the goal of preparing future scientists and science for all – despite the rhetoric about the curriculum being science for all, the reality appears to be more preparing future scientists. If appropriate teaching and learning strategies are not used, it is difficult for them to participate in decision- making and to take responsible action to deal with real-world problems.

7.3 Implications of the Findings of the Study

7.3.1 Implications of imbalanced curriculum emphases in the specific objectives and learning outcomes of the curriculum for textbook authors

The aim of the curriculum was to orient students in such a way so that they can use their acquired scientific knowledge and skills to improve their quality of lives, solve day-to-day problems and make decisions through life oriented and work oriented education in accordance with personal and societal needs. This aim allows teachers to use real-life emphases in teaching science. However, the current emphasis of learning outcomes and specific objectives of the curriculum are not targeted on all the curriculum emphases. Much emphasis was placed on pure science content by giving excessive focus on Solid Foundation and Structure of Science in the specific objectives and learning outcomes of the curriculum. Moreover, limited emphasis on Science, Technology and Decisions; Scientific Skill Development; Science in Making and absence of Correct Explanations in the objectives and learning outcomes, and absence of real-life curriculum emphases in some of the topics created imbalances of curriculum emphases in the objectives and related learning outcomes.

Therefore, if authors of the textbooks are aware of the real-life curriculum emphases then they can avoid the imbalance of the specific objectives and learning outcomes of the intended curriculum by focussing on more real-life oriented applications in the textbook content. Otherwise, the above results suggest that textbook authors stressed the pure science content rather than accentuating other non-real-life (Correct Explanations, Scientific Skill Development, Self as Explainer) and real-life (Everyday Coping, Science, Technology, and Decisions, Science for Nurturing, Science in Application, and Science in Making) curriculum emphases as they follow the curricular objectives and learning outcomes when they develop the textbook content.

For example, during curriculum analysis, it was identified that there was no emphasis concerning Science, Technology, and Decisions in the specific objectives and outcomes of the Grade VIII curriculum for the topic *Hardness of Water*. Consequently, in the textbook content, it was noticed that authors described experiments of identification and removal of hardness of water, and advantages and disadvantages of using hard water but there was no discussion about the use of technology and its mechanisms, such as domestic water filtration systems connected to the main water-supply or to a water tap. In other words, authors might not address the uses of science and technology related knowledge when developing textbook topics and, as a result, not adequately address students' personal and social needs.

Sometimes students' scientific explanations regarding everyday phenomena might be influenced by personal experiences, social environment, religion and other contextual considerations, resulting in misconceptions. In most cases, when students hold misconceptions, teachers find it difficult to change their views and introduce alternative conceptions (Basil and Sandford 1991, cited in Demircioğlu et al, 2005). Students' misconceptions may hamper their subsequent learning (Haidar et al, 1991) and so encouraging students' misconceptions or alternative conceptions should be considered when teachers implement the curriculum. Moreover, the implication of the absence of the emphasis Self as Explainer in the specific objectives and learning outcomes of the curricula in all three grades may not ensure students "active involvement in scientific reasoning" (Fensham, 1997) and helps teachers to identify students' alternative conceptions or misconceptions, and facilitate their conceptual change.

Similarly, the absence of the emphasis Self as Explainer in the specific objectives and learning outcomes of the curricula may not assists authors to develop curriculum materials for students' active engagement in a process of knowledge restructuring. Involving students in activities regarding scientific reasoning, encouraging questions in the classroom and including such type of questioning in the textbooks may be helpful for eliminating students' misconceptions.

Likewise, emphases on Correct Explanations in the specific objectives and learning outcomes would assist textbook authors to understand the depth and breadth of scientific knowledge required to be included in the textbook content and assist teachers to teach students accordingly. Lesson observations revealed that none of the six teachers addressed Correct Explanations or Self as Explainer in their teaching as these were not emphasised in the curriculum and textbooks. Fensham (1994, 1996), from his experience with the school science curriculum and from discussions with teachers, identified that some of these emphases are more relevant and meaningful for particular topics at different levels of students' school careers. Hence, to find the absence of some curriculum emphases in the specific objectives and learning outcomes of the curriculum is problematic.

Fensham (1994a) recommended Science in Making for early childhood and primary levels and Correct Explanations for all levels of schooling in Australia. It should be mentioned here that Grade VI is included in the upper primary level in Australia but, in Bangladesh, Grade VI is included in the junior secondary level. Therefore, Science in Making should be included in the specific objectives and learning outcomes of the JSSC. Furthermore, this emphasis in the curriculum should be addressed by textbook authors when developing textbook content and teachers should encourage students to make objects accordingly, applying the scientific concepts presented in the textbook topics. For example, a thermos flask can be made applying the concepts of transmission of heat through conduction, convection and radiation, and the way these processes are minimised. Fensham (2004) points out that, in the objectives for the lower secondary level, Science, Technology and Decisions, Science in Application and Structure of Science (or Nature of Science) should be given high priority, as the majority of students will not continue with future studies in science. Along with these, Fensham emphasises Everyday Coping, Scientific Skills Development, Self as Explainer and Science for Nurturing because they meet students' interest and needs at this level. Considering the above discussion, it might be suggested that, in Bangladesh, emphasis on Structure of Science, Everyday Coping, Science in Application, Science for Nurturing, Scientific Skill Development, Science, Technology and Decisions, Science in Making, Correct Explanations and Self as Explainer should get higher priority in the junior secondary level science curriculum. Since, in Grades VI-VII, Correct Explanations and, in Grades VII-VIII, Science, Technology and Decisions and, in all grades, Self as Explainer are not addressed in the objectives and students' learning outcomes of the curriculum, it can be reasonably asked how this curriculum is suitable for the junior secondary level students to apply their knowledge in real-life. These emphases need to be included in the specific objectives and learning outcomes of the JSSC if it is to meet students' interests and needs.

7.3.2 Implications of imbalanced curriculum emphases in the content of the junior secondary science textbooks for teachers and students

The discussion from the above results emerging from curriculum document analysis revealed that over-emphasis on pure science content in terms of Solid Foundation and Structure of Science have important implications in developing the content of textbook topics. Of particular majority of textbook topics at all three levels are over-emphasised on pure science content and shifted away from real-life curriculum emphases. Consequently, teachers favored more content-dominated teaching and assessed students' learning based on science content rather than making other, non-real-life and real-life curriculum emphases more prominent. As a result the textbooks are orientated away from real life orientation of the students.

However, teachers are not necessarily to blame for not linking curriculum content to students' lives when using these textbooks. This is, because, in this curriculum, the extensive emphasis placed on theories and facts may influence teachers to place excessive importance on theoretical knowledge, whether through lectures or demonstrations, without involving students in the classroom activities. Although there is some instruction in the curriculum to engage students in 'learning by doing' or using an inquiry-based approach, these approaches are poorly reflected in the specific objectives and learning outcomes of the curriculum. If the curriculum is developed with real-life emphases especially targeted in the specific objectives and learning outcomes for all topics, then more student-centered learning might result. Thus, there is an urgent need to revise the curriculum objectives and outcomes in line with the recommended emphases and with instructions given to teachers so they get a picture of not only how science is connected to students' everyday life situations but how they can convey this in the classroom. Professional development in terms of curriculum dissemination training can help teachers in this regard.

Other causes of content-dominated teaching may include: teachers in Bangladesh do not study the curriculum for teaching purposes, they see the textbooks as *defacto* curriculum (Siddique, 2008); and learning objectives and outcomes of the topics are not mentioned in the textbooks. So, when undertaking their duties, teachers may be unaware about the expected learning outcomes of the topics in relation to real-life. These aspects could be worthwhile investigating in future research studies.

Moreover, in the textbook-oriented examination system in Bangladesh teachers fully rely on textbooks to teach and students are heavily guided by these textbooks (Holbrook, 2005, Sark). The factors of textbooks without learning objectives or outcomes, higher emphasis on Solid Foundation and/or Structure of Science and content-dominated teaching lead students towards rote learning and memorizing content without understanding the concepts. Consequently, students may be unable to think about and relate scientific ideas to their opinions and to solve daily life, science problems. Furthermore, students' lack of understanding or application of scientific concepts can result in their lack of interest in science and its study. The content of topics in which real-life emphases were totally absent may fail to attract students' attention if they do not see any relationship with their lives. If this occurs, it is possible that teachers' transmission of knowledge may lead to non-meaningful learning that is not retained for any length of time.

Since the textbook is the main resource for the teachers and learners, there is an urgent need to revise the specific objectives and learning outcomes of the curriculum and the textbooks, focusing the curriculum emphases in such a way that they demonstrate how science is and can be connected to students' everyday life situations. Just fixing the curricula will not help until textbook authors need to pay attention to the alignment of the specific objectives and learning outcomes of the curriculum and textbook content, both for real-life and non-real-life curriculum emphases. The textbook content should be related to students' daily lives and meet specific needs of students and schools in different areas with less emphasis on factual knowledge. Various types of instructional activities with real-life curriculum emphases should be added in the teachers' guide related to topics of textbooks as they may help teachers to see the connections of topics to real-life. In addition to these measures, teachers' guides with instructions on how to teach lessons, and assess students learning with real-life curriculum emphases should be available to the teachers. For effective implementation of formative assessment in the classroom, teachers need to dedicate their efforts to ensuring good links exist between the learning outcomes and the assessment system. Creative question development training is a way to help teachers involve students in formative assessment activities instead of following more traditional approaches to assessing students' learning through achievement or mastery of content. Another way to facilitate students' orientation to real-life could be by reducing the number of some abstract or difficult topics by transferring in the later stage of students' schooling and shift attention to other topics for real-life orientations. Also, to ensure the overall quality, a number of different textbooks could be published. Along with this, may be government could be partner with publishers to improve the quality of textbooks.

Since class teaching load and large class size impact on teachers' capacity to appropriately prepare and teach the content and assessing students' learning using varieties of methods and techniques to meet students' need for meaningful learning. So, alternative arrangements, such as appointing separate higher secondary level subject teachers and provision in policy documents for employing para-teachers or teacher assistants, may help school authorities to decrease science teachers' work load at the junior secondary level.

When the textbooks are the only available resource for the teachers, teachers' ability to orient students to apply their scientific knowledge in real-life situation is limited. Teachers need to be encouraged to think about subject ideology to provide real-life curriculum emphases, which is less likely when they follow the textbook exactly. It is, thus, important for curriculum developers to inform teachers about real-life curriculum emphases during curriculum dissemination training. In the curriculum dissemination training and/or pre-service teacher training, it is worth including activities where teachers select a set of curriculum emphases for a topic from the specific objectives and learning outcomes and content of the textbooks as an exercise in determining certain outcomes for students to apply in real-life. Other initiatives that may help teachers to make students' learning relevant to real-life include: appointing meritorious and efficient subject teachers; ensuring availability of the curriculum and current teachers' guides to teachers; decreasing science teachers' work load; decreasing the volume of content of the syllabus; dividing classes into sections; increasing teaching time; making teaching aids accessible; and, resolving infrastructure problems. Along with these, the pre-service and in-service teachers' training program needs to be restructured to provide proper pedagogic training in terms of curriculum emphases and, also, needs to include teaching the content of General Science following Roberts' Vision I-II (Aikenhead 2007) approaches of scientific literacy, in a way that promotes students' meaningful learning. It might help students to continue to further study in science and choose science related careers along with functional knowledge of science in real-life.

7.4 Limitations of the Study and Direction for Future Research

The study aimed to be comprehensive by analyzing the junior secondary science curriculum (Grades VI to VIII), mapping the corresponding textbooks, observing teachers' teaching practices, interviewing teachers and engaging in students' focus group discussions. But still it has some limitations.

The analyses of the relation of the junior secondary science curriculum and textbooks to real-life were performed based on the Roberts' (1982, 1988, 1995) and Fensham's (1994, 2004) curriculum emphases. However, since the process of curriculum development is a collaboration of different stakeholders, opinions regarding connections of the curriculum and textbooks to students' real lives could be collected from a wider range of these stakeholders. In Bangladesh, there is scope to include other professionals in research on this topic. The research may be better accepted and more useful in various research communities if policy- makers who developed the National Education Policy, 2010 and the junior secondary level science curriculum (1995), as well as the authors of textbooks and teachers' guides were included. They could be provided with the broad range of curriculum emphases list that is present across these years of schooling of the science curriculum to collect their views on focusing these emphases in the specific objectives and learning outcomes of the curriculum, content of the textbooks and instructions in the teachers' guides.

Another limitation of this study was the number of questionnaire participants involved in providing teachers' responses about science education and their teaching practices. Despite the questionnaire being distributed to teachers in 300 randomly selected schools in seven divisions in Bangladesh, a total of only 194 teachers responded. This number is very small when compared to the number of teachers in Bangladesh teaching General Science at the junior secondary level. Thus, ascertaining teachers' views of science education and aspects of teaching science in implementing the curriculum from such a small number of teachers provided just a glimpse of the views of a large group of teaching professionals and may not be representative of the total number of teachers from different geographical locations in Bangladesh. Therefore, further investigation, with a larger sample of teachers covering all the geographical regions of Bangladesh could help to get a more comprehensive picture of teachers' views about science education and their teaching practices.

Another limitation was that only six teachers from urban, semi-urban and rural areas of only two districts and two to three lesson observations of one topic in their science classes were included. Increasing the number of teachers, districts, topics and range of geographical regions, plus observing more lessons, could enrich the representativeness of the findings.

These limitations invite additional opportunities for generative study. Based on the restricted nature of this research, conducting further investigation with a more extensively representative sample is recommended to add to the findings' reflectivity and to ensure generalization of the findings. The curriculum emphases can be examined in the specific objectives and learning outcomes of different levels of science curricula to provide evidence of the degree to which curricula are elite or oriented to the future populace. The curriculum emphases can also be investigated in teaching approaches, to stimulate teachers' competence in engaging students both in hands-on activities related to real-life and in assessment strategies, to promote their questioning skills and, especially, their higher order thinking abilities. Furthermore, in view of the aims and objectives of science education, the importance of the curriculum emphases in science-related teacher training and professional development training of pre- and in-service teachers need to be investigated.

Despite its limitations, it is anticipated that this study will inform the stakeholders of education in Bangladesh about the issues and challenges in implementing the curriculum in relation to real-life.

7.5 Concluding Remarks

The purpose of this study was to explore Roberts' (1995, 1998a 1998b) and Fensham's (1994a, 1994b, 1996) curriculum emphases in the specific objectives and learning outcomes of the junior secondary (Grades VI to VIII) science curriculum (NCTB, 1995) to investigate the relationship of the curriculum to students' lives. These curriculum emphases represent the objectives of learning science. As textbooks were prepared following the specific objectives and learning outcomes of the curriculum and textbooks are the only materials available to science teachers in this context, the second purpose was to examine the extent of the relationship of science textbooks to real-life, based on the same curriculum emphases. The third purpose of this study was to investigate how the intended curriculum was implemented in the classroom.

The findings showed that the curriculum, textbooks and teaching approaches were mainly focused on pure science content, neglecting any real-life curriculum emphases. Science teaching was teacher-centered with no attention paid to students' needs, interests or participation in learning. Teachers were not at all aware of the learning outcomes that contribute to students applying scientific knowledge in their everyday lives. Formative assessment of the students reflected rote memorization of content knowledge. Higher order questions or task-oriented affective and psychomotor domains were totally absent. The features of the curriculum, textbooks and teachers' approaches highlighted in this study demonstrate characteristics of traditional science education with focus on Roberts' Vision I (Roberts' 2007) approach to scientific literacy that does not orient students to apply their science knowledge in real-life situations.

Currently, the main function of science education is to develop students' scientific literacy. Therefore, the focus of the curriculum should be to help students to apply their knowledge in real-life. This research has demonstrated that, to fulfill the purpose of science education in Bangladesh, there is an urgent need to revise the junior secondary level science curriculum (NCTB, 1995) and affiliated textbooks to make them real-life oriented. Connecting Roberts' (1982, 1998a, 1998b) and Fensham's (1994a, 1994b, 1996) curriculum emphases to students' needs and interests at the junior secondary level should be the basis for selecting specific objectives and learning outcomes for each topic. The objectives and outcome should be correspondingly represented in the textbook topics for developing appropriate content and activities for the students. The revision of the curriculum should address the logistical problems raised in this study along with the curriculum emphases that is still waiting for resolution.

As a first step to achieving this, it is necessary to enhance the awareness of all stakeholders, i.e. policy makers, curriculum specialists, teacher trainers, and school teachers, about the importance of scientific literacy in line with Roberts (2007) Vision I-II approaches and curriculum emphases. This needs to be followed by building expert teaching professionals through enhanced teacher education programs. To make the objectives fruitful, curriculum emphases and Roberts' Vision I-II approaches of scientific literacy should be included in teacher training courses for pre-service teachers. These can assist teachers to develop more powerful pedagogies to teach, assess, support and encourage students in learning science that links with their lives, interests and broader aspirations. Curriculum dissemination training, proper pedagogic training along with content knowledge and creative question development training is necessary for all in-service General Science teachers to maximize their potential for engaging students and give them appropriate pedagogical support for successfully implementing the prime goal of science education in Bangladesh, to prepare young citizens as scientifically literate people. On top of this, teachers need adequate and appropriate curriculum resources, facilities and equipment to implement the curriculum. In the absence of these and until such time as they are provided, teacher trainers must devise strategies that take into account the constraints that science teachers face in their actual classroom teaching.

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Appendices

Appendix 1: Human Ethics Certificate of Approval

MONASH University

Monash University Human Research Ethics Committee (MUHREC)
Research Office

Human Ethics Certificate of Approval

Date:	**7 April 2011**
Project Number:	**CF10/2964 - 2010001627**
Project Title:	**A study of junior secondary science curriculum in Bangladesh and its relationship with real life situation**
Chief Investigator:	**Assoc Prof Deborah Corrigan**
Approved:	**From: 7 April 2011** **To: 7 April 2016**

Terms of approval

1. The Chief investigator is responsible for ensuring that permission letters are obtained, if relevant, and a copy forwarded to MUHREC before any data collection can occur at the specified organisation. **Failure to provide permission letters to MUHREC before data collection commences is in breach of the National Statement on Ethical Conduct in Human Research and the Australian Code for the Responsible Conduct of Research.**
2. Approval is only valid whilst you hold a position at Monash University.
3. It is the responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval and to ensure the project is conducted as approved by MUHREC.
4. You should notify MUHREC immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
5. The Explanatory Statement must be on Monash University letterhead and the Monash University complaints clause must contain your project number.
6. **Amendments to the approved project (including changes in personnel):** Requires the submission of a Request for Amendment form to MUHREC and must not begin without written approval from MUHREC. Substantial variations may require a new application.
7. **Future correspondence:** Please quote the project number and project title above in any further correspondence.
8. **Annual reports:** Continued approval of this project is dependent on the submission of an Annual Report. This is determined by the date of your letter of approval.
9. **Final report:** A Final Report should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected date of completion.
10. **Monitoring:** Projects may be subject to an audit or any other form of monitoring by MUHREC at any time.
11. **Retention and storage of data:** The Chief Investigator is responsible for the storage and retention of original data pertaining to a project for a minimum period of five years.

Ben Canny

Professor Ben Canny
Chair, MUHREC

cc: Ms Syeda Tamina Akhter

Postal – Monash University, Vic 3800, Australia
Building 3E, Room 111, Clayton Campus, Wellington Road, Clayton
Telephone +61 3 9905 5490 Facsimile +61 3 9905 3831
Email muhrec@adm.monash.edu.au www.monash.edu/research/ethics/human/index/html
ABN 12 377 614 012 CRICOS Provider #00008C

Appendix 2: Permission Letter from the Directorate of Secondary and Higher Education (DSHE)

Government of the people Republic of Bangladesh
Directorate of Secondary and Higher Education
Bangladesh, Dhaka.

Memo No: OM/159-Shamo/2007/18819 date: 23/09/2010

Sub: Permission to access secondary schools in Bangladesh for conducting research programme.

According to the above mentioned subject it is for your information that as per instruction of honourable Director General, Directorate of Secondary and Higher Education, you are requested to cooperate Syeda Tahmina Akhter, Professor, Institute of Education and Research (IER), Dhaka University (now working as Doctoral researcher, Faculty of Education, Monash University, Australia) to conduct research programme and to collect data from students and teachers of your institution.

Sakhayet Hossain Biswas
(Sakhayet Hossain Biswas) 23.9.2010

Assistant Director(Secondary-1)

Phone:9561254.

Head Master/Mistress

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Copy.

1. Deputy Director,
   Secondary and Higher Education
   ----------------- Zone ---------------.
2. District Education Officer,----------------.
3. Office copy.

Appendix 3: Questionnaire for the Teachers

Thank you very much for participating in this research project entitled "A study of the junior secondary level science curriculum in Bangladesh and its relationship with real life situations".

This questionnaire is divided into five sections, which seek out:

A. Your general information

B. Information related to your work load, class size, and availability of resource materials in school

C. Your views about science education/ teaching science

D. Your teaching barriers

Please fill in the questionnaire carefully.

A. General information

1. Age: ……………… years **2. Gender:** Male ☐ Female ☐

3. School type: Boys ☐ Girls ☐ Co-education ☐

4. School location: Urban ☐ Rural ☐

5. Highest level of education (please fill in the following table**)**

Degree	**Year**	**Major academic field**	**Institution**
General:			
Professional:			

6. Teaching experience: ……………………………… Years

7. Please mention in the table below if you participated in any professional development activities in the last 5 years.

Name of the program	Organization	Duration	Comment

8. If you are interested in participating in further activities of this research (e.g. follow up interviews, classroom observation), please give your contact details below.

Name**:** ………………………………………………………………………………..

Name of school…………………………………………………………………..

Post Office: ……………………………………….. Road/Street: ……………………

Thana/Upa-Zilla: …………… District: ………………Code number: …………………

Phone number: ……………..………….. E-mail address: ………………………………

B. Information regarding work load, class size and availability of resource materials for teaching and learning

9. How many periods are you assigned to teach in a week?

For science subject	No. of Periods:
For other subjects	No. of Periods:

10. In which grade(s) do you teach science at the junior secondary level? Please tick the box(es) below.

Grade VI ☐ Grade VII ☐ Grade VIII ☐

11. On average how many students are there in your school in grade VI to VIII science classes?

Average no. of students: …………… Boys: …………… Girls: …………

12. What are the resource materials available in your school for teaching science? Please give a tick mark in the box to indicate your answer.

Science curriculum ……………………………………………………..……… ☐

Science textbooks ……………………………………………………...…….. ☐

Teachers guides ……………………………………………………………… ☐

Question booklet .... ☐

Training manuals …………………………………………………………. ☐

Please specify if any other materials are available in your school for the teaching and learning of science.

……………………………………………………………………………… ☐

……………………………………………………………………………… ☐

C. Personal views about science education/teaching science

13. In your opinion what should be the major purpose of the General Science course at the junior secondary level? Please put a tick mark in the appropriate box.

Allow all students to be able to apply their science learning in real life situations…. ☐

Build a solid foundation to prepare students for further studies in science ………… ☐

14. Which of the following aspects in teaching science do you feel contributes to building science learning that is relevant to the students' real-life? Please put tick in the appropriate box.

Link the topic or lesson with students' prior knowledge and experience… ☐

Link topic with real-life examples………………………………………… ☐

Explain application of science in everyday life situations………………… ☐

Present up-to-date knowledge regarding real-life related topics…………… ☐

Present science related theme/topics/issues that require awareness……..… ☐

Involve students in hands-on activities……………………………………. ☐

Encourage students to learn science using different sources other than textbooks, for example, newspaper, radio, TV, the internet etc………..………………… ☐

15. Which of the following strategies do you feel contributes to teaching science for the real-life orientation of the students? Please put tick mark in the appropriate boxes.

Teaching strategies	**Grade VI**	**Grade VII**	**Grade VIII**
Lecture			
Question- answer			
Demonstration			
Whole class discussion			
Small group discussion			
Brain storming			
Hands-on-investigation			
Project: Individual			
Project: Group			
Field trips			
Others (Please specify):			

16. What are the teaching aids you used in teaching science in grades VI-VIII that are relevant to students' everyday life situations? Please give examples for each grade.

Teaching aids	**Grade VI**	**Grade VII**	**Grade VIII**
Real objects (e.g. clinical thermometer)			
Low cost apparatus / teaching aids made by you/students (e.g. electric circuit)			
Model (organs of human body)			
Audio-visual materials (e.g. television, radio, overhead projector)			
Chart/poster (e.g. digestive system, symptoms of diseases)			
Newspapers/ magazines)			
Others (Please specify):			

17. Which of the following aspects of assessment do you feel contribute to building science learning relevant to students' real-life?

Emphasis on memorising scientific terms, and facts………………………… ☐

Asking students a range of open questions to assess students' understanding of applying science knowledge in real-life……………………………….…... ☐

Providing students with appropriate assignment/activities related to real-life to assess students' ability to apply science learning in real-life……………… ☐

Providing feedback after assessment………………………………………. ☐

D. Barriers in teaching and learning

18. Please rank the following aspects as barriers to context based science teaching. Rank these indicating your choice: '1' indicates your first choice, '2' your second choice, and so on. You can put the same rank for more than one aspect.

Lack of resources ………………………………………………………… ☐

Big class size …………………………………………………………… ☐

Heavy class load ……………………………………………………….. ☐

Inadequate instruction in curriculum ………………………………………☐

Inadequate instruction in teachers guide …………………………………. ☐

Inadequate instructions in textbooks.. ☐

Please add any other barriers you face and rank them.

…………………………………………………………………………..… ☐

…………………………………………………………………………… ☐

19. How do you overcome those barriers? Please, write in your words.

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

20. What initiatives should be taken to make science learning relevant to real-life situations?

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

Thank you very much for your time

Appendix 4: Questions/Themes for the Teachers' Pre-lesson Interview

1. Can you please clarify why you said…? (Referring to teachers' responses in the questionnaire that demand an explanation)?
2. What do you think about the goals of the current science curriculum at the junior secondary level?
3. Could you please tell me, what you believe should be the goal of science education?
4. Could you give some examples of real-life problems/issues that are included in the curriculum/textbook at the junior secondary level?
5. What are some real-life problems/issues that you used in your teaching?
6. How did the textbook help you to select teaching and learning strategies for everyday science?
7. How did the teachers' guides help you to select teaching and learning strategies for everyday science?
8. What ideas do you have regarding teaching and learning strategies for everyday science content, to be followed in the junior secondary level science curriculum?

Appendix 5: Questions/Themes for the Teachers' Post-lesson Interview

1. What were the purposes of today's science lesson?
2. How do you feel about teaching this topic?
3. Would you please explain how this learning will be useful for the students?
4. Do you think that this is (referring to the teachers' teaching strategies) an effective way of teaching this topic to promote students' learning, enabling them to apply it in real life? Why or why not? What would you like to do?
5. What are the strategies presented in the textbook for today's lesson to be followed for enabling students' learning?
6. What are the strategies presented in the teachers' guide for today's lesson to be followed for enabling students' learning?
7. How could you engage students in a better way enabling them to utilize their learning in everyday life? Please explain.
8. Could you please explain, why you did/didn't use….? (Referring to classroom activities)
9. Do you have any barriers in teaching real-life related lessons?
10. How could you overcome these barriers?
11. Would you like to add anything else regarding your science teaching?

Appendix 6: A Sample of the classroom Observation checklist

Date: ………………………………………. Time: ……………………………………

Name of the teacher: ………………………………………………………………………………

Name of the school: ……………………………………………………………………………….

School location: Rural ☐ Urban ☐ Grade: ………………………………..

Number of students present: ……………. Boys: ……………… Girls: …………………

Topic of the lesson: ……………………………………………………………………………….

Effective teaching behaviours for real-life orientation	**Yes**	**No**	**Comments**
Clearly defined the purposes/intended learning outcomes of the lesson			
Planned themes for discussion and tasks to be undertaken			
Starts the lesson related to context with real-life applications of students personal or societal concerns			
Linked the topic to previous learning			
Asked students about issues to be discussed			
Gave clear indication of tasks			
Engaged students in activities			
Had a thorough awareness of students' prior knowledge and experiences			
Encouraged students to describe their experiences			
Emphasised key points			
Identified and corrected students' misunderstandings			
Used relevant real life examples to make the explanations clear			
Related new ideas to familiar concepts			
Explanations were clear to students			
Discussion was stimulating and thought provoking			

Encouraged students to ask their own questions			
Gave satisfactory answers to students questions			
Involved students in hands-on/minds-on activities			
Maintained attention on students			
Asked related questions to monitor students' progress			
Used questions to involve students in discussion			
Involved students in designing activities in their own way			
Asked students to give reasons for designing their activities			
Encouraged students to answer difficult questions			
Asked probing questions to get students to complete answers			
Demonstrated experiment			
Gave students the opportunity to predict something regarding the experiment			
Encouraged students to share their ideas			
Asked reasons for their predictions			
Involved students in experiment			
Involved students in group discussion			
Involved students in presenting their ideas logically			
Presented science knowledge as certain or absolute truth			
Asked students for decision making			
Met intellectual needs of students			
Encouraged students to summarise discussion			
Asked students a range of open questions to make informal assessments			
Assessed students' learning based on context			
Provided appropriate assignment for assessing students			

Other observable notes:

Appendix 7: Questions/Themes for the focus Group Discussion with Students

1. Why are you learning science?
2. What did you learn in the lessons (referring to the lesson I observed)?
3. How can you use your learning from the science lessons?
4. How do you want to learn science in your class?
5. How did your teacher engage you in activities for learning science?
6. How useful are these ways of teaching and learning to you?
7. Do you usually share your experiences related to the topic in your science class? Why is it necessary?
8. Did you notice any differences of teaching and learning processes between the former science classes and the classes I observed?
9. Do you memorise your science lessons? Why or why not?

Appendix 8: A Sample of the Pre-lesson Interview Transcript

Date: 03/ 7 / 2011

Teacher: Nabila Jahan (pseudonym)

I: Let me thank you Nabila for participating in this research project. As I have discussed before, the aim of this research is to explore the relationship of the junior secondary science curriculum to students' real-life situations. Being an experienced science teacher your views are important for this research. I am confirming with you that I will not judge your knowledge. I will try to understand your perspectives regarding implementing the curriculum for students' orientations to real-life. Please feel free to talk to me. I am assuring you that I will not share any information regarding our conversation with anyone. I will only use the information for research purposes. In reporting this research, your identity will not be disclosed rather, pseudonyms will be used. If you need any clarification please feel free to ask me.

Nabila: It's alright. We can talk.

I: In the questionnaire you mentioned that you have participated in CPD (Continuous Professional Development) training. Could you please clarify for which subject you participated in this training?

Nabila: It was in chemistry.

I: Any other training?

Nabila: CPD-2, the follow-up training and in training to prepare structured questions (creative questions) on chemistry. It was 3-days training.

I: How do you feel about the training?

Nabila: It was not that difficult following the different methods and techniques. But I face a problem in applying them in school because, during the training, we didn't think about the syllabus or other pressures as we do at school. At the training, we had simulation for a small part of a lesson. The participant teachers were the students. But the training would be more helpful for us if it were life-oriented or based on the reality of a school atmosphere: in school we just don't have enough time to complete the syllabus.

I: What about the structured questions? Do you have model questions?

Nabila: Yes, following the model questions, I developed questions for examinations but it is hard to develop creative questions.

I: What do you think about the goals of the current science curriculum at the junior secondary level?

Nabila: Actually, I haven't seen the objectives in the recent curriculum. I once read the curriculum while I was doing my B.Ed. Now, I have forgotten that the goal of science education must be to enable students to apply their science knowledge in real-life.

I: Do you have the curriculum in your school?

Nabila: Yes, we have.

I: Could you give some examples of real-life problems/issues that are included in the curriculum/textbook at the junior secondary level?

Nabila: Well, simple machines, some common diseases such as, hypertension, diabetes, blindness; drug addiction, AIDS, food preservation and so on. In the chapter on Population and Environment, there are different types of pollution.These are included in the textbooks and related to real life for example, simple machines can be used to do work easily using minimum effort. But all chapters are not as real-life oriented as these chapters. I can say that the chapters about cells, cell divisions in biology, and other chapters are difficult for the students to learn. These chapters will help them in their higher studies but not for now. I am just trying to say that all topics are not fully real-life related.

I: What are some real-life problems/issues that you used in your teaching?

Nabila: I always try to give examples related to real life. For example, in the lesson about chemical reactions I explained "rust on iron ", how "milk is converted into yogurt" and how "rice is converted into soft rice", due to chemical changes. I explained how to manage natural disasters: pre, post and during management. I gave real-life examples; I tried to explain them all. Let me give an example. In the chapter about population and environment there are different types of pollution. I explained to the students how over population and its associated activities can increase air, water and land pollution. Also, I explained how these factors create problems in every sphere of our lives. We can show these things practically.

I: Did you show them practically?

Nabila: No it is not possible to take the whole class practically. There are too many students but we tell our students. For example, we can give the example of Banani —one area of the capital city— where the number of people is very small but, in the slums, there are many people. We describe the types of facilities they have, their environment and overall we explain how their lives are going to be destroyed in the slums. Peoples' lives are affected by diseases because of living with different types of populations. The slum dwellers cannot have healthy lives. We can tell our students that by comparing the lives of the slum dwellers with those of non-slum-dwellers.

I: How do textbooks help you to select teaching and learning strategies of everyday science?

Nabila: For selecting teaching-learning methods the textbook plays an important role. It can help both the teacher and students. It tells me which content I should select for a particular topic. The area of learning can be very wide but the textbooks instruct me regarding which topics I should add which method I should follow and also about the tasks I should perform or which experiments to conduct in the class.

I: How do teachers' guides help you to select teaching and learning strategies of everyday science?

Nabila: Well, teachers' guides help us to understand the methods and teaching aids that should be used for easy comprehension of the lesson for the students. It can also show us how we can make the students active, how to develop their learning, and how the learning can be permanent.

I: Do you follow the teachers' guide?

Nabila: The teacher's guide is not available to us. But, I have seen the teachers' guides when I was a Bachelor of Education student. We can see it if we want. But these are old versions of the textbooks.

I: What ideas have you got regarding the teaching and learning strategies of everyday science content to be followed from junior secondary level science curriculum?

Nabila: Well, I cannot remember the teaching strategies written in the science curriculum. I saw the curriculum when I was a Bachelor of Education. I did not use the curriculum for teaching purpose but I try to teach lessons following the textbooks, and by relating them to real-life.

I: Would you like to tell me anything else?

Nabila: Not really.

I: Alright, that's all for now. Next, I will observe some of your lessons for any topic. Could you please let me know the day and time to observe the lessons?

Nabila: You can come tomorrow. I have a class in grade VIII at 11:20 pm.

I: Thank you so much for giving me time.

Nabila: You are welcome.

Appendix 9: A Sample of the Post-lesson Interview Transcript

Date: 07 / 07 /2012

Teacher: Nabila Jahan (pseudonym)

I: I have observed some lessons you taught grade VIII students for a topic. What were the purposes of those lessons?

Nabila: Yes, I taught the topic, "Living organisms and their environment". There were three lessons, in which students learnt about characteristics of different types of plants based on their environment, and ecosystem. I described the ecosystem of a pond. Some of these factors were familiar to them as they see them in the environment and some were new to them. With these lessons they will be more curious about nature and the environment.

I: How do you feel about teaching this topic?

Nabila: I feel I'm successful in implementing the aim because after finishing the lesson when I assessed them they were giving correct answers about the questions I asked.

I: Would you please explain how will this learning be useful for the students?

Nabila: The students will be more curious about the nature and environment. I don't think these lessons can help the students very much in everyday life. But water hyacinth is used to make organic fertilizer. I forgot to share that with the students.

I: Could you please explain how can they use their learning of the classification of plants in real-life situations?

Nabila: They have known about different types of plants and their characteristics. They can apply their learning in the future but not now. But some of the aquatic plants, for example, water hyacinth, can be used to make organic fertilizer and paper, and all of these plants help to balance nature, but in fact I forgot to tell the students about their many uses.

I: Are these in textbooks?

Nabila: No, these are not in the book.

I: I observed that you followed demonstration and question-answer methods, and drew pictures on the chalkboard to help students understand the characteristics of different types of plants. Do you think that these were effective ways of teaching this topic, to promote students' learning enabling them to apply it in real-life?

Nabila: Well, I do not think that the methods I follow are completely suitable for the students. Since I am teaching science, this needs more practical tasks and more life related approaches. But I can't do in that way because of the lack of time and there are lots of topics on the syllabus, and I have many students. I have three to four classes one after another. Besides that, I also take classes in Grades 11 and 12. I cannot bring all the materials for all the classes, for example, I have many materials ready but when I go from one class to another it is really difficult to take them with me. The supply and preservation of materials are also a problem. So, if we could keep them in the classroom, or there were someone to bring or collect the materials for me for the classes, it would be easier for me to use the materials. There is the pressure of syllabus completion, and if I want to complete the syllabus in time, I cannot do everything practically. If I could arrange a video clip, it would be more effective. For example: regarding the uses of water hyacinth and water lily; I couldn't arrange a field trip or something special for the students. It is tough to organise or maintain such activities because of infrastructural management problems, and time limitations we can't follow suitable methods for teaching every lesson. We use materials when we can. With all these issues we cannot perform in class in ways in which we should. But, we try our best.

I: What are the strategies reflected in the textbook for the lessons to be followed for students' learning?

Nabila: There was nothing in the textbook but there are some pictures of plants with their features.

I: What are the strategies in the teachers' guide for these lessons to be followed?

Nabila: Teacher's guides are not available for us. I saw the old teachers' guides a few years ago. There are no teachers' guides for the revised textbooks. These are very important for us.

I: Do you have any other issues in teaching lessons?

Nabila: The supply and preservation of materials are also a problem. If we could keep them in the classroom or someone helped to bring or collect the materials for me to take to the class it would be easier for me to use the materials. We have a huge syllabus but sometimes due to political unrest in our country, the school remains closed. In these circumstances, we need to take extra classes because students have sit for the public examination at the end of grade VIII. If they don't get good marks in science then their parents and school authorities will blame us saying that we didn't teach well.

I: How can you deal with these barriers?

Nabila: It is very tough. There is no way to overcome these barriers. We need to divide the classes into more sections and more science teachers need to be recruited.

I: Do you want to tell me anything more regarding science teaching?

Nabila: Training helps to develop the teaching learning process of the teachers. There is no alternative training. According to me, training must be conducted in such a way that it will tell us how we can teach a lesson using materials. Through training we know, how we can make the students active. If anyone can show us the way to perform in a classroom of 70 to 80 students, as in the present situation, then it would be more helpful. If we could be taught how to use teaching materials in this environment, in which 70 or 80 students are seated, it would be more effective.

I: Anything more?

Nabila: The modification of the curriculum and textbooks is essential. The presentation of teaching aids and student activities are very important for their learning. We have to manage a huge amount of time for the SBA (school based assessment). We, the teachers, need to do a lot of work.

I: Thank you, that's all. It was very nice to have your cooperation in my research project. Thanks again for giving me your time.

Nabila: I'm also feeling happy participating in your project. It opens my eyes about being a teacher, and keeping in mind the importance of helping students to apply their knowledge in real-life.

Appendix 10: A Sample of the Focus Group Discussion Transcript

Date: 07/07/2012

I: Thank you all for participating in this research project. You have already been informed that I am conducting research on the scope of the relationship of the junior secondary science curriculum with students' real-life situations. For this purpose I would like to hear from you, how you learn science, how your science learning is helpful for you to apply in real-life situations, and so on. Please don't hesitate to talk to me. I assure you that I will not share any information from you with anybody else. All information will be used for research purposes. If you feel uncomfortable about answering some of my questions you can avoid those. During the reporting of this research your identity will not be disclosed, rather I will use pseudonyms. If you have any questions, please feel free to ask me.

SS: It's alright. .

I: My first question is why are you learning science?

Faria: Mam, each person has an aim. I have also an aim in life. I want to be a doctor or scientist. That is why I want to learn science.

Sadia: The present world is very advanced in science and technology. Our country is poor, but we need to improve in science and technology. So, I think it is very essential for us to gain knowledge of science. In our daily life we need science for various purposes. Today communication systems are very advanced. We can communicate with others through the internet.

Mehnaj: Science is very important for our lives. There are lots of things to learn from science classes. I try to get good results studying science. If we come up with good results, it will be helpful for us in our higher classes and we will not face severe problems. Science is a very important subject; everyday, we use science from morning until going to bed. We need to, and we must stick to, this subject.

Nushrat: We can be a doctor, scientist, or an engineer, which are important. If a person wants to be a doctor he or she must study science. I want to know about the human body. Why we become ill. I want to learn about that. I want to be a doctor and help the poor. That is why I want to learn about science.

Sadia: I want to gather a lot of general knowledge from science classes. Using this knowledge, we will be able to do many things in our lives or when we grow up. If we get acquainted with science experiments from this age, it will be helpful for our future research after growing up. This could help us develop and prosper in our life.

Tamanna: I want to learn biology. It deals with the human body. I am interested in knowing about the cells in the human body. We can invent a lot of things through science.

I: What is the benefit of knowing about cells?

Tamanna: Well, cells play a vital role in our health. If we think about our height, it helps to become a tall man.

Nazia: I want to be a scientist. We know about Newton. Basically he was a scientist.

I: What did you learn in the lessons about living creatures and their environments?

Faria: We have learned about living creatures and their environments. We see different kinds of living creatures in our surroundings. Among them there are lots of trees. These trees have different characteristics. They are different in terms of their habitant and characteristics. We have learned about all those differences and characteristics.

Nushrat: Well, the classification and characteristics of different types of plants were the major topics. These were Hydrophytes, Mesophytes, Xerophytes, and Halophytes. Among the aquatic plants there are some plants that float freely in the water, such as water hyacinth and some are soil-bound, for example, water lily. Among the terrestrial plants there are huge differences in shapes and characteristics. Other plants, such as Cactus, grow in places where the soil is little bit dry. These types of plants are Xerophytes. Some plants grow in saline soil and water like in our Sundarbans (one of the largest forests in the world); these types of plants are Halophytes. We have learnt about these classifications and their characteristics.

Mehjabin: I have learned about aquatic plants. These are called Hydrophytes. Some are free floating hydrophytes and some are rooted floating hydrophytes. These plants have waxy coated leaves. Water lily, lotus these plants are rooted floating hydrophytes. Hydrilla and Patajhajhi (local name) belong to submerged aquatic plants. The plants we see in TV under the sea and ocean are submerged aquatic plants. Plants, such as Mesophytes grow in the soil where water is neither in neither excess nor scanty. Mango and jackfruit are Mesophytes. Plants like Cactus, Karabi (Oleander) in arid soil are Xerophytes. The features of these plants are different.

Nazia: I have learned that plants in the Sundarban (forest) of our country can adjust to saline soil and water; they are Halophytes types of plants. In the tidal regions they are called Mangrove plants. Sundari, Gewa, Goran trees in the Sundarban are mangrove plants. These plants absorb saline water. The features of these plants are not found in other types of plants.

I: What about others?

Farhana: Classification of plants and their habitant were the major topics. Today we've learned about the importance of plants and the ecosystem of a pond.

Tamanna: We've understood that ecosystems maintain the balance of nature.

Sadia: Like others I have learned about the classification of plants, which is very new to us.

I: Alright, now tell me how can you use your learning from the science lessons?

Tamanna: We have learned, in lower classes, that plants help us a lot in our daily lives. We get oxygen from plants. We are dependent on plants for food. Plants absorb the dangerous carbon di-oxide from the air and release oxygen. Plants help to balance the natural atmosphere. Thus plants help us. If we know the exact habitat of all types of plants, we could be more careful regarding the planting of trees.

Sadia: We are very much dependent on the plants for our respiration and for other purposes. It is important to have the knowledge about which plants grow in which place.

This chapter is helpful to teach us about that. Aquatic plants, such as water hyacinth are very useful for the fertilization of the lands. Kalmi spinach and water lily can be eaten as food. As we are dependent on plants; we should have knowledge regarding how to cultivate these plants.

Mehnaj: Kalmi spinach can be grown on both land and in water. This spinach helps to meet our nutrition needs.

Nushrat: Plants help us maintain an ecological balance. Kalmi spinach can be used as food for domestic animals and as a fertilizer.

Mehjabin: Well, water hyacinth is a great example of aquatic plants. It can be used in making paper and as an organic fertilizer. Fertilizer is used by farmers for the fertilization of lands. Chemical fertilizer is harmful, whereas organic fertilizer is very much effective for the land to grow crops. Kalmi spinach and helencha can be eaten meeting our nutritional needs. Besides water hyacinth, khudipana, and topa moss can be used as fertilizer.

Nazia: There are some medicinal plants. We have tulshi plants in our garden. My mother fed me Juice of tulshi leaves as a cough remedy. She said methi leaves are good for lowering cholesterol, diabetes, and healing stomach ulcers.

Faria: We can make different types of dolls, toys and organic fertilizer from water hyacinth which can help us in our daily lives.

I: How do you want to learn science in your class?

Faria: To learn science practically is very interesting. We feel more curious to study science, and we can remember all the studied things clearly, if these are shown us practically. After having a practical class we don't need to organise and there is little chance we will forget the things. Practical classes help us to write effectively and skilfully in the answer script. To learn practically is very effective with today's question patterns. There is no scope to write from whatever we organise; it is completely skill-based.

Sadia: Science is an important subject. I want to learn science in different ways, through pictures, and using different materials. I think we all want to learn science practically. It helps us to remember our lessons properly.

Mehjabin: Yes, we want to learn science interestingly and for all chapters.

Nushrat: We can also learn through pictures, from VDOs, and using models.

I: Any other ways you want to learn science?

No response from the others.

I: How did your teacher engage you in activities for learning science?

Nazia: Yes, she does. For the taught lessons, when you were present in our class, she demonstrated the characteristics of various types of plants. She instructed us to collect different types of aquatic plants to teach us. She told us some of the names of plants. We collected those plants.

Farhana: We read measurement and simple machines recently. She brought slide callipers into class to make us understand. Each of us used slide callipers and understood how these work. She also showed and explained how simple machines help us to work easily. Our teacher told us that simple machines can increase the force, for example if we use a stick to lift up an Almira it will produce lots of force but only uses little force.

I: Really? Did you try that?

Farhana: No mam, our elders can do that. I: Are there any other ways you were involved in activities?

Mehjabin: Sometimes we worked in a group. Our teacher demonstrated how to identify acids and bases using blue and red litmus papers. We identified acid in lemon and lime water as a base.

Nushrat: If the teacher demonstrated an experiment then we helped her.

I: How useful were these ways of teaching and learning to you?

Mehjabin: Yes, these are good ways to understand our textbook content properly. There are figures in our book but some pictures are not easy to understand. If we see something conducted practically we can remember it.

Nushrat: If we see something directly then we can understand but, if our teacher involves each student separately in hands-on activities, then it helps us to understand it even better. We know how it works and how we can apply our learning in future.

Tamanna: If our teacher could show us the practical work in the laboratory instead of the classroom, it would be better.

Nushrat: If we were in Grade IX or X then she could take us into the laboratory.

Sadia: We are now in Grade VIII and there are many chemical reactions that we cannot do practically but our seniors can do these. So, if we can see them practically, from grade VIII, it would be more helpful.

Mehnaj: If each student can do practical work by her, it works better but, it needs more time. It will help us to remember and it would help those who are less skilled even more.
Faria: The class duration should be more than 35 minutes.

I: Do you think time should be increased for science classes?

Faria: Yes, I think so. The teacher should be given more time to prepare for classes. They should not do one class after another. There must be a break time between two classes. If the teacher takes one class after another her patience can decrease. As science is a difficult subject, her mind should be clear for teaching.

I: Nazia, would you like to tell me anything?

Nazia: We would like to work in the laboratory.

I: It seems Tamanna and Nazia like to do activities on their own in the lab. What about others? Do all of you agree with her?

SS: Yes mam.

I: Do you usually share your experiences in science classes? Why is it necessary?

Sadia: No, not in the science class but we discuss after finishing our class. This is because we don’t have the same ability. If we discuss the lesson ourselves, it helps us to have a clear idea about the topic. Those students, who understand less, can learn the lesson easily listening to others, who can understand better.

I: What are the other advantages of it?

Nushrat: Everybody can learn equally and can understand well. If anybody faces a problem, she can learn from others and build on her weakness. This discussion helps us to remember science knowledge for a long time.

I: Any other thing?

Farhana: We can get good results if we discuss the lesson amongst ourselves.

I: Nazia, would you like to tell something?

Nazia: No madam.

I: Did you notice any differences in the teaching and learning processes between the former science classes and the classes I observed?

Sadia: We do not see any difference; our teacher explains lessons in the same way every day. She draws figures on the board. While teaching about plants, she demonstrated different parts. She also demonstrated the inner structure of a flower by cutting it. We also cut it at home. In the first chapter [i.e., Heat], she showed the scales of a thermometer for us to observe the room temperature. For the topic, Living Creature and its Environment, she discussed various kinds of aquatic plants and showed their characteristics.

Faria: One day our teacher did the experiment (demonstration) of pressure of liquid. She used a container made of tin and made three holes in it at distances of equal height. Then we put tap water in it. In this way she did an experiment demonstrating the pressure of liquid. For the last topic, we collected aquatic plants; the teacher showed us their different characteristics

Mehjabin: Our teacher wrote a topic about biology on the board and told us to write our concept of that topic in groups. Then she discussed the topic. She gave us slide callipers to observe for two to three minutes. Then she told us to measure the diameter of the chalk. She demonstrated how to identify acid or base with the help of litmus paper. We used lemon as acid and lime water as base. In the last class she also drew pictures on the chalk board.

I: What about others?

Mehjabin: Our teacher told us to collect flowering and non-flowering plants. We collected and stuck the plants on art paper. We displayed these in the classroom and everyone saw them. During teaching of the chapter, our teacher showed us the group tasks so that we could see these directly and understand them easily.

Sadia: Our teacher draws the figure on the blackboard and shows us the teaching materials if she has any. Recently she taught us about measurement. She brought slide callipers into class to help us understand measurement. Each of us used the callipers and understood how they work.

I: No differences?

No response from the others.

I: All of you agree with these responses?

SS: Yes mam.

I: Do you memorise your science lessons? Why or why not?

Tamanna: We try to understand. If we do not understand content from description then we organise, because we have to do well in the examination. We have to get good marks. So, to get good marks in the examination you have to organise.

I: Do any one want to add something?

Nazia: I have problem in remembering symbols, valences, atomic mass, and molecular mass. We need to remember these because these are important for mathematical solutions. Also, we have to write equations.

I: We are at the last stage of our discussion. Would you like to say anything more about your learning of science?

Sadia: Science is very interesting. We want to learn science. We need to learn about it. We don’t want to memorise.

I: what do others think about Sadia’s comment?

Mehjabin: I agree with her.

I: Lovely, I have gathered good experience about teaching and learning science from you all. Thank you very much.

SS: Thank you too.

Appendix 11: A Sample of the Lesson Observation Report

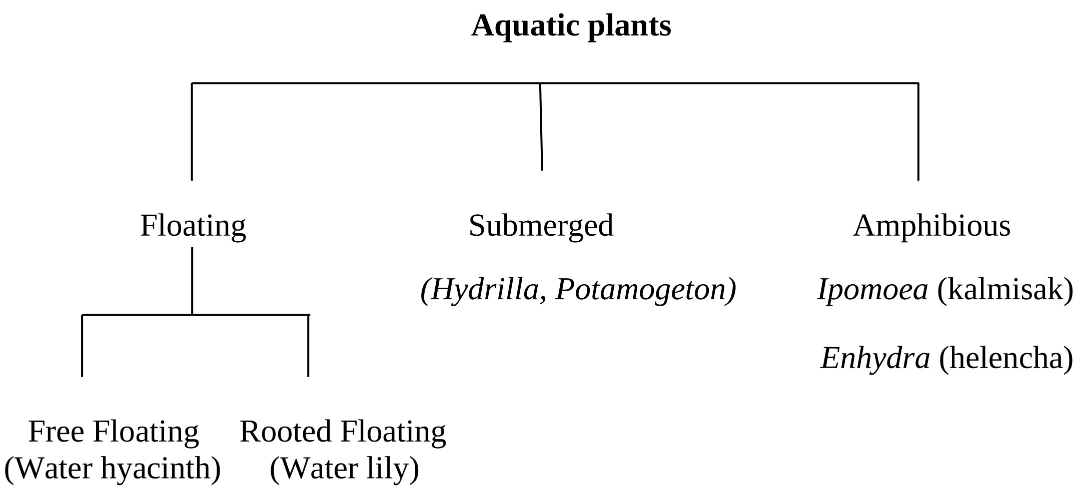
Date: 04 /07/ 2011	Lesson time: 11:20 -- 12:00 AM
Name of the teacher: Nabila Jahan (pseudonyms)	
Grade: VIII	Number of students: 50 (Girls)
Topic of the lesson: Living Organisms and Environment: Aquatic Plants (lesson 1)	

Beginning of the lesson (about 5 minutes)

Nabila exchanged greetings with the students and started the class with some questions about plants and environment from the previous lesson. She asked, "*What do you understand by environment?"* The students began to answer randomly but without noticing the students' answer, she started to answer the question, *"Whatever we have around us is called our environment. We have plants around us. They are living organisms. They have an environment as well. What do we understand by the environment of plants? They have water, air, soil around them. Isn't it?"* The teacher again asked, *"Do you think, we need to know about the environment of plants? Don't you think they are important?"* The students replied together, *"Yes, madam".* Then she again asked questions about the classification of plants with examples. Some of the students replied together, *"Trees, herbs and shrubs on basis of the shape of the stem".* She then brought out some more examples of herbs and shrubs mentioning the characteristics of flowering and non-flowering plants. By using question and answer she reviewed the former lesson to link with the present lesson. Based on these questions, she wrote the topic name, *"Living organisms and their environment"*, on the chalkboard. Subsequently, she focused on the objective of today's lesson. She said, *"Today we will learn about aquatic plants (hydrophytes) based on their habitats".* She explained the term “habitats”, and added, *“Botanists have divided plants into four classes on the basis of the availability of water and salinity prevailing in their habitat, all plants cannot grow in the same place, for example, the plants of mangrove forest will not grow in deserts”.* After that she wrote the classes on the blackboard, “Hydrophytes, Mesophytes, Xerophytes and Halophytes”.

Teaching and learning process (about 25 minutes)

Next, Nabila discussed hydrophytes. She asked students to give her some examples of hydrophytes to test their understanding of the subject. The students gave some examples of aquatic plants like, “Water lily, lotus and water hyacinth*”.* Then the teacher said, *“Plants which grow in water or places having water are known as aquatic plants.”* Then she demonstrated water hyacinth and *Eichornia* (local name: topa pana) explaining “*These are floating plants, the characteristics of all plants are not same. You see, these plants are different from all plants outside the classroom. What are the differences? Could you mention the characteristics of aquatic plants by observing these two plants?”* The students began to point out the characteristics, that is, the roots are very short and there is no root hair, root pockets are present at the tip of the root, leaves of floating plants are large, round and with long petioles, flowers of floating plants are bright, floating plants reproduce vegetatively. Nabila compared the characteristics with Mesophytes and mentioned some more examples like, water lily to clear the characteristics. She demonstrated a flower of water hyacinth which was brought by a student from the class. She mentioned the name of Enhydra (local name: Helencha) as an example. Afterward she said, *“All the aquatic plants are not same. There are some more classifications of aquatic plants. You see, both the water hyacinth and water lily are floating plants. But they are different in some extent. Could you find out the* *difference?"* A student tried to answer but the teacher herself replied, *"The water hyacinth is a free floating plant and water lily is a rooted floating plant. A water lily cannot move like a water hyacinth."* She then said, *"We can classify aquatic plants in some ways. They are three types: floating hydrophytes, submerged hydrophytes and amphibious hydrophytes".* She started to draw a flow chart of this classification as an example on the chalkboard. It looked like the following:



While Nabila was drawing the chart on the blackboard, she was repeating the examples twice and the students were also repeating what she was saying. The students were attentive at that time. The teacher told the students to concentrate on their textbooks as well. She mentioned television as a medium to expand their learning as they can often see different plants in television programs about the deep ocean. She stated that those plants under the ocean were submerged hydrophytes. She then gave the definition of submerged hydrophytes, *"Plants which always remain under water are termed as being submerged hydrophytes".* She was writing the examples on the blackboard and repeating them continuously. She apologized for not bringing *Hydrilla* for the students. Next she defined and explained about amphibious hydrophytes describing them as *"Plants which grow partly in water and partly on land are known as amphibious* *hydrophytes .These plants grow by the side of water bodies but extend their stems long distances up to the water surface”.* She added, “If we know about such plants we can apply that knowledge in real life. That is why it is important to know about the plants. You will be able to understand their application in the future”. Nabila did not mention or share with the students how this knowledge about these plants, and their characteristics, will be applicable in real-life.

Assessment (about 5 minutes)

Nabila started assessing the students learning by pointing to some students from the front benches to answer her questions. She did not concentrate on the activities of other students in the classroom. The questions were as follows:

What is an aquatic plant? Mention some examples of aquatic plants?

How many types of aquatic plants are there? Name them.

How many types of floating plants are there? Give some examples.

What are submerged hydrophytes? Give some examples.

What are amphibious hydrophytes?

What are the characteristics of aquatic plants?”

Nabila was listening to the students and, all the students were giving the correct answers. Sometimes the teacher repeated the students’ answers and sometimes she answered the questions herself. She showed a picture of a water lily as an example of submerged hydrophytes in between the evaluation session and described the characteristics of this plant and its leaf. After that she asked students to ask questions regarding the lesson, if they had any questions. One of the students asked about the wax coating on the leaf since this was a characteristic of aquatic plants, *“Why does the upper surface of the leaves have a waxy coating?”* In that case the teacher replied, *“If you see the upper* *surface of the leaves, you will see that there are no pores on that surface and the leaves will feel very oily. And the stoma lies in the lower surface of the leaves."*

At the end of assessing the students' learning, Nabila opened the textbook and said to the students, *"After aquatic plants we will discuss Mesophytes; plants growing in the soil".* She was in a hurry to continue the lesson. She defined *Mesophytes* as: *"Plants growing in the soil where the availability of water is neither in neither excess nor scanty are regarded as Mesophytes"* and asked students for some examples. She wrote some of the examples on the chalkboard, and asked about the students about the characteristics of *Mesophytes*. One student said, *"Roots are provided with root hair, root cap and branches".* The teacher said, *"Yes, you are right. We can see all that in a chili plant. What are the parts?"* The students were replying haphazardly. Nabila then asked for some more characteristics but answered herself. *"Stems are distinct and well developed, leaves are provided with numerous stomata"*. Nabila said, *"You have already known about stomata, what happens during respiration?"* She herself explained the process of respiration, and stomata by mentioning photosynthesis. She was referring to the textbook. Suddenly, the bell rang and one of students asked about cuticle. The teacher said that, *"Cuticles are the layer of wax on the surface of leaves".*

Home task

Nabila wrote the homework on the blackboard, *"Write down 5 characteristics of aquatic plants with examples".* Afterwards she finished the class by giving thanks to all the students.