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Doctoral Thesis

Learning Partner Recommender System (LPRS): Promoting Informal Online Learning Communities in Higher Education

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Abstract

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With the massive growth of online learning, students' face-to-face interaction has decreased, leading to an increase in their feeling of isolation, which makes formation of students' online communities a challenging task. The research aims to find a way to encourage informal Learning Communities amongst students in the higher education context through suggesting study partners. Students individual characteristics have been found to have important roles in their collaborative learning activities as well as the formation of learning communities. Therefore, a learning partner recommender system (LPRS) has been proposed that takes into account students' characteristics and their preferences for study partners. The aim is to encourage positive interactions amongst students and to facilitate the creation of informal learning communities.

A Design Science Research approach was employed to conduct the project which consisted of four phases: 1) Building the LPRS Conceptual Model, 2) LPRS Design and Implementation, 3) LPRS Evaluation, and 4) Students' Technology Adoption in Voluntary Situations. The first two phases were performed in the first two years of the PhD candidature. In phase 3, evaluation, data collection was performed with both students and educators to examine the strengths, weaknesses, and the potential impact of the developed system. During the evaluation phase, the LPRS was evaluated in an informal voluntary setting with real users who were students in the Faculty of Information Technology at Monash University in semester 1 2019. Low system uptake from students in the real-life setting motivated a thorough investigation on barriers to LPRS adoption and educational technology in informal voluntary situations in general, which was conducted in phase 4 using semi-structured interviews with educators and students.

Results from phase 3 demonstrated that LPRS functioned well in a real-life context with positive feedback from students in terms of its potential for facilitating students in finding study partners with compatible characteristics. The system was also found by educators to have prospects of other side benefits, encouraging students' self-reflection and being integrated into units in formal learning contexts. The study in phase 4 resulted in a preliminary finding: in informal voluntary situations the very first stumbling block for students' adoption of new educational technology is attributed to factors including social norms, immediacy of result, and visual appeal.

Declaration

This thesis is an original work of my research and contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

Signature:

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Contents

List of Figures

List of Tables

List of Abbreviations

AGF	**A**utomatic **G**roup **F**ormation
CL	**C**ollaborative **L**earning
CoI	**C**ommunity **o**f **I**nquiry
CoP	**C**ommunity **o**f **P**ractice
CSCL	**C**omputer **S**upported **C**ollaborative **L**earning
CSS	**C**lassroom **C**ommunity **S**cale
DSR	**D**esign **S**cience **R**esearch
HE	**H**igher **E**ducation
IDT	**I**nnovation **D**iffusion **T**heory
IS	**I**nformation **S**ystem
LA	**L**earning **A**nalytics
LCs	**L**earning **C**ommunities
LC	**L**earning **C**ommunity
LMS	**L**earning **M**anagement **S**ystem
LPRS	**L**earning **P**artner **R**ecommender **S**ystem
OLEs	**O**nline **L**earning **E**nvironments
OLCs	**O**nline **L**earning **C**ommunities
OLC	**O**nline **L**earning **C**ommunity
PEOU	**P**erceived **E**ase **O**f **U**se
PU	**P**erceived **U**sefulness
RS	**R**ecommender **S**ystem
SoC	**S**ense **o**f **C**ommunity
TAM	**T**echnology **A**cceptance **M**odel
TLCs	**T**raditional **L**earning **C**ommunities
UTAUT	**U**nified **T**heory of **A**cceptance and **U**se of **T**echnology

Chapter 1

Introduction

1.1 Overview

This research project aims to promote informal online learning communities amongst students in higher education through providing them with recommendations for compatible study partners. The study is tightly connected with areas including Online Learning Environments (OLEs), Online Learning Communities (OLCs), Learning Management Systems (LMSs), Learning Analytics (LA), Information Visualisation (InfoVis), and Recommender Systems (RSs) in Higher Education (HE). Ambition of the work is twofold: (1) to obtain a better understanding of OLCs from students' perspectives, and (2) to promote informal learning communities amongst students through a provision of recommendations on collaborators with compatible characteristics.

The project goal is to design and develop a Learning Partner Recommender System (LPRS) which provides students with suggestions on compatible learning partners based on their individual characteristics and preferences. Results of recommendations on learning partners are presented to students as an interactive visualisation user interface in order to provide target users with a meaningful, engaging, and fun way for them to explore their potential networks of peers.

The rationale behind the research comes from knowledge retrieved from previous work which suggests that:

1. OLCs in the context of online environments have substantial impacts on students' learning experiences in respect of both cognitive and social-psychological development;

2. Students' characteristics play a significant part in the formation of OLCs and Learning Communities (LCs) in general;

3. A safe, supporting environment can emerge when students are surrounded by and connected with "those whom they believe want and welcome them" (McMillan, 1996);

4. With the increasing amount of learning which occurs online, LA has good potential for collecting data regarding students' characteristics and preferences, then analysing and providing results back to students;

5. Visual representations can facilitate in presenting the key message of information, raising self-awareness, and increasing collaboration amongst students.

This chapter covers an overview of the whole research. The following sections in this chapter are organised as follows. Section 1.2 briefly discusses the research background which includes a discussion on previous work regarding Collaborative Learning (CL), LCs and OLCs, LA, Automatic Group Formation (AGF), and Reciprocal Recommender

Systems (RRSs). The goal and scope of the current research project are specified in Section 1.3. Next, research questions are introduced (Section 1.4), then the significance of the work is stated (Section 1.5). After that, the research methodology employed is presented in Section 1.6. Finally, the structure of this thesis is provided in Section 1.7.

1.2 Background of the Study

This section provides the context in which the current research project is conducted; and it highlights the motivation for the research. It discusses the current complex environments of ubiquitous online learning where Collaborative Learning, Learning Communities, particularly Online Learning Communities, have become of greater importance. After that, the potential of utilising Learning Analytics in collecting and analysing data about students to facilitate better understanding of their characteristics is demonstrated. Moreover, a discussion on related research areas is presented including automatic group formation and reciprocal recommender systems.

1.2.1 Learning Environments

A learning environment, in a broad sense, consists of all physical, psychological and social conditions that are relevant to learners' learning processes. The meaning of a traditional learning environment involves these components in an on-campus classroom setting (Wu, Tennyson, and Hsia, 2010). However, technology has significantly transformed educational environments and learning currently is not restricted within an institutional boundary. It has been greatly facilitating the improvement in learning experience by bringing flexibility and convenience into the learning process, introducing different approaches to learning such as Massive Online Open Courses (MOOCs) and Personal Learning Environments (PLEs).

In the context of complex learning environments where learning is likely to take place in different forms with various approaches, apart from the skills of "know-what" and "know-how", "know-where" plays a significant role in learners' learning journey (Siemens, 2005). While "know-what" refers to knowledge about facts and "know-how" refers to skills, "know-where" refers to where to obtain requested information and knowledge. This concept is corresponding to "know-who" discussed in (Lundvall and Johnson, 1994) – who to go to for information needed. Thus, the necessity of collaboration in learning becomes more crucial.

1.2.2 Collaborative Learning

Collaborative Learning (CL) refers to an umbrella term for different teaching and learning approaches which encourage students to participate in interactive intellectual activities in order to enable mutual understandings and constructing meanings out of learning material (Smith and MacGregor, 1992). In the context of this research, by adopting definitions from literature (Dillenbourg, 1999; Hiltz, 1998), CL is viewed as a situation emerging from a social process carried out by learners where they actively engage in communication with other peers. As communication and interaction occurs, learners are willing to share information, discuss ideas, negotiate meanings, and reciprocally build their knowledge by articulating their understandings which are built upon through "reactions and responses of others" (Hiltz, 1998, pp. 4) into words.

In higher education, three forms of CL that have been commonly employed and most researched include group work, peer learning and learning communities. Small group work approach has a long history and it is widely employed aiming at academic, intellectual and social benefits for students as well as resource sharing (Cohen and Lotan, 2014; Thorley and Gregory, 2013; Pauli et al., 2008). Although the ideal size of a learning group has not been clearly defined in literature, in formal learning settings, the recommended group size is three to eight members depending on tasks assigned (Kreijns, Kirschner, and Jochems, 2003; Schellens and Valcke, 2006; Strijbos, Martens, and Jochems, 2004; Yang, 2006). Group work in HE contexts is mainly task- or project-oriented where students form (or are assigned to) groups and work towards a collective goal (product or task) where all group participants work based on a clear assigned task (Cohen and Lotan, 2014; Jones, 2007). Many approaches have been studied in order to realise and improve this form of CL, such as tutorials, problem-based learning, or role plays (Jones, 2007).

Similar to group work, peer learning is also rooted a long way back; however, activities might have been conducted implicitly (Topping, 2005). Increasing efforts have been made in order to explicitly promote this CL form. As defined by Boud, Cohen, and Sampson (1999, p.413-414), peer learning is the "use of teaching and learning strategies in which students learn with and from each other without the immediate intervention of a teacher". The two most popular forms of peer learning in HE contexts include (1) peer tutoring which involves students taking roles as tutor and tutee, and (2) cooperative learning which encompasses goal specification, member roles, divided tasks and rewards from teachers (Topping, 2005). With the aim of realising several potential advantages such as promotion of active learning and enhancement of inter- and intra-personal skills (Boud, Cohen, and Sampson, 1999; Boud, Cohen, and Sampson, 2014; Houston and Lazenbatt, 1999), peer learning is a teaching strategy where the instructor carefully designs tasks with appropriate indirect interventions, provides training to students (at varying levels of formality) so that they can perform cooperation in an effective manner. Accordingly, peer learning is considered as curriculum-oriented, formal or informal, with a requirement of training and structure varying depending on the particular learning objectives established by the instructor.

Thus, group work and peer learning refer to pedagogical strategies which are more dedicated to formal learning settings where emphasis is placed on course curriculum and learning content. Moreover, this usually requires the structure of the collective organisation as well as clearly assigned tasks and procedures for students' interactions in these two forms of CL (Cohen and Lotan, 2014; Topping, 2005). Learning Communities (LCs), on the other hand, are more generic and considered as a convergence of learners' choice based on their socio-psychological and learning aspects where informality, personalisation and self-regulation is emphasised and embraced. LCs are often formed around an intentional curriculum structure where two or more courses are linked around an interdisciplinary topic in which a common cohort of learners are enrolled (Kellogg, 1999; Love, 2012; Smith and MacGregor, 1992; Tinto, 2000). In this research, the concept of LCs is adopted in a more generic sense as demonstrated in the work of Kilpatrick, Jones, and Barrett (2003) and Cross (1998). In general, LCs refer to groups of learners who come together to fulfil their needs of learning and build a shared sense of community through regular mutual social intellectual interactions and communications. The use of LCs has been supported in the literature because of various benefits including: students' intellectual and psychological development, stimulation of richer thinking and deeper learning, and improved learning outcome (Zhao and Kuh, 2004).

1.2.3 Online Learning Communities

In an LC, members together perform group activities and communications to achieve some certain goals while gaining skills and experiences as they progress. When these interactions and activities become computer-mediated in an online environment, online learning communities (OLCs) are formed and developed. In the age of educational computing where e-learning has been rapidly developing and the number of online learners is continuously growing, online communities for learning purposes have been playing an increasingly vital role in virtual learning environments.

In education institutions, blended learning, which refers to the integration of traditional face-to-face classroom learning experience and online learning activities, has been gaining increasing popularity and significance. Regardless of the face-to-face element, students' feeling of disconnectedness with other peers remains one of the major challenges (Poon, 2013; Smyth et al., 2012), especially when the class size is large. The issues emerging from disconnected students are many, including a loss of motivation, poor academic performance, and higher dropout rates (Rovai and Jordan, 2004; Tinto, 1975). There is evidence in the literature that OLCs can help improve the situation. Palloff and Pratt (2007) argue that the creation and maintenance of a learning community is greatly important to students' learning and overall satisfaction. Empirical studies have also confirmed positive relationships between sense of community and several aspects such as learning engagement, course satisfaction and learning outcomes (Liu et al., 2007; Rovai, 2002a; Shea, 2006). Thus, by enhancing learners' sense of community in online learning environments, several desired outcomes are feasible including higher involvement, increased commitment, as well as greater motivation and satisfaction. Moreover, students with a high sense of community are reported to feel less burnt-out at college (Rovai, 2002a; Rovai, 2002d).

Approaches to promote OLCs have been studied in literature. However, previous work focuses on syllabus design, instructor's role and behaviour as well as strategies to encourage students' interactions (Calhoun and Green, 2015; Shea, 2006; Swan and Shih, 2005; Wilson et al., 2004). Moreover, the interactions encouraged are centred around subject contents in formal learning contexts. With a focus on promoting the informal side of online learning communities, the current research aims to explore and promote students' interactions outside of classroom boundary rather than focusing on task-based or content-oriented activities.

1.2.4 Reciprocal Recommender Systems

The current research attempts to promote informal online learning communities amongst students by means of suggesting compatible learning partners. The recommendations are generated based on their individual intrinsic characteristics and preferences on what they would want to find in their learning partners. Such a system takes into account features and preferences of both parties of the recommendations, which makes it called reciprocal or two-way recommender system (Pizzato et al., 2010). Reciprocal RSs have been studied mostly in the domain of online dating (Diaz, Metzler, and Amer-Yahia, 2010; Krzywicki et al., 2015; Park, 2013). Thus, this project involves the design and development of a recommender system which provides learners with suggestions on whom to contact, to learn, and to work with.

There has been a recent increase in interest in providing students with recommendations on study partners based on students' characteristics (Potts et al., 2018; Prabhakar, Spanakis, and Zaïane, 2017). These studies have brought valuable contributions to research in the field and showed the potential of improving learners' experience through suggesting suitable peers. However, previous work was either a mere proposed recommendation approach without implementation or focusing on study partner recommendations regarding specific topics.

One research area which is relevant to the current research is automatic group formation which refers to approaches to compose learning groups based on certain grouping criteria. The criteria which are retrieved from best pedagogical practices, have been used to form groups, aiming to maximising learning performance and social interactions amongst students. They are typically related to students' learning aspects (Lin, Huang, and Cheng, 2010) or collaboration goals set by the teacher (Ounnas, Davis, and Millard, 2009). A fair number of studies have proposed approaches to automate the process of group formation using several grouping criteria such as students' knowledge level, interests in learning topics, learning styles or thinking styles. Research in the Group Formation area has potential usefulness in terms of grouping criteria and data collection techniques which can be employed in the present work. Moreover, previous work on formation of student groups shows that students' preferences are taken into account in the group formation process; yet only on projects or activities they would want to work in (Spoelstra et al., 2013; Srba and Bielikova, 2015). This is sensible since students nowadays are encouraged to be transforming towards more self-directed and intrinsically motivated learners (Calhoun and Green, 2015; Goodyear and Retalis, 2010). They have been gaining skills to self-regulate their studies and they have their own requirements/preferences on choosing who to learn with. Therefore, in recommending compatible learning partners to students, it is reasonable for their preferences to play an important role.

In the context of pervasive online learning and the huge quantity of learner-produced data, Learning Analytics (LA) presents advantages that include enabling insights into complex data and providing a shared comprehension of the educational context. In online environments, activity data produced by students is captured to be made available for analysis in order for insights into students' learning to be obtained (Clow, 2012; Siemens et al., 2011; Siemens and Long, 2011). This suggests great potential for LA to be utilised in collecting data about students' characteristics, which in turn can be used in a reciprocal recommender system for learning purposes. Furthermore, visualisation has been utilised in LA systems to facilitate both teachers and learners in exploring and obtaining an understanding of relevant traces that are retrieved from various online environments as well as to walk them through the ocean of available learning resources (Duval, 2011; Romero and Ventura, 2007; Verbert et al., 2014). Thus, visualisation might also have a noticeable role in facilitating the understandability of results generated by the recommender system.

Another important aspect in the current project is about application usability. The research involves the design, implementation and evaluation of a recommender system with target users being students. Therefore, the process of building the system needs to be conducted with consideration for the usefulness, ease of use, ease of learning, and satisfaction of the application (Lund, 2001).

1.2.5 The Need for the Current Research

A great amount of research has been conducted with the aim of improving students' collaboration opportunities in higher education, mostly focusing on group work and peer learning in formal learning situations which involves content-specific collective tasks and course requirements. In contrast, learning more often takes place outside the scope of classrooms through diverse students' self-directed activities such as study groups or casual discussions between peers (Lu et al., 2017). However, these activities are either spontaneous or based on existing friendship relationships which might lead to group homogeneity and hinder students' benefits from obtaining as well as sharing ideas and knowledge beyond the boundaries of the extant communities (Cho et al., 2007; Wang, Lin, and Sun, 2007; Srba and Bielikova, 2015). Moreover, non-attendance in lectures and tutorials in higher education appears to be increasing (Massingham and Herrington, 2006; Barnes and Tynan, 2007), which contributes to a decrease in students' frequent face-to-face contact with others. These phenomena result in a situation where the creation of informal learning groups of students becomes problematic.

In this context, partnership recommender systems have potential to encourage interactions amongst students and promote LCs. In the meantime, individual characteristics and preferences play an important role in learners' collaboration and the formation of LCs. Therefore, students' characteristics and preferences for study partners need to be taken into account when suggesting compatible peers in order to stimulate positive interactions, which is the essential prerequisite for the emergence of LCs.

1.3 Research Goal & Scope

1.3.1 Research Goal

The primary goal of the research is to encourage the formation of informal online learning communities in higher education settings. The **informal** nature emphasises that the research does not aim to facilitate forming groups for a particular task-based assignment in a formal learning context which is normally regulated by unit academics and influenced by grading pressure.

1.3.2 Scope

With the established research goal, which is to promote informal online learning communities in higher education, the focus is placed on the informal aspect of these activities. As stated previously, the research is not dedicated to the formation of task-specific or unit-specific learning groups. Therefore, evaluation of learning outcome is not within the scope. Rather, the study focuses on student engagement, the social side of learning communities.

As for context, the project is conducted for three years within the Faculty of Information Technology at Monash University. Students and academic staff are involved in all rounds of data collection throughout the project.

The research proposal involves building a Learning Partner Recommender System (LPRS) which suggests students with compatible study partners based on their characteristics and preferences. Although Learning Analytics (LA) has great potential for automatic identification of students' characteristics, the utilisation of LA with a full integration with Learning Management Systems (LMSs) for the purpose of input data retrieval is out of scope of the project. This is because the task with highest priority is to obtain understandings of the students' needs and the impact of LPRS implementation on their engagement.

1.4 Research Questions

The current work attempts to answer one main research question with eight sub-questions (SQ). The first seven sub-questions centre around different aspects of the proposed LPRS from design to development and evaluation. Since it is expected that the proposed system will be used by students in a real life context, the last sub-question focuses on factors that can influence their decisions to accept or reject the application.

The main research question is: **Can a learning partner recommender system (LPRS) help promote effective informal Online Learning Communities in higher education settings?**

The eight sub-questions are:

SQ1. What characteristics do students consider important when choosing learning partners?

SQ2. Which measures can be used to assess the effectiveness of an Online Learning Community?

SQ3. How can a Learning Partner Recommender System (LPRS) be modelled to match students with compatible characteristics?

SQ4. What data sources are available for an LPRS and can be used to collect the information needed to match partners according to the identified list of characteristics?

SQ5. Which matching algorithms can be employed to generate matching scores based on important characteristics and their significance level?

SQ6. How can matching results be presented to learners in a meaningful and engaging way?

SQ7. What is the impact of the partner matching system in creating and increasing positive interactions amongst students?

SQ8. What are the factors influencing students' adoption of voluntary applications for learning purposes?

1.5 Contributions

The intended contributions of the present work are twofold. On the theoretical side: firstly, the project aims to identify a set of students' individual characteristics important to their collaborative learning and the formation of learning communities, which can be used as matching criteria in a learning partner recommender system. Secondly, a conceptual model will be proposed for a system which recommends compatible study partners based on students' attributes and preferences. Thirdly, it is expected to provide a better understanding of factors that influence students' decisions to accept or reject a new educational technology, particularly in a voluntary context.

On the practical side: A working learning partner recommender system (or an instantiation of the proposed conceptual model), which will result from the project, can be used by students as a tool to find peers who have compatible characteristics. From that, students can form their own learning groups with peers with whom they feel comfortable and valued.

1.6 Overview of Methodology

Design Science Research (DSR) (Hevner et al., 2004; Venable, 2006) is applied to conduct this present project. In DSR, a pragmatic research paradigm is supported to promote the creation of artefacts to solve real-life problems (Prat, Comyn-Wattiau, and Akoka, 2014). Artefacts here involve "constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices), and instantiations (implemented and prototype systems)" (Hevner et al., 2004, p. 77).

1.6.1 Research Design

By adopting the general methodology of Design Science Research (Vaishnavi and Kuechler, 2004), the research design of the project is established to tackle the research questions. General steps in DSR include awareness of the problem, suggestion, development, evaluation, and conclusion. How these steps are applied in the present research is presented in detail in Chapter 3 - Methodology.

1.6.2 Research Project Phases

Considering the project from a practical view, there are four key phases to conduct. The four main phases are identified as presented below:

Phase 1: LPRS Conceptual Model. The first phase is about the process of building the conceptual model of LPRS which involves synthesis from literature and investigation of students' perspectives. This phase aims at tackling the first three research questions regarding identification of a collection of students' characteristics used as matching criteria in the recommender system, how to assess an effective OLC, and how to model the LPRS.

Phase 2: LPRS Design & Implementation. The second phase focuses on the process of the design and implementation of LPRS, aiming to address the next three research questions including available data sources which can be used by LPRS, matching and presentation approaches.

Phase 3: Evaluation. The third phase concerns planning and conducting the research evaluation. The evaluation process involves a system pilot test, followed by a deployment on a larger scale with a greater number of students in order to investigate its usability and potential impacts.

Phase 4: Study of Barriers to Students' Adoption in Voluntary Situations. In the fourth phase, an investigation is conducted on factors influencing students' adoption of voluntary applications for learning purposes, with LPRS as a case study.

1.7 Thesis Structure

This thesis consists of eight chapters:

Chapter 1. Introduction. This chapter provides an overview of the thesis including the context, motivation, and the goal of the research. Also, the methodology employed is presented with the phases in which the project is conducted.

Chapter 2. Literature Review. This chapter discusses in detail the research background: the significance of collaborative learning and learning communities in the context of growing online learning activities along with increasing feelings of isolation amongst online learners. Then, the potentials of LA in collecting data about students' characteristics is put forward; and research on closely associated areas is analysed so that gaps in literatures can be clearly identified.

Chapter 3. Methodology. This chapter discusses the methodology approach employed to guide the research, which is Design Science Research which involves the creation of artefacts aiming to solve a real life problem. The chapter presents how the research design is established to tackle the research questions.

Chapter 4. Phase 1: The Process of Building LPRS Conceptual Model. This chapter proposes a model of the Learning Partner Recommender System (LPRS) which attempts to utilise LA to provide students with suggestions on study partners based on their characteristics and preferences. The model is created based on the synthesis from literature in relevant areas and results from investigation of students' perspectives on the interested matters.

Chapter 5. Phase 2: System Design & Implementation. This chapter presents the process of how the LPRS model is realised through the design and development of a functioning system. The building process involves the choice of characteristic questionnaires used to collect data about students' characteristics, adopted matching algorithm to generate compatibility scores, adopted presentation approach to make recommendation results accessible to students.

Chapter 6. Phase 3: Evaluation. This chapter focuses on the evaluation of the developed recommender system. It is expected that LPRS be deployed in a real-life context and students are end users. Different perspectives from different participants are also collected in order to examine potential impacts as well as drawbacks of the system.

Chapter 7. Phase 4: Barriers to Voluntary Educational Technology Adoption. This chapter presents a study of factors influencing students' adoption (and rejection) of technology for learning purposes in completely voluntary contexts, with LPRS as a use case.

Chapter 8. Conclusion & Further Research. This chapter discusses the key findings from the research project and proposes the potential approaches to further research in order to make the most of what has been found/emerged from the present work.

Chapter 2

Literature Review

The primary concern of the research project is to stimulate informal Online Learning Communities (OLCs) in higher education through providing students with recommendations on compatible study partners. This chapter, therefore, aims to give an overall picture of relevant areas and set the research context where the present work is situated. Section 2.1 presents the currently complex learning environments which contribute to the importance of collaboration and communities to learners' learning journey. The following Section 2.2 provides a fundamental understanding of Collaborative Learning (CL), along with its most studied forms including group work, peer learning and learning communities. This elucidates the areas to which the research attempts to make a contribution. Next, the significance of informal OLCs in Higher Education (HE) is highlighted in Section 2.3. After that, Section 2.4 discusses one approach to promote OLCs: reciprocal recommender systems in education which suggest students with peers. It highlights the potential of utilisation of Learning Analytics and visualisation in such recommender systems.

2.1 Learning Environments

This thesis presents the work with a key goal being promoting informal collaborative learning communities in learning environments. It is argued that the current learning context has changed into a complex setting which necessitates efforts to stimulate and nurture communities of learners in order to facilitate life-long learning to meet the demand of a knowledge-based economy.

2.1.1 Introduction

One definition of a learning environment, which has been used in several studies (Hietanen, 2015; Marquardt and Oberg, 2011; Sipilä, 2014), is provided in the National Core Curriculum for Basic Education by The Finnish National Board of Education (FNBE) in 2004 as the "entirety of the learning-related physical environment, psychological factors, and social relationships" (p.6). According to this explanation, a learning environment, in a broad sense, consists of all physical, psychological, and social environments that are relevant to a learner's learning process. The meaning of a traditional learning environment involves these components in an on-campus classroom setting (Wu, Tennyson, and Hsia, 2010).

Nevertheless, technology has significantly transformed educational environments and learning currently is not restricted within an institutional boundary. As Davis and Botkin speculated in 1994 (cited in (Davis, 2011)), learning would not be constructed solely of bricks and mortar – restricted within education institutions, but would become a "just-in-time" process facilitated by multimedia networks. With the emergence and increasing usage of computer networks and social media in communication and education, learning now has changed into a social process which is widely spread amongst learners, contents and organisations on a worldwide scale (Charalambos, Michalinos, and Chamberlain, 2004). Individuals with an internet connection who have a need for learning can easily find suitable courses with flexibility of time, location and cost. Efforts have been made to make learning sources easily accessible to learners through programmes of open access, open online courses and open educational resources (Downes, 2007; Yuan and Powell, 2013).

Taking the tremendous impact of technology on learning environments into consideration, Piccoli, Ahmad, and Ives (2001), instead of giving a broad definition of this concept, presented three further dimensions of learning environments in addition to time (timing of instructions), place (physical location of instruction) and space (learning materials accessible to learners). Those three elements included technology, interaction and control. The technology aspect involves tools used for instruction delivery and communication amongst participants; interaction refers to the extent to which participants contact and exchange information with each other; control indicates the degree in which learners can manage how learning instructions are presented.

In this research, the definition of learning environments is not restricted to either a setting of physical classroom courses or an online learning context. A learning environment involves both physical and virtual contexts where there are interactions amongst learning parties (including learners, teachers and learning contents) in order to achieve certain learning purposes and goals. As from a constructivist perspective, a learning environment is a "place where learners may work together and support each other as they use a variety of tools and information resources in their pursuit of learning goals and problem-solving activities" (Wilson, 1995, p.5).

However, this research takes the directive agent as the indicator to categorise learning environments into teacher-directed and learner-directed learning environments. In the former learning setting, the teacher sets learning objectives, plans the activities for the learners to do, motivates the learners through extrinsic stimulants such as grades or prizes, and controls interactions amongst the learners including group membership, member roles and nature of interactions (Pedersen and Liu, 2003). While in learner-directed environments, with the substantial employment of ICT in education sector to improve communication, interactions and material delivery, learners take greater control over their learning (Wu, Tennyson, and Hsia, 2010). Learners set their own goal for learning, identify activities and resources to use, keep themselves motivated by the established goal; and they are encouraged to make decisions on who to work with and how (Pedersen and Liu, 2003). In this research, the main focus is related to learner-directed learning environments.

The main points covered in the remainder of this section include major changes in learning environments and emerging computer-mediated learning approaches including (a) blended learning, (b) Massive Open Online Courses (MOOCs) and (c) Personal Learning Environments (PLEs). It discusses opportunities and challenges for student-directed learning environments which necessitate the creation and development of online learning communities where learners can seek and gain a sense of community on the way of reciprocal knowledge construction using computer-mediated communication technologies and tools.

2.1.2 Trends in Learning Environments

There are some driving factors for the changes in learning environments over the last two decades (Siemens, 2005) including knowledge-based economy, education institutions awareness of the required shift in paradigm, and technology advancements.

Firstly, the knowledge economy introduces a greatly increasing demand for capable staff who possess fundamental skills such as critical thinking, problem solving, flexibility, collaboration and willingness to learn (Shum and Ferguson, 2012). In response to that demand, education institutions have become aware of the skills required for the labour force of the new world and that encourages them to adopt new methods of delivering education so that learners are offered chances to obtain new knowledge and practice new skills in an effective and efficient manner. Traditional education, where learning is bounded in classrooms, is no longer satisfying the needs of the changing economy and lifelong learning. Learning approaches are required to be more flexible, personalised and timely. The considerably growing use of networked computers and advancements in communication technologies and social media offers learners with diverse channels for education and training.

Three changing focuses in education and learning are discussed in the work of Rovai and Jordan (2004). Firstly, education paradigm has been changing its emphasis – less on instruction delivery and more on learning production. Learning now has switched from teacher-centred knowledge transmission where learners passively accept what is taught by instructors, to learner-centred knowledge construction in which learners build their own understanding and knowledge about the world. Secondly, education is no longer restricted within traditional face-to-face classrooms, but is expanding rapidly to both on and off-campus learning using technology, similarly to Davis and Botkin's prediction (Davis, 2011). Thirdly, learners' sense of community has received increasing attention. This is because of growing awareness of the positive influence of sense of community to significant aspects in learning and teaching such as improved dropouts rate in online courses (Rovai, 2002a; Tinto, 1975), higher course engagement, greater perceived academic and social achievement as well as overall satisfaction (Means et al., 2009; Rovai, 2002d; Wilson et al., 2004; Zhao and Kuh, 2004). The research presented in this thesis seeks to respond to these substantial changes in a way that it focuses on facilitating creation of an advantageous condition for interactions amongst students, a critical component of learner-directed learning communities, where students' characteristics and preferences are taken into account.

Noteworthy trends in learning are presented in the work of Siemens (2005) which accord well with several research papers. First of all, learners in the 21st century are highly likely to perform their learning in a wide variety of courses in possibly different areas. This is assumedly a consequence of requirements introduced by the knowledge-based economy which has a high demand of a labour force equipped with multi-disciplinary skills (Cobo, 2013; Stukalina, 2008). Secondly, as discussed above, learning is now perceived as a life-long process which can be realised by integrating both formal education and training provided by education organisations and informal learning (Punie, 2007) through personal learning networks (Attwell, 2007; Dabbagh and Kitsantas, 2012; McLoughlin and Lee, 2010), communities of practice (Johnson, 2001; Wenger, 2000b) and many other forms of collaborative learning. Moreover, technologies have contributed significantly to the learning experience in a way that forms the manner as well as approaches that people conduct their learning and facilitates learners' information analysis process (e.g., information visualisation). Finally, Siemens (2005) also listed the significance of "know-where" – where to obtain the requested knowledge, in the supplement to "know-how" and "know-what". While "know-what" refers to knowledge about facts and "know-how" refers to skills, "know-where" refers to where to obtain requested information and knowledge. This concept of "know-where" is corresponding to "know-who" which has been discussed in the work of Lundvall and Johnson (1994). Know-who, in the context of learning networks, involves the recognition of who to come to for information needed.

Here, the section synthesises the four key trends in current learning environments. (1) Focus: learners, not instructors. Learning used to be conducted as knowledge being passed from teachers to students facilitated by pre-designed curriculum; learners obtained what is taught passively. This situation has been changing into a scenario where faculty and instructors are facilitators during students' journeys. Learners are expected to be proactive in their learning and encouraged to perform their study in a social context where their knowledge and skills are enriched through mutual interactions (Charalambos, Michalinos, and Chamberlain, 2004; Kop, 2011; Rovai and Jordan, 2004). (2) Duration of learning: lifelong journey. As previously discussed, due to ever-changing requirements introduced by the knowledge-based economy, learning is perceived as a lifelong process where learners need to continuously think, learn and improve their knowledge. Educational institutions with faculties and teachers are those who provide learners with the basis for the long-term endeavour. In this context, learners demand an approach to conducting their study in a flexible, convenient way that matches their individual needs. Online learning is the way for which most learners opt to pursue their study. (3) Approach: technologies and tools. Learning Management Systems are used by almost all educational institutions to provide and manage learning materials, track and evaluate learning process, gather and present requested data to education administrators (Ellis, 2009; Watson and Watson, 2007). Computer mediated communication technologies have been intensively applied to the education sector. Technologies such as email, bulletin boards, video conferencing and threaded discussion forums are employed to enhance interactions amongst facilitators, amongst students, as well as between instructors and students (Downes, 2015; Hawkes and Romiszowski, 2001; Swan, 2002; Veerman and Veldhuis-Diermanse, 2001). (4) Learners' perspective on increasing importance of learning networks. Because learning online introduces issues of timely responses and the potential for feelings of isolation (Song et al., 2004), without building active learning communities, online learners can find themselves detached from the learning environment and finally lose interest and motivation.

This research project is conducted with a focus on learners, aiming to encourage increased interactions amongst learners with diverse characteristics and needs regarding compatible learning partners in mind. It attempts to collect data needed in order to obtain a comprehensive understanding of learners' learning features and perceptions which affect their participation when working with peers. Satisfaction of their features and preferences on compatible partners may create a favourable condition for building learning networks and improved learning satisfaction.

2.1.3 Emerging Learning Approaches

Inevitably, the context of learning has dramatically changed with the ease of communication and capability of content aggregators to filter and bundle information as well as communications (Kop, 2011). As a growing number of educational institutions are providing online courses, and an increasing amount of learning materials are being shared on the web, more and more learners are performing their study in virtual environments. As reported by Babson Survey Research Group, by fall 2014 in America, there were 5.8 million students taking part in distance learning with nearly half of them (2.85 million) doing all their courses online (Allen and Seaman, 2016).

However, despite the tremendous growth of online education, there remain widely known issues. Peltier, Schibrowsky, and Drago (2007) in their study pointed out challenges for online learning, one of which was a failure in offering multiple means of communication with and between learners which led to poor learning experiences.

Notwithstanding some initial failures, a wide range of studies have indicated that online learning (including fully online and blended environments) is truly an "educational medium of the future". Means et al. (2009) found that online learners performed better than those in traditional classrooms (p. xiv). These results are corresponding to findings of other researchers of perceived benefits provided by online education (Allen and Seaman, 2016).

Allen and Seaman (2008) provided a prototypical course classification based on the percentage of course content delivered online. According to Allen and Seaman, there have been four course delivery approaches with different proportions of course content being provided online, including traditional (0%), web mediated (1 – 29%), blended (30 – 79%) and online (80+%) (Allen and Seaman, 2008). Learners now are offered with a wide variety of options for conducting their study. With these education delivery methods, there are some noticeable types of emerging and rapidly growing learning experiences which include blended learning, Massive Online Open Courses (MOOCs) (Coffrin et al., 2014; Pappano, 2012; Siemens, 2012) and Personal Learning Environments (PLE) (Attwell, 2007; Martindale and Dowdy, 2010).

2.1.3.1 Blended Learning

With the fact that the internet and communication technologies have initiated dramatic transformations in society, education has also been experiencing this transformative process. Educational institutions have promoted the convergence of internet-based learning with traditional face-to-face classroom (known as blended learning) offering learners convenience and flexibility without completely losing face-to-face interactions (Garrison and Kanuka, 2004; Rovai and Jordan, 2004). Diverse technological approaches are being employed for learning purposes by both students and institutions, such as ebook, mobile learning and social networking channels (Morris, 2014).

Blended learning is both simple and complex, as posited by Garrison and Kanuka (2004). Thinking of it in a simple way, blended learning is a thoughtful integration of traditional face-to-face classroom with online learning experiences. Blended learning, in its complexity, requires significant integration of "student-centred, traditional in-class learning with other flexible learning methodologies using mobile and web-based online (especially collaborative) approaches in order to realise strategic advantages for the education system" (Department of Education and Early Childhood Development, 2012, p.6)

With careful thoughts of adjusting policies, plans, resources and supports, education institutions have been adopting blended learning and generating significant results. López-Pérez, Pérez-López, and Rodríguez-Ariza (2011) contended that the use of blended learning has a positive effect in reducing dropout rates and in improving exam marks. Effective use of technologies in blended learning environment has been proven to have positive impacts on students' engagement, learning experience and learning outcomes (Sharpe et al., 2006). Moreover, the students' perceptions of blended learning are interrelated with their final marks depending on the blended learning activities, as well as on the students' age, background and class attendance rate. Similarly, Garrison and Kanuka (2004) maintained that blended learning is a particularly effective educational medium because of its ability to facilitate the development of community of inquiry and nurture meaningful and critical learning. Rovai and Jordan (2004) found parallel results in which they asserted that sense of community was stronger than in fully traditional and fully online courses. Akyol, Garrison, and Ozden (2009) also came to a claim of the effectiveness of blended learning environments in supporting learning communities.

Nevertheless, there exist some challenges in hybrid learning environments that need to be addressed. Since blended learning is a combination of both face-to-face and computer-mediated learning, it not only can combine "the best of both worlds" but also has potential to bring out the weaknesses of both environments. Graham (2006) discussed advantages and drawbacks of both learning environments in terms of discussion conduct amongst learners. Regarding computer-mediated learning, disadvantages can include spontaneity, postponement and interpersonal connection. As for face-to-face courses, learners are likely to experience decreased participation – in a sense that not all participants can join into classroom activities, and inflexibility due the time limits of classroom programs. Moreover, as So and Brush (2008) mentioned, students might find it difficult in adjusting to blended learning environments due to ineffective time management skills. Issues and challenges of designing an effective blended learning environment are discussed in more details in the work of Graham (2006).

One critical note for hybrid learning has been stated by several researchers – which is that solely adopting internet technologies into face-to-face courses to turn them into blended formats does not mean learners are provided with effective and interactive learning experiences (Garrison and Kanuka, 2004; Graham, 2006; So and Brush, 2008). The art of creating an effective blended learning, as indicated by Graham (2006), is to understand both the virtues and flaws of face-to-face and computer-mediated learning environments, and then apply that understanding to instructional strategies and designs so that a suitable context-specified pedagogical approach is realised to yield better learning experiences for learners.

2.1.3.2 MOOCs

Growth, Characteristics & Pedagogical Base

The last few years have observed the rapid rise of Massive Online Open Courses (MOOCs) with the growth in number of education institutions offering free online courses (without course certificates) and increasing number of learners enrolling in those courses (Coffrin et al., 2014). Year 2012 was called "the Year of the MOOC" (Pappano, 2012) with dramatic figures of students signing up for courses introduced by providers such as edX, Coursera, and Udacity; as well as top universities becoming partners with these MOOC providers. According to ICEF Monitor report in January 2016, MOOCs enrolment in 2015 exceeded 35 million – higher than the number of participants of the three previous years combined (ICEF Monitor, 2016).

The term MOOC was created by George Siemens and Stephen Downes in 2008 when they introduced an open online course to promote the "connectivism" learning theory (Baturay, 2015; Daniel, 2012). So far, MOOC has still been poorly defined and there is no globally adopted definition for the term (Jansen and Schuwer, 2015; Tabaa and Medouri, 2013). However, it is widely accepted that a MOOC is a course which is delivered on the internet, aims at a large number of learners and provides some certain types of openness (Bremer and Weiß, 2013). The "open" aspect of MOOCs can be interpreted in different ways regarding course fees, course content or course pre-requirements (Bremer and Weiß, 2013; Jansen and Schuwer, 2015; Yousef et al., 2014). Essentially, MOOCs are a platform which creates an ecosystem for a wide range of operations to be developed in order for a MOOC to be delivered effectively (Daniel, 2012; Siemens, 2012).

It has been stated that fundamental features of a MOOC consist of openness, voluntary participation and distributed knowledge (Baturay, 2015, p.428). Openness denotes that learning resources are openly available to learners and the work produced during a course is shared and becomes publicly available. Voluntary participation means participants learn through voluntarily creating, sharing and communicating their knowledge while going through a course. Distributed knowledge demonstrates the "connectivist" concept behind the design of MOOCs where information is spread over a network of learners.

A standard MOOC is claimed to be designed based on some pedagogical foundations (Glance, Forsey, and Riley, 2013). In terms of course format, there are some fundamental features which can be observed in MOOCs. Firstly, short videos with a length of eight to ten minutes each are used to demonstrate the concept being taught. This is inspired by courses provided by Khan Academy (Glance, Forsey, and Riley, 2013; Pappano, 2012) in order to increase learners' focus and attention to the video content. Secondly, quizzes are embedded in and after each video so that learners can reflect on what they have learnt. The design of such short videos combined with quizzes aims to facilitate mastery learning – obtaining a thorough understanding of a concept before moving to the next one (Glance, Forsey, and Riley, 2013). Thirdly, assessment is conducted through either peer and self-assessment or automated grading tests. There have been some critical views on the use of peer assessment in MOOCs (Daniel, 2012; Glance, Forsey, and Riley, 2013); however, with benefits reported by known literature, this approach has been commonly used in MOOCs. Fourthly, interaction is realised through online forums, live video sessions and social media to promote a learning community (Baturay, 2015; Glance, Forsey, and Riley, 2013).

Types of MOOCs

According to literature, there are two distinguishable types of MOOCs – cMOOCs with "c" standing for connectivist and xMOOCs with "x" being borrowed from edX and MITx (Daniel, 2012; Rodriguez, 2013; Siemens, 2012). Courses of the former branch are designed and delivered based on connectivism learning theory which places great emphasis on social and cultural aspects of a learning process; while those of the latter are often structured in a more traditional fashion and partnered with education institutions (Daniel, 2012; Karsenti, 2013; Rodriguez, 2013). Table 2.1 shows several key distinct points between the two discussed types of MOOCs.

Aspect	cMOOCs	xMOOCs
Learning theory	Connectivism	Behaviourism
Focus	Knowledge creation	Knowledge replication
Structure	Distributed, non-linear/linear, network-based	Centralised, linear, content-based
Format	Peer & social learning, peer & self-assessment	Short videos with quizzes, automated grading assessment
Openness	Greater	Restricted

TABLE 2.1: Main differences between cMOOCs and xMOOCs

As Siemens (2012) stated, "cMOOCs focus on knowledge creation and generation whereas xMOOCs focus on knowledge duplication". As a consequence, cMOOCs make much use of models of social learning and peer learning in order to promote interaction, discussion, exploration and knowledge construction amongst learners. While xMOOCs have only become widely known since a number of prestigious universities started offering MOOCs, the course format is based much on knowledge transmission approach with lectures being delivered as short videos interspersed with quizzes and assessment through exams (Baturay, 2015; Yuan and Powell, 2013). Structure of cMOOCs is generally (1) distributed with expertise being dispersed across the network of participants, (2) more flexible – either linear or non-linear depending on the learner's self-regulation ability, and (3) network-based since according to connectivism theory, learning happens through interaction in and amongst networks of knowledge resources and learners (ElAtia, Ipperciel, and Zaïane, 2016; Margaryan, Bianco, and Littlejohn, 2015). As for xMOOCs, they are usually (1) centralised since they are mostly backed by a collection of universities, (2) content-based – focusing on lectures, quizzes and testing, and (3) linear – topics taught in an xMOOC are presented in a certain relevant order and the journey of learners through a course is sequential (Margaryan, Bianco, and Littlejohn, 2015). Also, the concept of "openness" in cMOOCs and xMOOCs are distinct. In cMOOCs, learning materials are freely available with unlimited participants and openly shared contributions; while in xMOOCs access to course content is under some restriction and certain pedagogical approaches are imposed. A comprehensive discussion on openness can be found in (Rodriguez, 2013).

Advantages and issues related to learners

Benefits provided by MOOCs have been discussed in many studies. MOOCs are a product of online education, therefore they share the efficacy of online learning, including flexibility, wide range of course choice and encouragement of learners' self-learning (Glance, Forsey, and Riley, 2013; Karsenti, 2013; North, Richardson, and North, 2014). Dillenbourg et al. (2014) posited that with excellent strategy and plan as well as sensible implementation, MOOCs can widely open the venue for an institution to reach thousands of learners. In addition to common digital course materials such as videos, audios, ebooks or slides, a variety of communication tools and technologies are integrated to promote interactions during the course. Consequently, a MOOC helps stimulate the formation of learning communities. Moreover, as Breslow et al. (2013) and Coffrin et al. (2014) suggested, the huge amount of data created by those who participate in activities in MOOCs provides a great potential for researchers, educators and managers to perform Learning Analytics (LA) to gain insights into online learners' learning experiences. A number of studies have applied LA to analyse massive data generated by MOOCs environment to have better insights into online learning context (Fournier, Kop, and Sitlia, 2011; Joksimovic, Gasevic, and Hatala, 2014; Joksimović et al., 2015; Kop, 2011).

Nevertheless, along with advantages, several existing issues have been raised concerning the dropout rate of MOOCs and plagiarism (Daniel, 2012), instructional design in xMOOCs (Margaryan, Bianco, and Littlejohn, 2015), and openness in MOOCs (Rodriguez, 2013). It is a widely known fact that the attrition rate in MOOCs is appalling. For example, only about 7,100 out of 155,000 participants in Circuits and Electronics course provided by MIT completed the program (Daniel, 2012). However, as Gillani (2013) remarked that attrition in MOOCs settings is "inherently ambiguous" (p.24) since MOOCs courses require low commitment and attract learners who are more interested in acquiring knowledge than in obtaining official qualifications. Plagiarism and cheating are also a recognised issue in MOOCs, which is also a key challenge in online education (North, Richardson, and North, 2014). Potential solutions to this problem are plagiarism detecting specialised software and proctored tests (North, Richardson, and North, 2014; Yuan and Powell, 2013). In addition, instructional design is also considered as an existing weakness of MOOCs. Margaryan, Bianco, and Littlejohn (2015) performed an analysis on 76 MOOCs of both types (cMOOCs and xMOOCs) and found that the majority of these courses had low scores on most principles of designing instructions. According to the findings, most of the courses are not problem-centred, unable to activate learners' existing experience, limited at encouraging learners to integrate new knowledge or skills and poor at promoting collective knowledge and collaborative learning.

All in all, MOOCs are believed to have the potential to enhance a learning environment. Daniel (2012) argued that MOOCs may help stimulate universities' awareness of developing online learning intentionally with careful pedagogical approaches. Courses offered by MOOCs providers aim at reaching an enormous number of learners; and those programs present participants with a chance to pursue their lifelong learning.

The research presented in this thesis attempts to match students with compatible characteristics with the aim of stimulating interactions amongst learners. The context specific to the work is a blended learning environment. However, there is a great potential for this work to be applied in a MOOCs setting since the face-to-face element is unavailable in a MOOC and the need for helping participants get connected is even more critical (Siemens, 2013).

2.1.3.3 Personal Learning Environments (PLEs)

Definition and driving factors

A Personal Learning Environment (PLE) is defined as a collection of "tools, communities, and services that constitute the individual educational platforms learners use to direct their own learning and pursue educational goals" (EDUCAUSE Learning Initiative (ELI), 2009, p.1). As stated by Attwell (2007), the idea of a personal learning environment stems from lifelong learning concept in a way that a PLE recognises that learning is a continuous process and that individual learners have the ability to organise and manage their own learning. In the same vein, Martindale and Dowdy (2010) posited that growing awareness of the significance of lifelong, informal learning is one driving factor of the emergence of PLEs. Another influencing factor is the limitation of LMSs commonly used by education institutions. An LMS can effectively deal with the management of learning resources, monitoring and evaluation of learning process, collection and presentation of learning data to educators. However, such a system does typically not utilise social media in facilitating learners' maintenance of their own learning space and formation of connections with other peers (McLoughlin and Lee, 2010; Wilson et al., 2007). Whereas, according to Dabbagh and Kitsantas (2012), social media plays a critical part in the creation and development of PLEs. Similarly, Attwell (2007) maintained that changing technologies which include ubiquitous computing and social software have a significant impact on the development of PLEs. The usage of these technologies has great effect on shaping the way people learn.

Advantages & challenges of PLEs

There have been advocates supporting the proliferation of PLEs which can be found in literature. Dron (2007) emphasised the need for promoting and supporting learners' control on the learning process. PLEs embrace informal learning and constructivist theory, both of which consider learners as the central agent of the whole knowledge building process (Martindale and Dowdy, 2010). The most fundamental argument for PLEs, according to Attwell (2007), is that PLEs allow learners to form their own learning networks (communities) according to a wide range of interests or categories aligning to their own needs, and to produce, remix and distribute their learning resources. He also posited that PLEs have the ability to facilitate different learning styles in a way that learners can adjust and develop their learning environments according to their preferred learning styles. In other words, PLE is a potential pedagogical approach to supporting self-regulated learning – regarded as a learner's ability to set their own learning goals, to determine steps needed to achieve the goals, to realise those steps, and to self-reflect on their learning performance (Dabbagh and Kitsantas, 2012; McLoughlin and Lee, 2010). Fournier, Kop, and Sitlia (2011) conducted a study on an open course in a MOOC environment using both qualitative and quantitative methods. According to their findings, a personal learning network was found to be useful since learners can search for resources of interest and obtain a better idea of how they were connected to a wide range of content and co-learners who were keen on similar areas.

However, there have been arguments about the feasibility and challenges related to PLEs in the currently complex learning context. In order for a PLE to emerge and generate positive outcomes, there has to be a change in pedagogy and greater emphasis on personalisation of learning (McLoughlin and Lee, 2010). Informal learning should be included in learning experience to support learners' lifelong learning journey. Also, instructional design should take great consideration of learners' needs and preferences. Kop (2011) discussed challenges introduced to learners in connectivist learning and the PLE context in terms of self-directed learning, how learners project themselves as real individuals in online environments, and skills needed to make judgements on available information and to approach expertise sources to facilitate their learning. Other important issues in PLEs relate to privacy and identity management across several social services (Attwell, 2007; Martindale and Dowdy, 2010; McLoughlin and Lee, 2010). Moreover, students may feel their own space to be intruded when their social media channels are adopted by instructors even if it was for learning and communication purposes.

PLE approaches and models

A number of studies have provided models for employment of social media in supporting self-regulated learning and PLEs. A conceptual model of PLE was introduced by Wilson et al. (2007) which emphasises symmetric connections between learner capability and a variety of available technologies and social media to support lifelong learning and personalisation.

The PLE, as Wilson et al. (2007) stated, is not supposed to focus on any particular context but it should allow coordination of various contexts in order for learners' goals to be supported. In a PLE, learners can create and consume any learning resources as well as re-arrange information according to their own needs. PLEs encourage users to generate and share their learning resources, to make use of a variety of services to facilitate their learning; therefore, PLEs cover both the personal and global range.

Dabbagh and Kitsantas (2012) proposed a pedagogical framework which utilises social media in three levels in order to support the creation of PLEs. The framework targeted at faculty and instructors, aiming to advise them of approaches to engaging learners in PLE formation and self-directed learning improvement. The two researchers claimed that the framework aligned with Zimmerman's three phase model of self-regulated learning – "forethought, performance or volitional control, and self-reflection processes" (Zimmerman, 2000a, p.16). The first phase consists of goal settings and plan development to achieve the goal; the performance stage refers to learners engaging themselves in the learning process, applying strategies to obtain the established goals; and self-reflection involves learners making evaluations of their learning outcomes and suitable adjustments to the forethought phase are made. Based on the cyclical self-reflection model, Dabbagh and Kitsantas (2012) suggested that social media can be employed at three stages of interactivity. The first level is personal information management where learners are encouraged to use social software to create their own PLE. The second stage is social interaction and collaboration where social media are employed by learners to share and collaborate with others. The third stage is information aggregation and management where learners make use of information generated at the two previous levels to self-reflect on their learning experiences.

Thus, learners now have higher and more diverse demands, not only for quality learning experiences, but also for better service provided and convenience in learning process (Garrison and Kanuka, 2004). Internet communication tools and social media provide platforms to facilitate personalisation and community development in learning.

2.1.4 Summary

In summary, the current learning environment has been experiencing rapid changes and growing complexity which introduces opportunities for learners to pursue their long-term learning in diverse fashions. Internet-based and computer-mediated learning and communication has facilitated interactions amongst learners. However, the provision of technologies does not guarantee interactive and collaborative learning to occur. Furthermore, the scarceness of factors such as physical and interpersonal interactions makes the formation of learning communities in online environments a non-trivial challenge (Arasaratnam-Smith and Northcote, 2017; Swan, Garrison, and Richardson, 2009). This research project attempts to explore features that have a significant impact on how learners choose their learning partners for their study; then identify peers who are compatible with a particular learner based on their individual characteristics and preferences. This is expected to create a stimulation of improved interaction and better learning experiences.

2.2 Collaborative Learning

Collaborative Learning (CL) has gained great attention and interest from both educators in learning contexts and managers in workplace settings. The concept of CL has been studied and reported to be an umbrella term covering a wide variety of learning environments where people learn together rather than individually. The present research attempts to build a collaborative system which facilitates learners in finding peers with compatible characteristics so that they can work and learn together. Therefore, a primary understanding of collaborative learning including its fundamental constructs and processes is important in designing an effective system.

The following subsections aim to provide an overview of the broad context of collaboration for learning purposes. Different definitions of CL are discussed and the one adopted in this research is presented in subsection 2.2.1. Next, subsection 2.2.2 and 2.2.3 discuss the theoretical foundation of CL and CL principles, respectively. Then the benefits of CL and several forms of CL studied in the literature are described in subsection 2.2.4 and 2.2.5. Finally, the last subsection 2.2.6 attempts to give a brief discussion on the potentials for and challenges of collaboration in computer-mediated internet-based learning environments.

2.2.1 Definition

CL is a term that has been considered by many researchers as any pedagogical approach that involves groups of learners working together towards a common goal. Smith and MacGregor (1992) propose that in collaborative learning, "students are working in groups of two or more, mutually searching for understanding, solutions, or meanings, or creating a product" (p.1). This educational approach can take many forms with different numbers of participants, from informal to highly structured systems. However, the core aspect of CL involves students mutually participating in the process of exploring and making sense of learning material instead of instructors lecturing and explaining what is presented in learning content (Hiltz, 1998; Smith and MacGregor, 1992). Another interesting view on CL has been given by Dillenbourg (1999) in which the scholar argues that CL is not a mechanism or method. Instead, he asserts that it is a situation in which a certain form of interaction amongst learners can occur which might initiate a learning process; but there is no assurance that the interaction will actually happen. This view is shared by Schwartz (1995) and Warschauer (1997) as they suggest that potential and reality should be distinguished – the availability of computer-supported collaborative learning systems does not assure students' collaborative activities. The major concern regarding CL is to create an environment/method/system to increase the probability of the expected interactions manifesting themselves.

The current research acknowledges the awareness raised by Dillenbourg (1999) that interactions amongst students in a learning context are not guaranteed to automatically occur. A supporting environment is required to stimulate interactions, communications and collaboration between students. In this research, by adopting definitions suggested by Dillenbourg (1999) and Hiltz (1998), CL is defined as a situation emerging from a social process carried out by learners where they actively engage in communication with other peers. As communication and interaction occurs, learners are willing to share information, discuss ideas, negotiate meanings, and reciprocally build their knowledge by articulating their understandings which are built upon through "reactions and responses of others" (Hiltz, 1998, p.4).

Collaborative Learning has been studied in both workplace contexts and educational settings. In workplace environments, employees learn from each other to improve their expertise and to perform tasks more productively. This research aims to facilitate the creation of communities of learners in higher education, and consequently focuses on educational contexts. The remainders of the section provide discussions on the theory associated with CL, its benefits, common approaches to CL and CL in online learning environments.

2.2.2 Theoretical Foundation of Collaborative Learning

Collaborative Learning is rooted in the socio-cultural theory of Vygotsky (1980). Vygotsky's theoretical framework emphasises the critical role of social interactions either between teachers and students or amongst learners in a cognitive development process. He suggested that learning occurs on two levels: firstly, through interaction with others in a sociocultural setting (inter-psychological); and secondly individually in the learner's internal mental structure (intra-psychological). Through the two levels understandings are obtained and knowledge is constructed. Thus, socio-cultural interactions are asserted to play the central role in facilitating learners' "qualitative transformation" to advance through their Zone of Proximal Development (ZPD) (Warschauer, 1997; Wertsch, 1984). ZPD is described as the gap between what the learner can accomplish individually and what he or she cannot complete without external help or guidance or collaboration with others (Warschauer, 1997). Significance of social interaction in one's learning process was demonstrated by the concept of ZPD. However, the notion of ZPD emphasises the asymmetry feature between the two separate parties – the helper and the helped. This research attempts to encourage social interactions amongst learners but the level of possessed knowledge situation is not necessarily asymmetric. That means it is not required that learners who are suggested to be study partners have different levels of knowledge in a particular area.

The present work takes into account several characteristics of students, not only their knowledge level or skills.

The concept of CL is discussed and theorised by Dillenbourg (1999) which consists of four aspects – situations, interactions, processes and effects. Figure 2.1 demonstrates the four aspects of Collaborative Learning presented by Dillenbourg (1999).

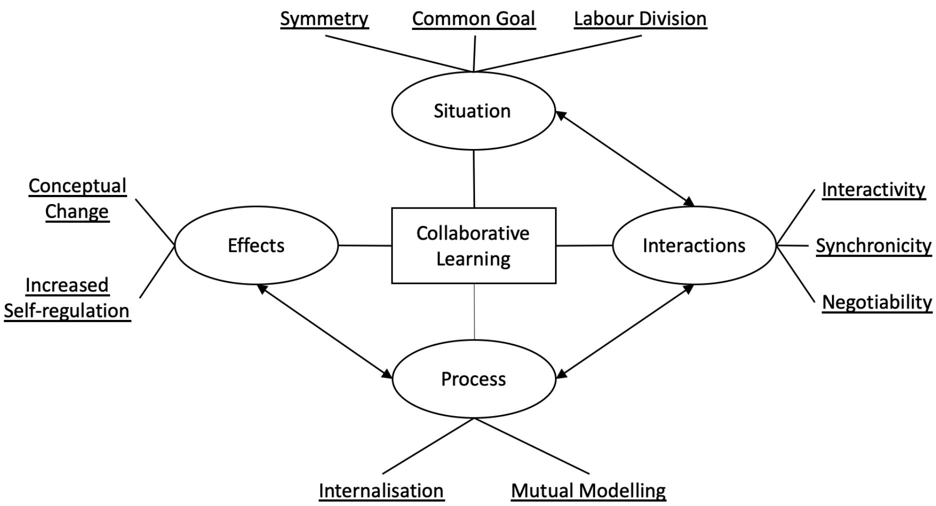


FIGURE 2.1: Theory of Collaborative Learning (summarised from (Dillenbourg, 1999))

Situations for CL to emerge, according to Dillenbourg (1999), should contain symmetric (relatively equivalent) levels amongst participants in terms of knowledge, action and status; shared learning goals which are mutually agreed; and horizontal division of labour where collaborative members perform interwoven tasks. Interactions element involves interactivity between participants during the process of performing tasks/work; synchronicity which denotes timely response amongst learners; and negotiability which refers to constructivist nature of interaction in CL. Thus, in a situation where learners with relatively equal levels of action, knowledge and status share common learning goals and work in an interdependent manner, interactive timely and constructive interactions should occur. Together the collaborative learners then go through a process involving internal meaning making (internalisation) and joint knowledge construction (mutual modelling). The effects emerging from CL include conceptual change, which refers to a change where new cognitive structure is created internally in learners (Clement and Vosniadou, 2008), and increased self-regulation, which refers to learners' proactive and constructive management of cognition, motivation behaviour and context in their learning (Pintrich, 2000).

Another area which is tightly related to collaborative learning is cooperative learning. The two concepts, sometimes referred to as collaboration and cooperation, are often used interchangeably (Dillenbourg, 1999; Panitz, 1999a). Although both require interactions to take place within groups of two or more learners (Gerry, Koschmann, and Suthers, 2006), researchers tend to distinguish the two terms. Differences between collaborative learning and cooperative learning have been studied by several scholars (Panitz, 1999a; Rockwood III, 1995; Smith and MacGregor, 1992). Table 2.2 lists some primary differences between the two concepts synthesised from previous literature. The distinguishing characteristics of Collaborative Learning (as listed in Table 2.2) correspond with the goal of this research. It takes into consideration students' individual features, aiming to promote learner-directed communities where students engage in a process of interaction and exploration with other peers which can lead to the formation of a learning community.

Cooperative Learning	Collaborative Learning
An instructional strategy with focus on structures and activities	Personal philosophy based
More teacher-directed	More student-centred
Work is divided vertically into independent sub-tasks	Work is divided horizontally into reasoning layers (intertwined subtasks)
Can be studied with traditional educational & psychological methods	Cannot be studied with traditional psychological methods
More suitable for mastery of foundational knowledge	More suitable for more conversant learners

Table 2.2: Differences between cooperative learning and collaborative learning (synthesised from Panitz (1999a), Dillenbourg (1999), and Gerry, Koschmann, and Suthers (2006))

Given the differences identified in literature, the current research, with the goal of encouraging informal learning communities, falls into the area of collaborative learning. The current work does not aim to facilitate the formation of task-specific/unit-specific groups in formal learning contexts which is typically regulated by academics and influenced by grading pressure. In cooperative learning, students are assigned independent tasks and work towards an outcome for the whole group (grades in most cases). Whereas, the context of this project is to promote informal learning activities through providing students with suggestions on study partners with compatible characteristics. The emphasis on students' individual characteristics and the informal nature of learning activities that the present work attempts to promote results in the research focus on collaborative learning.

2.2.3 Collaborative Learning Principles

The rationale for the research focus on collaborative learning aligns with principles upon which CL is grounded. Panitz (1999a) pointed out five key principles of CL. Several studies after his paper were conducted with results aligning with those principles. The first principle states that better understanding of a matter of interest is more likely to be achievable when one works with others compared to working independently (Panitz, 1999a). As Dillenbourg (1999) suggests, cognitive processes such as induction, cognitive load and self-explanation happen when a learner studies individually, but they are likely to occur more often in collaboration situations. As Dillenbourg (1999) suggests, CL promotes a situation where learners are presented with different perspectives and build their own understanding through interactions and meaning negotiations with other peers. With that being said, the present research holds a view that students' personal factors, such as prior knowledge, personality traits and self-perception, have an important impact on how they learn in a collective setting which consequently affects their perceived learning in a community of learners.

The second principle of CL mentioned by Panitz (1999a) was about the significance of both "spoken and written interactions" in increasing learners' understanding. Students are used to interacting with instructors and peers in person in traditional educational settings where non-verbal immediacy such as gestures or proximity can help enhance communications. Despite the lack of non-verbal cues in online learning environment, as Panitz suggests, better understanding can still be engendered in online settings, not necessarily only in face-to-face contexts. This view corresponds with findings in the work of other researchers such as Swan (2002) and Darabi et al. (2011).

The third principle of CL concerns the association between greater comprehension and social interactions (Panitz, 1999a). CL is perceived as a social process where students actively become involved in learning activities with others and they improve their knowledge as the participation keeps going. This viewpoint has been supported by a substantial number of studies in collaborative learning (Kreijns, Kirschner, and Jochems, 2003).

The last two principles of CL mentioned by Panitz (1999a) include the unpredictable and voluntary nature of collaboration in learning. Regarding the unpredictability, this author stated that "some elements of this increased understanding are idiosyncratic and unpredictable" (Panitz, 1999a). CL involves individuals as group members; and although there exists symmetry of action, knowledge and status amongst the members, there is no situation where the individuals possess exact equal levels regarding the three aspects (Dillenbourg, 1999). Therefore, individual characteristics can potentially influence the effectiveness of CL, for instance learning styles (Kreijns, Kirschner, and Jochems, 2003). Moreover, as Dillenbourg (1999) suggests, there is no guarantee that interactions amongst individuals which trigger learning mechanisms will occur despite a desirable environment being provided.

In terms of the voluntariness, "participation is voluntary and must be freely entered into" (Panitz, 1999a). An encouraging environment/situation should be designed and created in order for students to feel motivated and engaged in collaborative activities. Intrinsic motivation should be cultivated so that learners can perceive collaboration as a meaningful learning process and contributive to their development. Learners tend to be willing to actively engage in discussions if they are aware of benefits they can obtain through their participation (Darabi et al., 2011; Smith and MacGregor, 1992).

As the goal of the present research is to support collaboration amongst students in a learning community through building a learning partner recommender system, it is important to understand the basis for collaborative learning, what process it involves and the key principles upon which CL is rooted. Given the argument that CL is unpredictable and efforts need to be made to create a supporting context for CL to emerge, the current project aims to facilitate the creation of a situation where students' characteristics and preferences are explored and matched in order for positive interactions to emerge which may lead to some learning outcomes. The research also acknowledges the significance of personalisation and intrinsic motivations in the efforts to improve collaboration amongst students.

2.2.4 Benefits

CL has been enthusiastically encouraged by educational researchers and practitioners since the benefits provided by CL are numerous and significant. A large number of studies have discussed a variety of advantages that collaborative learning can bring to learners such as academic achievement, improved higher order thinking and increased satisfaction (Resta and Laferrière, 2007); development of critical thinking (Gokhale, 1995); greater perceived social presence and course satisfaction (So and Brush, 2008).

Benefits of CL can be appraised at an individual level. Laal and Ghodsi (2012) view collaborative learning as an approach in which learners get together to work on solving a problem or accomplish a task. Citing Panitz (1999b), they classify benefits offered by CL into four categories: social, psychological, academic and assessment. Panitz (1999b) has listed 67 distinct benefits that can be offered through the application of CL. Academic advantages include stimulation of critical thinking skills, improvement of active learning, higher learning outcomes, better problem solving employment, personalisation, and greater motivation. Social benefits of CL refer to facilitation in developing a social support system for learners, encouraging an understanding of diversity amongst students as well as between students and academics, constructing an environment for practising cooperation, and fostering learning communities. Psychological benefits involve building self-esteem, reducing anxiety, and growing positive attitudes towards the educational institution. The advantages of CL regarding assessment depict a number of alternate forms of assessment such as group self-assessment and easier group supervision.

CL also has benefits at the group level. Gerry, Koschmann, and Suthers (2006) argue that there has been a focus shift in learning science from individual learning to both individual and group learning. In CL, learning occurs socially during participants' interaction, negotiation and sharing, which ideally leads to group cognition (Curşeu and Pluut, 2013). Considering groups of students as learning entities, Curşeu and Pluut (2013) focus on the teamwork quality and cognitive benefits of CL for groups as a whole. Practical implications for teachers when employing a CL approach suggest taking into consideration the group configuration in order to foster group-level benefits.

2.2.5 Collaborative Learning Approaches

Collaborative Learning as discussed in the work of (Smith and MacGregor, 1992) is an umbrella term for different teaching and learning approaches which encourage students to participate interactively in intellectual activities in order to enable mutual understandings and constructing meanings out of learning material. Widely varying in the level of learners' interactions and roles of instructors in the learning process, all CL approaches emphasise a substantial shift towards a learner-centred learning situation where students play an active role in their study through discussion, concept exploration, argument, negotiation and collective meaning making. CL practitioners consider themselves as "coaches or midwives of a more emergent learning process" (Goodsell et al., 1992, p. 11). The process is based on establishing a community of learners.

The following in this subsection discuss some of CL forms due to their popularity and relevance to the present research – greater focus on student self-directed learning and interactions amongst students rather than between students and academics. Three approaches to collaborative learning discussed here are: group work, peer learning and learning community.

2.2.5.1 Group Work

Group work has a long history, starting around 2,500 years ago with examples of Confucius and Socrates using small group teaching (Jones, 2007). This form of CL has managed to gain such a persistent development journey due to a variety of benefits it offers. Jones (2007) has listed some advantages of a small group learning and teaching approach including clarification of knowledge, conformity to active learning theory, promotion of deep learning, improved self-directed learning, enhanced teamwork skills and self-motivation. Benefits of group work have been reviewed and categorised based on three aspects: contemporary learning theory, advantages of collective learning over individual learning, and learners' motivation (Graham and Misanchuk, 2004).

The number of learners comprising a group can vary (Jones, 2007). In the higher education context, small group work approach is widely employed due to its potential to have advantages in terms of students' academic and social benefits as well as resource sharing (Thorley and Gregory, 2013; Pauli et al., 2008). Although the ideal size of a learning group has not been clearly defined in literature, in formal learning settings the recommended group size is typically three to eight members depending on tasks assigned (Kreijns, Kirschner, and Jochems, 2003; Schellens and Valcke, 2006; Strijbos, Martens, and Jochems, 2004; Yang, 2006). Since group work or teamwork is an approach used extensively in both educational and workplace contexts, Graham and Misanchuk (2004) have emphasised the need for differentiating learning groups from work groups. Table 2.3 demonstrates six fundamental differences between the two.

Work group characteristics	Learning group characteristics
Hierarchical leadership structure	Flat leadership structure
Clear role definitions	No role definitions
Collaboration is to maximise productivity	Collaboration is to maximise learning
Goals are product-oriented	Goals are learning-oriented
Group members take on tasks that reflect skills and strengths already acquired	Group members may accept tasks to gain skills they have not already acquired in order to learn
Focus is on the product or outcome	Focus is on the process or learning

TABLE 2.3: Differences between work group and learning group (retrieved from Graham and Misanchuk (2004, p.185))

The present research utilises the idea of small learning groups with a flat structure where learners generally possess a similar level of knowledge and roles, and the ultimate purpose involves positive social interactions which trigger learning. However, this research does not aim to facilitate forming groups for particular task-based assignments in a formal learning context which is normally regulated by the unit academics and influenced by grading pressure.

2.2.5.2 Peer Learning

Peer learning is defined by Topping (2005) as "the acquisition of knowledge and skill through active helping and supporting amongst status equals or matched companions" (p.631). Peer-to-peer interaction is claimed by modern constructivist theorists to have benefits in investigation and development of diverse perspectives amongst learners, such as collaborative skills, critical enquiry and reflection, communication and articulation of knowledge, and self and peer assessment (Anderson, 2008; Boud, Cohen, and Sampson, 2014). It is important and necessary for courses that students are encouraged to learn with and from other peers since, as Boud, Cohen, and Sampson (2014) asserted, although the role of peer learning varies and it can take multiple forms, without learning with and from peers, learners would only gain impoverished education.

Viewing peer learning in a broader sense as a wide range of activities, Boud, Cohen, and Sampson (2014) defined it as "students learning from and with each other in both formal and informal ways" (p.4). Boud, Cohen, and Sampson (2014) emphasised that in peer learning the benefits perceived should be reciprocal, or mutual learning. Students learn by explaining concepts/ideas to others and by participating in activities in which they can learn from others. Another essential aspect of peer learning stated by Boud, Cohen, and Sampson (2014) is the relatively equal level of expertise, status and power amongst the participants. The authors also argued that peer learning and peer teaching/peer tutoring should be distinguished. However, in higher education settings the teaching model is the most common approach to understand the process of how students assist each other.

Two main types of peer learning are discussed in the work of Topping (2005), including peer tutoring and cooperative learning. Peer tutoring can be conducted through pairwise peer tutoring, same-year group tutoring (Topping, 1996) or peer assisted study sessions (PASS), also known as supplemental instruction where academically successful students from previous years help out students in high-risk courses (Dancer, Morrison, and Tarr, 2015; Dawson et al., 2014). This form of peer education like PASS typically requires the tutor to have adequately formal training in order for the activities to be effective (McKenzie et al., 2005). Cooperative learning, according to Topping (2005), covers activities structured "in pursuit of a specific shared goal or output" (p.632). Note that, as previously discussed in 2.2.2, cooperative learning and collaborative learning are viewed as two distinct concepts in the current work. However, the two terms are regularly used interchangeably; and the way the two terms are used in previous studies is not of major relevance of the current work.

From literature review, peer learning is generally perceived as a variety of educational strategies which are course-oriented and realised at different formality levels, with requirement of training and structure varying depending on particular forms. The research presented in this thesis aims to foster a learning approach which is similar to peer learning (reciprocal peer learning, as in Boud, Cohen, and Sampson (2014)) in a way that it seeks to foster interactions amongst peers. However, it focuses on students whose level of knowledge and experience ranges widely, interact with each other regardless of assigned tasks and member roles. It aims at facilitating the creation of learning communities through recommendations on compatible learning partners.

2.2.5.3 Learning Communities

Learning Communities (LCs) are of great interest and play an increasingly important role in organisations and the education sector. However, the term is defined in diverse ways in literature (Cross, 1998; Kilpatrick, Jones, and Barrett, 2003). There are two parts in the term Learning Communities: learning and community.

Community

The concept of "community" has been discussed intensively in literature. In their in-depth review of literature on communities, McMillan and Chavis (1986) proposed a widely accepted definition of sense of community as

> "a feeling that members have of belonging, a feeling that members matter to one another and to the group, and a shared faith that members' needs will be met through their commitment to be together" (p.9)

This definition consists of four dimensions including membership, influence, fulfilment of needs, and shared emotional connection. Membership refers to individuals' perception of a feeling of belonging, of being a part of the collective. The primary part of the membership concept is boundaries, which provide participants with emotional safety, a sense of belonging, and identification. Influence denotes a bi-directional condition. In one direction, individuals become attracted to the group only when they perceives their impact on the group activities and development; in the other direction, in order for the group to be cohesive, it must have influence on its members as well. Fulfilment of needs, or reinforcement that binds members together, indicates the participants' belief that their needs can be satisfied through their participation in the group. Shared emotional connection refers to members' belief that they have experienced and will maintain a shared history and identification. McMillan and Chavis (1986) suggest some features of shared emotional connection – the more group participants interact, the more likely they are to become closer; the more positive participants' experience, the stronger the group's bond; the more investment (time, effort, intimacy) individuals put into the group, the greater their significance to the group. The four elements were revisited in McMillan's work in 1996; membership became spirit, influence was changed to trust, fulfilment of needs was replaced with trade, and shared emotional connection was substituted by art. A comprehensive study can be found in McMillan and Chavis (1986) and McMillan (1996).

Shared emotional connection is considered to be the definitive element of a true community (Brook and Oliver, 2003; McMillan and Chavis, 1986). Therefore, it is reasonable to expect that attempts to encourage positive interactions amongst individuals can help engender a cohesive community. This present research project strives to create a promising condition which can yield favourable interactions between learners by matching them with compatible co-learners based on their own perceptions. The focus is about encouraging the formation of informal learning communities amongst students.

Learning Communities

Learning Communities (LCs) have been a topic of great interest to higher education practitioners and scholars, as well as organisations (Cross, 1998; Kilpatrick, Jones, and Barrett, 2003; Zhao and Kuh, 2004); and yet there is no uniformly explicit definition of a learning community in literature.

Cross, in an attempt to explain the growing interest in LCs, defines them as "groups of people engaged in intellectual interaction for the purpose of learning" (Cross, 1998, p.4). This can be regarded as a broad description of LCs which emphasises the characteristic of interaction amongst individuals (intellectual) and the reason for the interaction (learning). LCs can be discerned from two perspectives – one involves an attempt to promote deeper learning of curriculum in institutional contexts and the other focuses on benefits gained by collectives of individuals (Kilpatrick, Jones, and Barrett, 2003).

In an educational institution setting, one highly quoted definition of LCs is given by Gabelnick et al. (1990). According to the authors,

> "a learning community is any one of a variety of curricular structures that link together several existing courses – or actually restructure the curricular material entirely – so that students have opportunities for deeper understanding and integration of the material they are learning, and more interaction with one another and their teachers as fellow participants in the learning enterprise" (Gabelnick et al., 1990, p.19).

This definition focuses on the curricular structure and/or course content which seeks to link students with some common academic and social characteristic together and stimulate interactions amongst them in order to promote deeper understanding of the materials they study (Brower and Dettinger, 1998; Zhao and Kuh, 2004).

The other perspective to consider is that learning communities concentrate on the human aspect and the benefits introduced by synergising individual learners in utilising learning to promote cohesive and prosperous communities. This view of LCs, according to Kilpatrick, Jones, and Barrett (2003), focuses not only on knowledge sharing but also knowledge creation and the beneficiary consists of both individuals and the community as a whole. Learning is used as a way to foster the cohesion and development of the community. Moreover, from this point of view, shared interest and/or goal is the fundamental element for locating LCs rather than their actual geographic locations. The current research tends to look on LCs from the shared interest/goal and respect for diversity point of view since it seeks to engender positive interactions amongst learners based on their individual characteristics and preferences.

From reviewing previous literature on communities and learning communities, the idea of learning communities adopted in the present research is as follows: a learning community refers to a group of individuals who are linked/connected by either geographical proximity/location or shared [interest/goal/objective/purpose] coming together to perform regular social intellectual interactions, for example sharing resources or solving problems together, in an environment where they feel comfortable, trusted and valued to fulfil their diverse needs regarding learning.

Benefits of LCs

There have been three major types of research which encourage the use of LCs – research on cognition and motivation, developmental theory and learning outcomes (Cross, 1998; Zhao and Kuh, 2004). Research on cognitive learning places great emphasis on the significance of learning contexts and the schema of how learners acquire the understanding of concepts. As Cross (1998) asserted, learners obtain meaning of a concept once they understand it, not at a later time of recall. LCs create opportunities for learners to gain their own understandings through meaning negotiation and integration of multi-perspectives into their own experiences. This results in learners gaining richer ways of thinking and deeper learning (Zhao and Kuh, 2004).

Learners' development refers to a process in which they advance from performing a single routine way of thinking about and perceiving the world to obtaining integrated perspectives and figuring out their own best-fit contextual truth for themselves. Developmentalists contend that learning communities promote interaction and exchange of diverse viewpoints, which leads to learners' attainment of intellectual development at higher levels. Moreover, skills of critical thinking and contextual learning are also stimulated, which are in turn beneficial for learners in collaboration with peers (Garrison and Kanuka, 2004; Zhao and Kuh, 2004).

Learning communities are claimed to provide a variety of positive outcomes in educational settings – from perspectives of both institutions and learners. In terms of the academic institutions, there is solid correlational evidence that students' improved sense of community helps achieve greater learner persistence (Rovai, 2002d), higher retention rate (Tinto, 2006), and reduced attrition rates (Angelino, Williams, and Natvig, 2007; Rovai, 2002d). As for learning experience, students who have high sense of community are more likely to experience better perceived learning (Richardson and Swan, 2003; Rovai, 2002d) and greater satisfaction (Richardson and Swan, 2003; So and Brush, 2008).

Another aspect of LCs' advantages is learners' perception of benefits which they gain from participating in a learning community. Learners engage themselves in learning communities because of several perceived benefits (Charalambos, Michalinos, and Chamberlain, 2004; Smith and MacGregor, 1992). Those advantages include: (1) social network resources – learning communities present learners with connections to large and diverse groups of individuals with various useful skills which are available to learners to approach, (2) knowledge capital – learning communities provide participants with a huge collection of information and intelligence resources where they can seek for timely answers to their problems, since knowledge is distributed across communities and located in different individuals, and (3) communication – participants can obtain mutual trust and psychological support from those with similar experiences.

2.2.5.4 Remark

Group work and peer learning refer to pedagogical strategies which are more dedicated to formal learning settings where emphasis is placed on course curriculum and learning content. Moreover, this usually requires the structure of the collective organisation as well as clearly assigned tasks and procedures for students' interactions in these two forms of CL (Boud, Cohen, and Sampson, 2014; Cohen and Lotan, 2014; Topping, 2005).

Learning Communities (LCs), on the other hand, are more generic and considered as a convergence of learners' choice based on their socio-psychological and learning aspects where informality, personalisation and self-regulation is emphasised and embraced. The current research aims to propose an approach to promote informal learner-driven LCs where learners take responsibility for who to learn with, how to learn and which goals they aim at. Features of the informal LCs which this project targets at align with the generic and overarching components of LCs presented by Kilpatrick, Jones, and Barrett (2003): (1) shared purpose, interest or geography, (2) collaboration, partnership and learning amongst participants, and (3) respect for diversity. The first component involves the similar characteristics that community members share such as goal, perception and/or responsibility for their mutual learning. This can be considered as the glue that holds individuals together. The second component refers to intentional interactions amongst community members in an interdependent manner with the aim of building social capital and constructing knowledge. The third component indicates learners' willingness to accept new ideas and various perspectives so that they can perceive the community as a safe and "free from shame" place for them to ask questions, share ideas and make contributions.

2.2.6 Collaborative Learning in Online Learning Environments

With the increasing employment of internet-based technologies in tertiary education and rapid growth of online learning, the potential for CL in OLEs have been investigated and enthusiastically promoted. Online learning environment has been commonly criticised for lack of non-verbal communication cues (which are available in face-to-face interaction) and paucity of spontaneity which leads to low social presence and feeling of isolation amongst online learners. However, research has demonstrated that collaborative learning is feasible, and sense of community is achievable in an online context. This subsection presents some potentials and challenges of CL in OLEs which have been discussed in the literature.

2.2.6.1 Potentials

Technology available for CL and its benefits
A great number of tools have been developed and implemented to support collaborative learning in online environments. Platforms and tools such as emails, messaging systems, video conferencing systems, bulletin boards, discussion forums, and virtual learning environments have been employed to facilitate collaboration between academics and students as well as amongst students. Widely accepted advantages of web-based technology for learning involve flexible communication for learners through synchronous and asynchronous communication tools, long-lasting knowledge repositories, ease of accessibility. Resta and Laferrière (2007) propose that one of the questions worth

being addressed is not whether collaboration in online settings outperforms that in onsite context. Instead, they recommend that the unique characteristics of technology should be cultivated to effectively promote collaborative learning.

Ubiquitous use of technology amongst students

Technology is transparent to the new generation of learners as it has become an integral part of their lives (Resta and Laferrière, 2007). Search tools are employed by students to look for learning material and obtain information and understanding of concepts; social networking sites are used to get connected with friends and project themselves in the virtual world; open source platforms are utilised to improve their technical skills and learn from others' work. The availability and advancement of technology as well as learners' familiarity with digital technology makes it inevitable for collaborative learning to be supported in online settings.

Facilitator Role

Gunawardena (1995) emphasised the role of computer conference moderators in fostering collaborative learning in distance learning settings through creation and maintenance of a conductive learning environment. Taking a discussion forum as an example, when a topic is misleading or confusing it is necessary for the moderator to step in (Kear, 2004). The significance of instructors in online learners' affective learning, cognition and motivation was studied by Baker (2010). This work showed that instructor's social presence realised through instructional design and organisation, productive discourse facilitation and direct instruction, had a positive impact on students' learning experiences. The instructor's role in an online learning environment has been studied extensively in literature on Community of Inquiry (CoI) and online social presence (Garrison, Anderson, and Archer, 1999; Garrison, Anderson, and Archer, 2001; Shea, 2006; Swan and Shih, 2005).

Peer Interaction

The most commonly mentioned weakness of online learning environments when it comes to collaborative learning is the lack of face-to-face interaction. However, several studies suggested that distance learners can effectively work together using systems which support communication and collaboration. Kear (2004) found that as long as online students perceive benefits that can be obtained through their participation in discussion forums, they will engage in collaborative activities mainly without direct intervention from instructors. Moreover, learners have developed their ability to adapt to a textual discussion context. As found in previous research, online learners in text-based collaborative learning environments employ a great amount of verbal immediacy behaviours to compensate for lack of non-verbal cues available in face-to-face communication (Swan, 2002). These verbal immediacy behaviours encompass affective (such as humour, self-disclosure and paralinguistic textual cues) for expressing personal emotions, ideas or opinion, cohesive (through greetings, direct reference by name or information sharing) for sustaining group cohesion, and interactive (for example asking questions, agreeing or disagreeing with others) for supporting interpersonal interactions. More information about types of non-verbal immediacy behaviours can be found in the work of Garrison (2007), Rourke et al. (1999), and Swan (2002).

Cognitive Presence

There has been an argument that online learning environments may hinder learners from obtaining higher level learning due to the lack of spontaneous insight production and continuous feedback (Darabi et al., 2011). Nevertheless, deep learning can still be achieved in online settings as suggested by studies which have been conducted on asynchronous online discussions. Darabi et al. (2011) contended that attentive design strategies for online discussions integrated with social media, which pay attention to promotion of learners' cognitive presence, have great potential for learners to evolve in their learning process. Besides, in such environments as discussion forums, learners have opportunities to revise their knowledge, to reflect their understandings on their writing and to make contributions to collective knowledge (Stacey, 1999; Swan and Shih, 2005).

2.2.6.2 Challenges

Although the potential for collaborative learning in online environments is promising and a great amount of work has been done to foster this situation, there exist challenges that need greater attention. Firstly, in asynchronous environments such as online discussions, activities should be applied with considerations for the instructional methods, social interactions, and cognitive learning. Secondly, social interaction, especially amongst online students, which is the "key to the efficacy of collaborative learning" (Kreijns, Kirschner, and Jochems, 2003, p.349) does not happen by itself. Provision of communication tools and platforms with emphasis on the cognitive aspect of learning is likely to result in paucity of social interactions which may lead to unexpected effects of CL. Thirdly, Web 2.0 technology and social media should be employed for more engaging and effective approaches. Social networking services such as Facebook, and micro-blogging systems like Twitter are recommended to be integrated in CL processes alongside traditional discussion formats (Darabi et al., 2011). Fourthly, students' individual characteristics and needs are required to be studied and addressed (Resta and Laferrière, 2007).

Information and communication technology has changed the way learners perform their study. Moreover, various factors inherent in their characteristics such as prior experience, personality, preferred learning styles and attitudes towards technology have an important impact on how they engage in collaborative learning which may affect their learning experience.

As mentioned above in subsection 2.2.5.4, the goal of the current research is to propose an approach to encourage informal LCs amongst students in higher education. With the substantial portion of the learning content delivered online in blended courses (Watson, 2008), this work is specifically focused on LCs in OLEs, or online LCs. It aims to explore learners' characteristics regarding both social and academic aspects with an aim to examine which factors are perceived as important to them when learning in a community with other peers. Social interaction is expected to occur amongst learners with compatible features and common learning purposes (Graham, Dust, and Ziegert, 2018), which in turn can promote sense of community and trigger learning.

2.3 Online Learning Communities

Advantages of LCs presented in the previous subsection are drawn from research which was conducted in both face-to-face and online learning environments. Generally speaking, in an LC, members together perform group activities and communications to achieve certain goals while gaining skills and experiences as they progress. When these interactions and activities become computer-mediated in an online environment, online learning communities (OLCs) emerge. Here, definition, advantages, components of OLCs and approaches to OLC are discussed. Moreover, this section seeks to demonstrate the differences between traditional LCs and OLCs as well as instructor-directed and learner-driven OLCs. Importantly, approaches to OLC evaluation in the literature and the stance of the current work are also discussed.

2.3.1 Definition

There has been a plethora of research on the topic of online learning communities; and yet the concept of OLCs has not been well-defined (Ke and Hoadley, 2009; Tu and Corry, 2002). Wilson et al. (2004) gave a relatively comprehensive definition of OLCs as follows

> "An online learning community is a group of people, connected via technology-mediated communication, who actively engage one another in collaborative learner-centred activities to intentionally foster the creation of knowledge, while sharing a number of values and practices" (Wilson et al., 2004, p.2).

This definition draws emphasis on the communication tools which are mediated by technology; the characteristics of participation: active, collaborative and learner-centred; purpose of interactions: building knowledge; and commonality: shared values and practices.

In this research, the adopted definition of an OLC is based on ideas presented by Ke and Hoadley (2009) and Lock (2002). According to Ke and Hoadley (2009), an OLC is

> "a developed activity system in which a group of learners, unified by a common cause and empowered by a supportive virtual environment, engage in collaborative learning within an atmosphere of trust and commitment" (Ke and Hoadley, 2009, p.489).

Also, according to Lock (2002), an OLC is not a product or an entity; it is a process which evolves in a stimulating condition. This condition involves multiple facets – participants, technology, shared features (interest/purpose/goal) amongst members, incremental development (through learning) and the comfortable, shame-free environment. The research presented in this thesis emphasises the shared academic interests and goals amongst learners and aims to promote an atmosphere where learners feel safe in order for them to be willing to express themselves and make contributions to the collective learning process.

2.3.2 Advantages of OLCs

As presented in subsection 2.2.5.3 of this chapter, learning communities have been asserted to bring various significant benefits to learners' learning experiences, learning outcomes, perceived learning as well as overall course satisfaction. In the age of educational computing where e-learning has been rapidly developing and the number of online learners is continuously growing, online communities for learning purposes have been playing an increasingly vital role in virtual learning environments.

Amongst these advantages, the fundamental virtue of OLCs is to provide online learners with a sense of community. The main criticism towards online learning environments is the lack of face-to-face interactions (Richardson and Swan, 2003), which contributes to learners' feeling of isolation (Wilson et al., 2004). Characteristics of learners which are related to attrition (dropouts) involve student burn-out and feelings of isolation (Rovai and Jordan, 2004). Students with low sense of community or in other words, those who do not feel that they fit into the learning environment, are inclined to feel isolated and likely to give up on their study (Rovai, 2002b; Tinto, 1975). OLCs can help alleviate the situation. By enhancing learners' sense of community in online learning environments, several desired outcomes are feasible including higher involvement, increased commitment, greater motivation and satisfaction (Rovai, 2002d). Moreover, students with high sense of community are reported to feel less burnt out at college (Rovai, 2002d).

2.3.3 Common Components of OLCs

There have been attempts to determine fundamental component of OLCs. Tu and Corry (2002), in their research on OLCs, have presented four basic elements of OLCs consisting of community, learning, network and technology. Community refers to activities conducted amongst individuals who share common geographical location or similar interests. Learning denotes the process in which participants transform experiences into knowledge, improve skills and form their own attitude through interactions with others. Learning involves formal, non-formal and informal learning. Network indicates participants' ability to self-regulate their own connections with other peers. This component also emphasises on resource sharing amongst community members. Technology is used as tools for communication and collaborative learning.

Another view of fundamental features of OLCs is presented by Lock (2002). The scholar stated that four cornerstones for development and maintenance of OLC are communication, collaboration, interaction and participation; and technologies play roles in all these features. Firstly, communication is crucial to OLCs. If there was no communication, OLCs would not exist. Communication should be open to all participants and be facilitated by various means such as synchronous as well as asynchronous, private as well as public discussion forums, and one-to-one as well as multi-participant channels. Secondly, collaboration refers to participants' activeness in engaging themselves in interdependent and self-directed interactions with others in a learning situation. Collaborative activities help result in knowledge construction (Dennen, 2000); and collaboration in online environments is facilitated by various tools. Thirdly, interaction refers to dialogue of some kind occurring between learners and instructors, other peers and learning content. Finally, participation includes involvement and presence, both socially and academically. This can be linked to the concept "presentation of the self" presented in McInnerney and Roberts (2004) – how a community participant presents themselves, what role they play, how they should behave and interact with others.

2.3.4 Types of OLCs

Approaches or strategies for building learning communities in online environments have been proposed in a great number of research papers such as through OLC frameworks and models (Brook and Oliver, 2003; Garrison, 2007; Khoo and Cowie, 2011; Seufert, Lechner, and Stanoevska, 2002; Tu and Corry, 2002; Wenger, 2000b; Wenger, 2000a) as well as guidelines and recommendations (Gabriel, 2004; Kreijns, Kirschner, and Jochems, 2003; McInnerney and Roberts, 2004; Rovai, 2002b; Shea et al., 2005; Schellens and Valcke, 2006; Shea, 2006; Swan, 2002). In this subsection, the classification of OCLs proposed by Riel and Polin (2004) is adopted, consisting of task-based, practice-based and knowledge-based OLCs. Then some guidelines in literature for building OLCs are discussed.

2.3.4.1 Task-based OLCs

Task-based OLCs refers to groups of individuals organised around a specific task who work together purposely and attentively to either create a product/deliverable or solve a problem or complete a task which requires collaboration amongst group members. Members in a task-based OLC are usually assigned and work closely towards a well-specified project within a relatively short timeline. Most importantly, the groupings are not voluntary. As Riel and Polin (2004) stated, in education institution contexts, learning communities are often task-based which focus on group learning through which individual learning is achieved.

In higher education settings, Garrison, Anderson, and Archer (1999) have developed a model of Community of Inquiry (CoI) with the aim of guiding the research and practice of online learning. The model consists of three elements – social, teaching and cognitive presence – as well as categories and indicators for each element that has emerged from analysis of computer conference transcripts. Social presence refers to learners' ability to project themselves as real individuals in online environments. Rourke et al. (1999) analysed this element of CoI model in detail and presented three categories of social presence consisting of affective, interactive and cohesive responses. Cognitive presence refers to "the extent to which learners are able to construct and confirm meaning through sustained discourse" (Garrison, Anderson, and Archer, 2001, p.1). Four phases included in cognitive presence component are triggering event, exploration, integration and resolution (Garrison, Anderson, and Archer, 2001). Teaching presence is described as a determinant which facilitates and improves social and cognitive presence for educational outcomes to be achieved (Garrison, Anderson, and Archer, 1999). Garrison (2007) has conceptualised teaching presence into instructional design and organization, facilitating discourse and direct instruction. Table 2.4 demonstrates indicators of the three essential elements of CoI models.

Elements	Categories	Indicators (example)
Cognitive presence	Triggering event	Sense of puzzlement
	Exploration	Information exchange
	Integration	Connecting ideas
	Resolution	Apply new ideas
Social presence	Emotional expression	Emotions
	Open communication	Risk-free expression
	Group cohesion	Encouraging collaboration
Teaching presence	Instructional management	Defining and initiating discussion topics
	Building understanding	Sharing personal meaning
	Direct instruction	Focusing discussion

TABLE 2.4: Indicators of three types of presences in CoI model (retrieved from Garrison, Anderson, and Archer (1999, p.89))

The CoI model has been confirmed in several research studies through factor analysis to demonstrate the relationship between social presence and students' perceived learning and satisfaction of the online course (Richardson and Swan, 2003); to examine the impact of teaching presence on online students' sense of community (Shea et al., 2005; Shea, 2006); to conduct an empirical verification of the elements of the CoI framework (Arbaugh, 2007); to examine social presence in computer conferencing environments (Rourke et al., 1999); and to clarify differences of the three types of presence in online and blended learning contexts (Akyol, Garrison, and Ozden, 2009).

CoI framework emphasises that in order for students' learning experiences to be improved and for online learning communities to be fostered, all of the three elements of the model must be carefully taken into consideration and incorporated into the design. The present research acknowledges the primary components of the CoI model and their impact on stimulating sense of community amongst students in HE contexts. Understanding what influences students' collaboration would be useful in designing a system that aims to promote the formation of learning communities, which is the goal of this research project.

2.3.4.2 Practice-based OLCs

Practice-based OLCs involve people joining together around a discipline, a profession or a certain area. The fundamental difference between this type of OLC and task-based OLCs is voluntary participation of community members. The focus, according to Riel and Polin (2004), is on practice in such a way that participants learn through continuous participation and responsibility in community activities and the knowledge acquired is "knowledge-in-use"(p.20).

The term Community of Practice (CoP) was defined by Wenger (2000b): "Communities of practice are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly" (p.1). This definition demonstrates the structural characteristics of a CoP which consist of a domain of knowledge (shared concern or a passion for something), a notion of community (they interact regularly) and a practice (they do and learn how to do it better). The theory behind CoP is the convergence of situated learning, constructivism and connectivism (Bates, 2014). In CoP, learning is an identity transformation process, individuals enhance their knowledge as they change their role in the community. The community, as Wenger (2000b) refers to it, acts as a living curriculum or an apprenticeship model for learners. Central is the concept of Legitimate Peripheral Participation (LPP) where newcomers enter the community from the periphery and move toward the centre beyond their initial roles as their skills grow during interactions with others – they turn into more knowledgeable old-timers and take more responsibility.

Communities of Practice are a form of informal learning communities (Gray, 2004), a CoP is inclined to exist in parallel with formal education and training provided by institutions. In order to promote and facilitate an online CoP, according to Cambridge, Kaplan, and Suter (2005), both technical and social architectures must be thoroughly designed and enabled. Technical architecture is to provide a platform for communication and collaboration amongst CoP participants; while social architecture is essential to generate adequate excitement, energy and relevance to enliven the community (Cambridge, Kaplan, and Suter, 2005; Wenger, McDermott, and Snyder, 2002). A wide range of technologies can be employed to support the development of CoP regarding aspects including expertise sharing, knowledge repository, group discussion, and synchronous communication (Bates, 2014). A step-by-step guide has been developed by Cambridge, Kaplan, and Suter (2005) to design and cultivate CoP in higher education environments. Wenger, McDermott, and Snyder (2002) have identified seven principles in designing effective CoP demonstrating that designers of communities of practice must (1) design for evolution, (2) open a dialogue between inside and outside perspectives, (3) invite different levels of participation, (4) develop both public and private community spaces, (5) focus on value, (6) combine familiarity and excitement, and (7) create a rhythm for the community. CoP is close to the concept of informal learning communities which the present research attempts to foster. Therefore, guidance and principles from previous studies are very useful in orienting the current research.

As previously mentioned, practice-based learning communities tend to exist in parallel with formal learning in education institution settings and members obtain knowledge mostly via practice (Boud and Middleton, 2003). However, formal education still plays a critical role in forming foundation of domain knowledge for learners in order for them to continue to enrich their experience and contribute to community learning.

2.3.4.3 Knowledge-based OLCs

Knowledge-based learning communities "construct, use, reconstruct, and reuse knowledge in deliberate, continuous cycles" (Riel and Polin, 2004, p.28). In task-based communities, participants perform activities towards deliverable generation as a reflection of what they have learnt, and the product is considered as finished. In contrast, knowledge-based LCs view each work as a single contribution to knowledge which is to be examined, adjusted and modified to fit the ongoing process of knowledge building. Being compared with practice-based LCs, the intention of evolving in the process of knowledge creation is explicit (Riel and Polin, 2004; Hoadley, 2012; Scardamalia and Bereiter, 2006).

This form of OLCs is similar to technology-mediated Knowledge Building Communities (KBCs) as studied in Scardamalia and Bereiter (1994), Hewitt and Scardamalia (1998), Scardamalia and Bereiter (1999) and Scardamalia and Bereiter (2006). With KBCs, students are no longer considered as only learners; but they become fundamental members of the community. As Scardamalia and Bereiter (2006) stated, knowing about others' work and connecting their own work with others is a delightful experience for students; and the internet-based technology "becomes the first realistic means for students to connect with civilisation-wide knowledge building" (p.2).

One of the examples of internet-based technology for facilitating KBCs is the Bugscope[1] project where teachers and students all over the world can sign up, mail bug samples to the Bugscope team for the team to prepare the bug viewing with electron microscope. The students then can examine the bugs using a web interface. All images and samples are stored so that all Bugscope participants can access them. As Riel and Polin (2004) remarked, although there is no true knowledge-based community around Bugscope since participants build the collective database individually, this is a demonstration of how online technology can be employed to support KBCs of those who have similar study interests.

2.3.5 Theoretical Constructs for OLCs Development

A number of studies have been conducted to propose factors which can contribute to the creation, development and maintenance of OLCs in educational institution settings. Tu and Corry (2002) proposed a theoretical construct for OLCs which is based on social learning theory and consists of four elements – community of practice (CoP), social presence, collaborative learning, and knowledge construction technology. The first three elements have been discussed in previous sections of the Literature Review chapter. As for knowledge construction technology, Tu and Corry (2002) stated that technology such as groupware and databases can support knowledge management functions including identification and mapping of knowledge assets, creation of new knowledge, access to great amounts of information and knowledge sharing.

[1] http://bugscope.beckman.uiuc.edu/

Brook and Oliver (2003) presented a design framework of OLCs for informing and guiding instructors in the process of developing such communities. Based on Biggs (1989) model, Brook and Oliver presented three categories of factors in the development of online learning communities including: presage, process and product. Factors of the presage form the conditions for a learning community, factors of the process category indicate recommended approaches taken by instructors to cultivate the sense of community, and factors of the last category demonstrate the outcomes generated from the development of a learning community.

Khoo and Cowie (2011) proposed a pedagogical framework for developing and implementing an online learning community. The framework adopted the notion of learning as "a mediated, situated, distributed, goal-directed, and participatory activity within a learning community" (Khoo and Cowie, 2011, p.48). Khoo and Cowie (2011), based on their survey findings in combination with literature, suggested five guiding principles of promoting OLCs. These included the importance of web-based technologies, creating a safe and fair environment, contextual and meaningful learning, goal directedness and significance of LCs for supporting meaningful learning. The suggested framework was used with the aim of assisting instructors to design courses in an OLC-promoted manner.

Apart from frameworks proposed to build OLCs, a large number of research studies have been conducted to demonstrate significant roles of several factors in promoting LCs in online environments including social interaction, group size, teaching presence and course design. With regards to social interaction, Swan (2002) emphasised the importance of interaction which students make with content, instructors and peers. Swan remarked that students' interactions, especially with their peers, deserve greater attention and a nurturing condition for them to develop. Focusing on social interactions in computer supported collaborative learning (CSCL) environment, Kreijns, Kirschner, and Jochems (2003) pointed out two pitfalls which include (1) social interactions being taken for granted, and (2) social interactions being restricted to cognitive process and task contexts. The three scholars then provided a set of guidelines for improving the pitfalls which consist of four categories: (1) use of collaborative learning methods in online environment, (2) improvement of interactivity in web-based learning environment, (3) change in teachers' and students' roles, and (4) increase in students' perceived social presence. Informed by the shortcomings related to social interactions amongst students presented by previous work, it is recognised by the current research that interactions amongst students need to be more encouraged, especially in the context of decreased amount of face-to-face interaction.

In terms of course design and teaching presence, Shea et al. (2005) and Shea (2006), using statistical analysis on data collected from an online survey and the CoI model, stated that students' sense of community in OLEs is related to teaching presence delivered by teachers during the course. Shea asserted that the stronger and more active the presence instructors showed, the greater students' perceived sense of belonging. The findings could help faculty to design and create an online environment which stimulates more of what students expect from teachers and provided direct facilitation. Rovai (2002b) synthesised from literature and suggested that instructors teaching at a distance could promote sense of community by attending to seven factors when designing the course: (1) transactional distance, (2) social presence, (3) social equality, (4) small group activities, (5) group facilitation, (6) teaching style and learning stage, and (7) community size.

Another factor to be considered when designing online courses for OLCs is the community size. Several researchers have confirmed that group size affects both the quantity and quality of group interactions (Schellens and Valcke, 2006; Strijbos, Martens, and Jochems, 2004; Yang, 2006). As Kreijns, Kirschner, and Jochems (2003) remarked, in a group with large number of participants there exist several negative effects such as free-riders, social loafing, and sucker effect. They recommended that in order for an OLC to function properly, the size should not be too large. In an online classroom context, recommended number of members in a group is three to seven.

It is acknowledged in the current work that course design and teaching presence play a crucial role in the formation and development of an OLC. Although the focus of this research is to promote students' informal OLCs which are not course-specific and not task-specific, given the context of the project (higher education) these two factors are likely to have significant influence on whether/how an OLC, even an informal one, can be formed. However, the present work aims to stimulate a safe environment where students can find peers with compatible characteristics so that they can form their own learning groups with those they feel comfortable with and valued by.

2.3.6 Traditional Learning Communities versus OLCs

As Tu and Corry (2002) suggested, there is no clear distinctions between traditional and online LCs. This subsection of the literature review presents a discussion of how OLCs are different from traditional LCs in the higher education context. The aspects discussed involve communication options, flexibility regarding environment and resources, method for information exchange, the role of social interaction, and community atmosphere. Table 2.5 summarises the key differences between the two types of LCs.

Aspect	TLCs	OLCs
Communication options	Face-to-face	Internet-based, computer-mediated
Flexibility (physical & resources)	Limited	More flexible
Information exchange	Including both non-verbal and verbal immediacy	Mostly verbal information
Social interaction	Significant	Greatly significant
Atmosphere/ camaraderie	Important	Increased importance of an environment of trust and support

TABLE 2.5: Traditional Learning Communities (TLCs) versus Online Learning Communities (OLCs)

Distinction in communication channel is the most obvious aspect which leads to the following discussed differences. Members in traditional learning communities (TLCs) communicate in person. Interactions and communications in classroom settings are more natural and therefore, require less efforts from both teachers and learners (Rovai, 2002a). OLCs, meanwhile, employ internet-based, computer-mediated communication tools for interactions to take place. In order for communications to occur, courses must focus more on creation of dialogue and instructors must invest more effort to encourage learners to participate in exchanging information and ideas (Rovai, 2002a; Swan, 2002).

As for flexibility relating to physical environment and resources, OLCs have some advantages over TLCs. Face-to-face LCs are limited in terms of physical environment – they have to gather at some specific location; while activities performed by OLCs take place in virtual space (Huang, 2016). Therefore, participants of an OLC can enjoy the flexible time and place when working with other members online. Huang (2016) contends that OLCs have wider range of shared resources instead of only traditional learning materials such as textbooks.

The nature of information exchange in OLCs is also different from that in TLCs. Members in a face-to-face community interact and exchange information through both non-verbal and verbal immediacy; while verbal immediacy is the most frequently used approach in OLCs due to the absence of social context cues (Rourke et al., 1999). Communication immediacy, which refers to physical (non-verbal) and verbal immediacy (Mehrabian, 1971), is used to shorten the psychological distance between communicators (Baker, 2010; Swan, 2002). In virtual environments, in order to compensate for lack of in-person interactions, participants of OLCs usually employ a greater number of verbal behaviours such as humour, praise and self-disclosure (Arasaratnam-Smith and Northcote, 2017; Rourke et al., 1999; Swan, 2002).

Social interactions and community atmosphere are another aspect that distinguishes TLCs and OLCs. Both are critical in the creation and maintenance of learning communities in the two contexts; however, their significance in online environments requires much more careful design and support. As Kreijns, Kirschner, and Jochems (2003) stated, social interactions in CSCL environments are taken for granted. Students are provided with communication tools and platforms; and they are expected to make interactions happen, which is not true in all cases. Moreover, as learners perform social interactions with others in a community, their social presence is formed. Social presence plays a crucial part in learners' engagement in collaborative activities and learning satisfaction (Akyol, Garrison, and Ozden, 2009; Richardson and Swan, 2003; So and Brush, 2008). Increased and improved social interaction is also the recommended strategy for building a comfortable supporting and trusting environment for online communities (Kop, 2011; Shum and Ferguson, 2012).

Positive social interactions and a nurturing environment are what the current research project seeks to generate from attempts to match compatible learners. Informed by the key differences between TLCs and OLCs, the work aims to cultivate the advantages held by OLCs such as greater flexibility for learners. It also attempts to alleviate the limitations related to the communication channel and the emergence of a community atmosphere by striving to create a platform where learners with compatible (either similar or complementary) characteristics can form connections and learn with/from each other.

2.3.7 Teacher-directed & Learner-directed OLCs

As discussed in the Learning Environment section in this chapter, the focus of learning has shifted from instructors to learners. The new paradigm for teaching and learning has changed the role for teacher from "sage on the stage" to "guide at the side" (Dykman and Davis, 2008; King, 1993). The transmittal model in which teachers are the centre who hold knowledge and transmit it to students, has led to the fact that students are passive knowledge receivers. That teaching and learning model is out of date and unable to prepare students for fast-changing demands introduced by the knowledge-based global economy (King, 1993). Teachers now play the guiding role that steers students towards relevant and useful learning content, facilitates them in their meaning making process instead of routinely sharing information without considering their already existing experience or missing required knowledge.

In the context of the guide-side paradigm, learners are the locus of knowledge building. Social constructivism emphasises on the social and cultural nature of knowledge. Learning is viewed as a social process where learners make meanings through interactions with other peers and the environment (Kim, 2001; Stodel, Thompson, and MacDonald, 2006). With the proliferation of Web 2.0 technologies such as blogs, wikis and social networking sites, students can create and share knowledge and experience, communicate and collaborate (Ajjan and Hartshorne, 2008). Online tools and technologies facilitate the social constructivist learning in a way that students can both actively engage in collaborative learning and at the same time gain power over their choice and self-direction (McLoughlin and Lee, 2007; McLoughlin and Lee, 2008).

The concept of self-direction is related to self-directed learning, which has been intensively studied in the literature (Confessore and Kops, 1998; Garrison, 1997; Loyens, Magda, and Rikers, 2008; Pedersen and Liu, 2003; Song and Hill, 2007). Knowles (1975) defines self-directed learning as a process in which learners have the need for learning by themselves, determine learning approaches, identify learning resources, perform learning process and self-evaluate their performance. Thus, learners in a self-directed learning context can gain collaborative independence, freedom of choice and self-monitoring – altogether known as personal autonomy (Garrison, 1997). Moreover, the ability to be self-directed is regarded as both means and goal of lifelong learning (Loyens, Magda, and Rikers, 2008).

As a consequence, OLCs have the potential to shift from teacher-directed to student-directed dynamic. As McLoughlin and Lee (2008) indicate, learners' growing use of Web 2.0 technologies has created potential for "individual learner empowerment through designs that focus on collaborative, networked interaction" (p.3). Also, learning and collaborative activities are changing into more personalised, self-directed, meaningful to individuals in order to fit learner-centred education (Garrison, 1997; McLoughlin and Lee, 2007).

However, self-direction is a major challenge for students, especially fully online learners. First of all, taking initiative and maintaining motivation throughout a learning process is not an easy task (Garrison, 1997; Kop, 2011). Second, they have to make choices of how to perform self-management, which learning contents to access, and who to work with. The present research seeks to help ease the process. The proposed matching system takes students' social and academic characteristics into consideration and helps them identify well suited peers.

2.3.8 Students' Individual Characteristics and Learning Communities

With the shift from a teacher-centred to a learner-centred teaching paradigm, students' characteristics have undoubtedly become of greater significance. A substantial number of studies have discussed the importance of learners' characteristics in different aspects of online learning contexts. For example, the relationship between learners' demographics and their decision to persist or drop out was examined in Park and Choi (2009); how students' features, including reading and writing skills, independent learning, motivation, and computer literacy, influence their success level in online learning was investigated in Kerr, Rynearson, and Kerr (2006); and the role that students' intrinsic motivation has in their online learning continuance was studied in Kop (2011). However, less attention has been given to the influence of students' individual features on their collaboration in online learning environments (Chan and Chan, 2011).

As discussed in subsection 2.2.5.3, four elements of a learning community suggested by McMillan and Chavis (1986) are membership, mutual influence, fulfilment of needs, and shared emotional connection. According to Brook and Oliver (2003), the last element is considered as the decisive component of a true community. It is stated by Brook and Oliver (2003) that learners' characteristics are one component that has a high impact on the level of students' participation and the development of online learning communities. Important students' characteristics suggested by the two authors include: education level, online learning experience, learning style, patterns of socialisation (gender-based), culture, goal, motivation, personality traits, perception of self (as separate or connected) and access to technology. The work of Brook and Oliver (2003) has affirmed the influence of students' characteristics on learning community creation and development. Cho et al. (2007) also suggest that when designing CSCL activities and environments, besides pre-existing friendship networks, individual factors (such as communication styles in their research) should receive thorough attention as well.

Previous studies in the literature have investigated the influence of different characteristics of students on online collaborative learning. Those characteristics include group member familiarity (Janssen et al., 2009), academic motivation (Rienties et al., 2009), students' communication styles (Cho et al., 2007), students' personalities (Chen and Caropreso, 2004; Jadin, Gnambs, and Batinic, 2013; Matzler et al., 2008), and students' views of collaboration (Chan and Chan, 2011). However, these individual characteristics are usually evaluated separately. Attempts to incorporate different characteristics of students in order to generate effective teams have been made in the automatic group formation (AGF) area (to be presented in subsection 2.4.4.1). However, the work in AGF mainly focuses on formal learning situations, and consequently facilitates forming task- and project-oriented teams according to academics' specific requirements. That being said, research in AGF has emphasised the significant role of several students' characteristics in collaborative learning activities.

One widely acknowledged phenomenon in the educational research is that today's learners are different in many ways (Tuan, 2012). Learners may have different goals, skills, learning styles, as well as interests. They are also diverse in their needs and preferences. The recognition of the diversity in students is reflected in instructors' attempts to diversify their teaching methods in order to accommodate the learners' different characteristics (abilities, learning preferences, and so on) (Kaur, 2017); and in the development of pedagogical interventions which take into account dissimilar profiles of students (Bendou, Megder, and Cherkaoui, 2017). Thus, the needs of learners have been highlighted and received greater attention from the pedagogical perspective in the literature. Similarly, students' preferences regarding preferable characteristics they expect to find in their collaborative peers need to be taken into consideration in attempts to promote collaboration and learning communities.

In this research project, factors of both socio-psychological and academic aspects are taken into consideration in order to provide learners with recommendations for study partners based on their own preferences. Learner characteristics play an important role in their participation in the creation of a learning community. Moreover, learners have diverse notions of desired characteristics possessed by their learning partners. Therefore, it is proposed by the current work that matching compatible learners based on their characteristics and preferences, then offering them with recommendations for matching peers, will help improve learners' interactions and a sense of community.

2.3.9 Evaluation of OLCs

By reviewing 42 evaluation studies of online learning communities, Ke and Hoadley (2009) proposed a taxonomy of OLC evaluation which consisted of four domains: evaluation purpose, evaluation approach, measures for evaluation, and evaluation techniques. Two purposes identified from the work of Ke and Hoadley (2009) were:

proving and improving. They found that studies with the proving purpose aimed to prove the value or emergence of an OLC in a specific context; while those with the improving purpose attempted to investigate issues or to identify factors for success of an existing OLC in order to guide future studies.

The objectives of a study of OLC evaluation, in turn, have influence on the methods employed (Ke and Hoadley, 2009). Results from their work indicated that research with the proving objective usually used a summative evaluation approach; while studies aiming to improve OLCs often employed a formative evaluation method. Two other often used approaches included participatory method which incorporated evaluation from both external evaluators and participants, and responsive method which involved only external investigators.

Regarding measures for evaluation, Ke and Hoadley (2009) found that three dimensions were of great interest namely usability of the system designed for developing OLCs, learning achievement (for individual learners and the organisation as a whole), and community-ness. In addition, previous OLC evaluation studies either focused on outcome which covered static status of the three often examined dimensions or process which measured the dynamic interactions between the dimensions.

Different approaches to data collection, analysis and report were also employed in the literature. Various techniques for collecting data were used including objective (digital activity record, knowledge test, or online forum interactions), qualitative (observation or interviews) and mixed. Correspondingly, diverse methods for analysing the data were adopted such as content analysis, discourse analysis, and social network analysis. Ke and Hoadley (2009) also noted that even though two different studies share the same purpose, the approaches to evaluating the effectiveness of OLCs can vary, depending on the choice of researchers. A summary of measures and evaluated components of each measure along with evaluation approaches is presented in Table 2.6.

Measure	Evaluated components	Approaches
System usability	Tools Protocols	Rating survey (learners' perceived benefits) Observation of user test
Learning achievement	Individual gains Achievement in subject	Formal tests, assessment, survey, interview
	General social & intellectual development	Content & discourse analysis, recalls & interviews
	Community as a whole	Interviews, document analysis
Community-ness	Participation & Sociability	Online observation Content analysis Survey, self-report

Table 2.6: OLC evaluation: summary of measures, evaluated components, and evaluation approaches. Retrieved from Ke and Hoadley (2009)

Purpose of the current research is about proving (as opposed to improving). The main research question involves whether matching students with compatible characteristics and satisfactory preferences coupled with basic support for maintaining the suggested collectives can help improve positive social interactions amongst students. Although it was found by Ke and Hoadley (2009) that formative methods were often used by previous studies with proving objectives, the present work is focused on an attempt to stimulate students' informal LCs. Therefore, their perspectives and preferences on factors influencing their engagement with OLC activities are crucial. Hence, formative evaluation approach is remarked as suitable for the current research so that in-depth understandings of students' needs and/or issues can be obtained throughout the project and appropriate adjustments can be made.

It should be noted that similarly to a number of previous studies, there exists an implicit assumption that "an OLC led to the desired (learning) outcomes without explicitly testing whether the desired outcomes took place" (Ke and Hoadley, 2009, p.499). As a consequence, students' community-ness, or sense of community, is a focus of examination in the current research rather than academic-specific outcomes.

In the literature, Palloff and Pratt (2007) contended that a learning community had emerged in an online environment when several indicators were present. Firstly, students actively engage in interactions both academically and socially. Secondly, collaborative activities take place mostly amongst learners rather than between students and teachers. Thirdly, meaning making is conducted through learners' interactions, information exchanges, encouragement, questions, challenges and agreements with peers. Fourthly, learners show willingness to share learning resources. Finally, there exists a nurturing and encouraging environment that stimulates students to feel comfortable in order to support and constructively evaluate others' work. These indicators demonstrate that OLCs are constituted by both intellectual and social aspects. In Rovai (2002d), the self-report Classroom Community Scale (CCS) is used to evaluate two components – connectedness and learning. Connectedness involves feelings of belonging, friendship, cohesion and satisfaction – in other words, social aspects. Learning refers to the perception of that knowledge is built as the learning community evolves, and learners' needs are met through their participation in collective activities. This is corresponding to the community definition presented by McMillan and Chavis (1986) regarding participants' fulfilment of needs (see subsection 2.2.5.3). CSS (Rovai, 2002c) has been widely used as a reliable tool to measure sense of community in learning contexts, and is adopted in the current study to explore students' feelings of community-ness.

2.3.10 Summary

In summary, in the context of complex learning environments with an increasing portion of course content delivered online and a variety of options for learners to perform their learning, OLCs have a greater role in engendering worthwhile learning experiences. In the higher education context, several approaches to promoting OLCs have been proposed. However, previous work focused on syllabus design, instructor's role and behaviour as well as strategies to encourage students' interactions (Calhoun and Green, 2015; Shea, 2006; Swan and Shih, 2005; Wilson et al., 2004). Moreover, the interactions encouraged were centred around subject contents in formal learning contexts. With a focus on promoting the informal side of online learning communities, the current research aims to explore and promote students' interactions outside of classroom boundary rather than focusing on task-based or content-oriented activities. Social interactions are likely to occur between individuals with compatible characteristics (Graham, Dust, and Ziegert, 2018); therefore, the current research attempts to provide students with recommendations for compatible peers based on their characteristics and preferences.

2.4 Reciprocal Recommender Systems in Education

This research aims to promote the formation of students' informal OLCs through suggesting study partners with compatible characteristics. The realisation of this concept involves building a recommender system which takes into account students' features and preferences, then generates recommendations for well-matched peers based on the inputs. This section firstly provides brief information about recommender systems in subsection 2.4.1 and reciprocal recommender systems in subsection 2.4.2. After that, previous studies in the literature on reciprocal recommender systems are discussed in subsection 2.4.3. The last subsection 2.4.4 highlights the potential for utilising Automatic Group Formation, Learning Analytics, and visualisation in the current research.

2.4.1 Recommender Systems

Recommender Systems (RSs) have been used significantly in e-commerce to offer suggestions on items that customers may wish to buy based on purchase patterns of their own or of those who have similar shopping history (Zaïane, 2002). When it comes to the education area, Chatti et al. (2012) described RS as an agent that collects and analyses data about learners' online activities in order to uncover patterns in their behaviour or preferences in order to draw conclusions for recommended items or set of action to take with the objective of improving learning performance. In such recommender agents, methods like clustering, association rules, web mining and content analysis are applied to explore, index, and filter online learning resources to guide learners "through the ocean" of overwhelming available choices (Romero and Ventura, 2007; Verbert et al., 2011).

From the technical perspective, recommender methods can be categorised into: content-based recommendations, collaborative filtering, and hybrid filtering (Adomavicius and Tuzhilin, 2005). Amongst them, the collaborative approach is the most popular (Verbert et al., 2011). Content-based recommender systems suggest a user with items which are similar to the ones in his or her favour (Adomavicius and Tuzhilin, 2005); and as Verbert et al. (2011) remarked, this approach is based on individual information gathered exclusively. Collaborative filtering systems are based on comparison amongst users with common characteristics or activity patterns. Lastly, the hybrid method is a combination of the aforementioned approaches.

2.4.2 Reciprocal Recommender Systems

RSs have been employed intensively in e-commerce websites to improve consumers' experience and increase sales (Krzywicki et al., 2015). Those RSs provide users with suggestions on items (item-to-people recommendations) which are likely to be of interest for users. The RSs the present research aims to build falls into a special form of social recommendations – people-to-people or reciprocal recommendations (Pizzato et al., 2010) – where preferences of both sides of a recommendation need to be satisfied (Koprinska and Yacef, 2015).

Key differences between item-to-people (one-way) RSs and people-to-people (two-way) RSs have been discussed including successful recommendation defining factors, roles of explicit profiles, roles of implicit profiles (based on users' interaction in online environments), overloaded user problem, and different roles of users (Koprinska and Yacef, 2015; Pizzato et al., 2013). All in all, as suggested by its name – reciprocal recommender system – the role of reciprocity is fundamental. Successful recommendations cannot be made unless both parties' requirements of the recommended other are satisfied.

There have been a number of studies on people-to-people recommendations, mainly in the online dating area. RECON (Pizzato et al., 2010) employed a content-based approach that considered data about those a user messaged to build his/her implicit preferences; and harmonic mean was used to calculate the reciprocity score between two users. Machine learning based approaches have also been applied in several studies, such as decision tree derived from interaction data (Diaz, Metzler, and Amer-Yahia, 2010; Krzywicki et al., 2015), and logistic regression model to adjust the weight of matching criteria based on users' previous behaviour (Park, 2013).

2.4.3 Reciprocal Recommender Systems in the Educational Context

An early work in the domain of recommending peers, PhelpS (Greer et al., 1998), was developed as an AI-based computer-mediated facilitator for collaborative learning amongst workers. The system aimed to facilitate identifying peers in the organisation who can support a particular worker who needs help in specific tasks. Another work by Yang (2006) employed context-aware peer-to-peer searching to form discussion groups amongst learners.

Only recently has there been an increase in the interest in research focusing on providing students with recommendations on study partners based on students' characteristics. Prabhakar, Spanakis, and Zaïane (2017) proposed a recommendation approach using five learners' characteristics – age, gender, location, qualifications, and interests – and their preferences regarding those characteristics to match learners. However, there was no evidence of a research basis for factors used in generation of recommendations. The matching criteria were chosen merely based on the researchers' rationale or types of learners' information collected by the system. Evaluation of the approach was conducted using historic data, focusing on statistical measures such as precision and recall.

Another work, RiPPLE (Potts et al., 2018), presented a reciprocal peer recommender system utilising learners' competency levels and their preferences regarding the roles they are willing to take in a relationship with another peer (supporter/supported/partner). The study attempted to generate matching results as a constraint-based problem consisting of four constraints – learners' requests, competencies, available time, and preferences for a favourable role. Evaluation was performed using synthetic data to examine statistical measures including scalability, coverage, reciprocity, and quality. Again, students' attitudes in actual settings were not explored. Also, RiPPLE only considered learners' preferences and competency with regard to specific course topics. The present research aims to encourage positive interactions and communications amongst students based on more intrinsic characteristics, with a goal of promoting more long-lasting and informal learning communities.

However, previous studies on reciprocal RSs in educational contexts have brought valuable contributions to research in the field and showed the potential of improving learners' experience through suggesting suitable peers. Moreover, discussions in previous work support the recommendation approach applied in this research: profile-preference matching (Potts et al., 2018; Prabhakar, Spanakis, and Zaïane, 2017). Since large amounts of historical data regarding learners' interaction with each other (as opposed to substantial data history in online dating domain) do not exist, machine learning techniques are not applicable at an early stage of such a learning partner recommender system.

2.4.4 Areas with Potential for Integration into RSs for Learning Purposes

The current study, which is aiming to stimulate positive social interactions amongst students, involves building a reciprocal recommender system which encourages students to make connections with peers who are mutually compatible based on characteristics and preferences. Such a recommender system is viewed, in this research, as a system which takes in data about users' characteristics along with their preferences regarding study partners, performs some processing/analysing, and generates recommendations on compatible peers as an output. This subsection discusses how studies from other areas (including Automatic Group Formation, Learning Analytics, and visualisation) can be employed in the current work.

2.4.4.1 Automatic Group Formation

A domain which is relevant to the area of peer recommendation is Automatic Group Formation (AGF) where students are grouped into teams working together. This is a critical task in promoting Collaborative Learning (Cruz and Isotani, 2014). In previous work, grouping criteria, which are retrieved from best pedagogical practices and approaches, have been used to form groups, aiming at maximising learning performance and social interactions amongst students. These criteria are typically related to students' learning aspects (Lin, Huang, and Cheng, 2010) or collaboration goals set by the teacher (Ounnas, Davis, and Millard, 2009). A number of studies have proposed approaches to automate the process of group formation using several grouping criteria such as students' knowledge level, interests in learning topics, learning styles or thinking styles. Moreover, students' preferences were also taken into account in generating group solutions.

Though not exhaustive, Table 2.7 presents a summary of previously explored (semi-) automated approaches to group creation, including parameters such as: context, target user, approach which includes grouping criteria, algorithm, data collection, and evaluation. Analysis of this research area has potential usefulness to the design and development of the proposed learning partner recommender system in terms of grouping criteria and data collection approaches.

Paper	Context	Target user	Approach			
			Grouping criteria	**Grouping Algorithm**	**Data Collection**	**Evaluation**
Yannibelli et al. (2016)	CL context	Teacher	Understanding level & interests in topic Instructor's requirement	Evolutionary algorithm	Synthetic data	Performance Robustness
Srba and Bielikova (2015)	OLE	Teacher	Collaborative skills Personality	Matrices Clustering Group technology	Sentence opener Personality quiz Collaborative tasks	Qualitative Quantitative: comparison with random & k-mean
Dascalu et al. (2014)	OLE	Teacher	Disciplinary background Similar interest types	Particle Swarm Optimisation (PSO)	Self-report data	Self-report satisfaction (questionnaire)
Mehennaoui et al. (2014)	CSCL	Teacher	Complementary skills on concepts Learning styles	Clustering based on competence level	Questionnaires	Comparison of mean group cognitive profile with random & self-organised groups
Balmaceda, Schiaffino, and Pace (2014)	CSCL	Teacher	Psychological styles Team roles Social networks	Weighted constraint satisfaction	Questionnaires Self-reported information	Pilot study in different scenarios
Spoelstra et al. (2013)	Social Learning Networks (SLNs)	Learner	Knowledge Personality Preference on project activities	Mathematical formulations	Synthetic data	N/A
Yannibelli and Amandi (2012)	CL context	Teacher	Members' roles	Deterministic crowding evolutionary algorithm	Synthetic data	Comparison with exhaustive & random method Performance & computation time
Moreno, Ovalle, and Vicari (2012)	HE	Teacher	Knowledge levels Communicative skills Leadership skills	Genetic algorithm	Questionnaires	Computational Pedagogical (grades; comparison with random & self-organised groups)
Cocea and Magoulas (2012)	Exploratory LE	Teacher	Strategies to perform tasks used by students Similarities between strategies for same tasks	Case-based reasoning Clustering	Tracking data of students' handling tasks online	N/A
Abnar, Orooji, and Taghiyareh (2012)	CSCL	Teacher	Personality Learning styles Performance Motivation Profile data	Genetic algorithm	Students' profile data Questionnaire Course assignment	Comparison of quality of groups with ones created randomly. No information about what quality means
Lin, Huang, and Cheng (2010)	CL context	Teacher	Understanding level & interests in topic Instructor's requirement	Particle Swarm Optimisation	Synthetic data	Performance: compare with random & exhaustive method Robustness: compare standard deviation with random method

Continued on next page

Table 2.7 – continued from previous page

Paper	Context	Target user	Approach			
			Grouping criteria	**Grouping Algorithm**	**Data Collection**	**Evaluation**
Meyer (2009)	OLE	Teacher	Students' preferences on project topics Constraints regarding group capacities	Binary linear assignment	Students' project ranking Teacher's parameter recalibration	User acceptance (quiz) Comparison with manual approach (technical & user perspective)
Ounnas, Davis, and Millard (2009)	OLE	Teacher	Gender, nationality, age, previous marks, team roles, interests, learning styles	Constraint satisfaction problem	Simulated data	Constraints being satisfied
Wang, Lin, and Sun (2007)	HE	Teacher	Thinking styles	Genetic algorithm	Thinking style questionnaire	Algorithm performance Students satisfaction
Graf and Bekele (2006)	HE	Teacher	Personality Performance	Vector space model Ant colony optimisation	Student data records	Datasets of 100 students Experiment with 512 (scalability)

TABLE 2.7: Group Formation in recently published studies

Some common trends emerge from the surveyed literature. Firstly, student groups were created in order to perform some assignments with certain learning objectives set by the teacher. Thus, group forming mainly focused on formal learning situations which are topic-/course-/task-/content-/project-specific. Secondly, proposed approaches to forming groups were primarily to facilitate teachers in assigning students into teams. Thus, the target users of systems are academics and therefore the students' perspective on the group formation process was mostly neglected. Thirdly, grouping criteria or grouping rules employed to form groups were either retrieved from literature and based on the researcher's rationale or dependent on instructor's choice. Students' characteristics (or attributes) were used to form those grouping criteria; however, only a small set of factors were considered, and the grouping process was basically task- and project-oriented. Fourthly, previous work placed much focus on the technical side (mathematical formulations and optimisation) with evaluation approaches concerning with algorithm performance (i.e., computation time) and satisfaction against pre-determined constraints. Students' attitudes and satisfaction have not been the focus of the evaluation process in previous studies.

Thus, previous work in the area of AGF aims to facilitate teachers in assigning students to a group based on some specific requirements in a formal learning context (course/topic-oriented). Moreover, those studies focused mainly on the technical side of grouping solutions, while students' perspectives and attitudes have not received much attention. Nevertheless, previous work in this area shows that students' preferences are taken into account in the group formation process; yet only on projects or activities they would want to work in (Spoelstra et al., 2013; Srba and Bielikova, 2015). This is sensible since students nowadays are encouraged to be more self-directed and intrinsically motivated learners (Calhoun and Green, 2015; Goodyear and Retalis, 2010). They have been gaining skills to self-regulate their studies and they have their own requirements/preferences on choosing who to learn with. Therefore, in recommending compatible learning partners to students, it is reasonable for their preferences to play an important role.

2.4.4.2 Learning Analytics

As discussed in Section 2.1, the current scenario of learning environments is complex with the proliferation of the internet, social media, mobile technologies and open education. Every online activity now leaves digital trails; and the abundance of data generated by learners provides great potential for gaining insights into the learning process and its environment (Elias, 2011; Siemens and Long, 2011). Siemens and Long (2011) posited that decision making processes should be built upon data and evidence to ensure improvement in institutional output and productiveness. They claimed online learning and the huge quantity of learner-produced data necessitated the application of Learning Analytics (LA). A widely accepted definition for LA is "the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs" (Siemens et al., 2011, p.4).

A wide range of studies have analysed how application of LA in education could present significant impacts at three different levels: institution, academics and learners. From the institutional perspective, LA benefits include: improving decision making process and resource allocation; facilitating determination of organisational values; enabling innovation and transformation of the institutional system; increasing productivity and effectiveness; and assisting recognition of core elements and their relationships in a sophisticated discipline (Siemens and Long, 2011). From the perspective of academics, LA allows teachers to identify at-risk students and make appropriate interventions (Siemens and Long, 2011), to self-reflect and improve their teaching (Clow, 2012), and to build student success models in order to encourage behaviours or activities attributed to learning success (Dietz-Uhler and Hurn, 2013). Regarding learners, LA offers them insights into their learning process and suggestions for enhancement (Siemens and Long, 2011). Moreover, with LA, personalised adaptive learning is enabled to promote lifelong learning.

Thus, there exists great potential for LA integration into a learning partner recommender system in order to make use of the large amount of student-produced data. There has been research attempting to automatically identify students' characteristics by analysing their activity data in online learning environments, for instance learning styles (Bernard et al., 2017), personality (Ghorbani and Montazer, 2015b), and motivation (Ghorbani and Montazer, 2015a). However, these previous studies had to compare with results generated by conventional characteristic questionnaires to evaluate the quality of their proposed approaches. Hence, the current research acknowledges the prospective role LA can play in facilitating collection of students' characteristic data. Nevertheless, full integration of LA with data extracted from different sources is out of scope of the present project because it is more crucial to explore students' needs and investigate whether (and how) the implementation of such a peer recommender system can have potential impacts on their social interactions and engagement.

2.4.4.3 Visualisation

In educational contexts, information and communication technologies have permeated the education sector and have made significant changes in the way education and training are provided and the manner learners are conducting their learning. Apart from face-to-face classes, nowadays almost all learning resources can be found on the internet and diverse kinds of courses are offered online with possibly hundreds of thousands of participants. Moreover, students are online posting blogs about what they learn from the courses, they make comments on others' posts, they use hashtags to create connections to the topics they learn. Thus, as learners are doing more of their work online, they leave a lot of digital traces of their activities. The activity data is captured to be made available for analysis. However, it is not an easy task to make sense of the retrieved data because of the continuous growth of educational data. Correspondingly, there is high demand for extracting valuable information from the large amount of data and presenting the massive digital data in a manner which is user-friendly, understandable, usable and meaningful. In that context, visualisation is a powerful approach with the capability of creating a significant impact (Bollier and Firestone, 2010; Chen, Mao, and Liu, 2014).

Visualisation and its impact on human cognition has been of great interest to many researchers; and it has been proven to be a powerful tool for enhancing data exploration and discovery in an effective and efficient manner. The major reason for its powerful effects is that visual representations take advantage of several distinctive features of the human cognitive process. In "Information Visualisation: Perception for Design", Ware (2012) stated that visualisation has been taking a greater and crucial part in amplifying the human cognitive system (p.2). He presented the advantages of visualisation as (1) allowing better interpretation of and insights into large data sets, (2) revealing unexpected patterns and properties in the huge data, (3) exposing issues/errors in the data which were unobvious before visualisation being employed, (4) facilitating recognition of linking patterns, and (5) enabling the process of hypotheses establishment. Sharing the same view on the benefits which visualisation promises to offer, Keller and Tergan (2005) affirmed that visualisation is considered as a great boost to the human cognitive system due to the fact that the problem solving process is significantly aided by pattern recognition which, with the help of external cognitive tools, can be faster and more effective in comparison with internal queries (in the human brain) of accessing and processing data.

Moreover, visualisation has been proven as beneficial for promoting collaboration in online learning environments by improving learners' awareness of social interaction. Janssen et al. (2007) conducted a study with the hypothesis set that visualisation of student participation can promote their participation in internal (motivation) and external (feedback) processes. They affirmed that students who were more engaged in building collaboration in the learning network were those who had more access to the visualisation tool. Furthermore, the study also demonstrated that visualisation can help trigger motivation amongst learners, as these participants had a greater concern to creating better collaboration. Holding a similar view on the positive effect of visualisation on learner collaboration, Govaerts et al. (2010) contended that with visualisation of learning activities within a network, learners can be more motivated. They can get feedback on their study and discover others' activities, which turns out to be significantly useful for the progress of their study.

For the current work, visualisation can be of great importance for presenting recommendation results for some key reasons. Firstly, with the help of graphical displays users can more easily make sense of connections formed amongst the large number of learners in the online learning systems. Secondly, visualisation possesses potential for an approach of presenting analysis results which is more engaging to users (learners) in the online learning environment. Hence, in this research project, information visualisation is expected to facilitate in the presentation of recommendation results back to students in a meaningful and comprehensive manner.

2.5 Summary

In summary, this chapter has discussed the significance of collaborative learning and emphasised the need for greater attention placed on promoting informal online learning communities by embracing differences in students' characteristics and preferences on study partners. By reviewing the literature, some gaps have been identified regarding approaches to promoting OLCs and tasks supported by RSs in learning contexts. Potential usefulness of other areas including LA, AGF and visualisation have also been discussed. Figure 2.2 demonstrates the identified research gaps and potentials.

2.5.1 Gaps

2.5.1.1 OLCs

The surveyed literature in OLCs suggests two gaps. Firstly, there has been much emphasis on cognition aspects, but little focus on affective, social-emotional processes and social interactions amongst learners (Kreijns, Kirschner, and Jochems, 2003; Sung and Mayer, 2012). This is reflected in the current context of OLC research in which approaches to improving LCs that have been recommended focus greatly on instructors' roles as well as course and instructional designs (Shea, 2006; Swan, 2002; Swan and Shih, 2005). Little work has been done to promote informal learning communities that strive to stimulate positive social interactions amongst students.

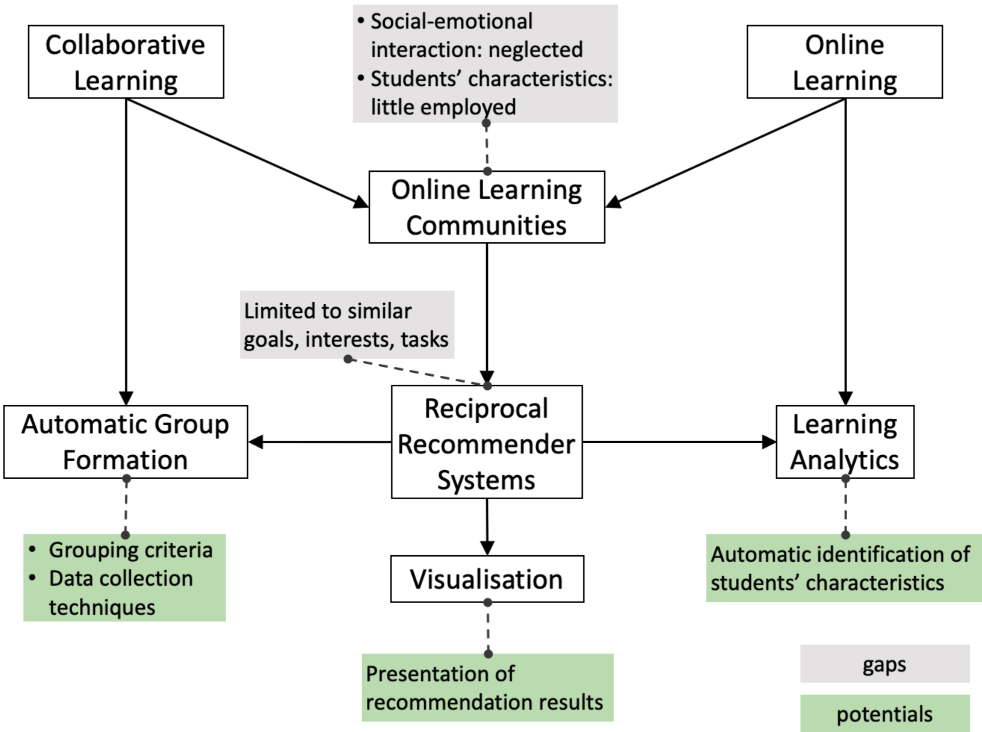


FIGURE 2.2: Gaps and potentials identified in relevant research areas

Secondly, a variety of students' characteristics have influence on their participation in collective learning as well as the creation and development of a learning community. Also, students' perspectives and preferences in this complex learning context need to be explored and taken into account in the process of promoting OLCs (Goodyear and Retalis, 2010; Song et al., 2004). Previous studies have investigated the role of a number of students' individual characteristics in their engagement in online collaborative learning, learners' knowledge sharing, and the formation as well as maintenance of OLCs. Those characteristics include group member familiarity (Janssen et al., 2009), academic motivation (Rienties et al., 2009), students' communication styles (Cho et al., 2007), students' personality (Chen and Caropreso, 2004; Jadin, Gnambs, and Batinic, 2013; Matzler et al., 2008), and learning patterns (Gabriel, 2004). However, each study investigated an individual characteristic or a small set of factors and most of the time considered learning performance (grades) as the ultimate goal of encouraging OLCs. Differences in students' characteristics are little employed and their diverse preferences on learning partners have not been taken into consideration in efforts to encourage positive interactions amongst students.

2.5.1.2 Recommender Systems for Peer Suggestions

The process of finding peers has been studied in order to encourage interaction and communication amongst students. However, recommendations are limited to those with similar interests or the same learning goals (Drachsler et al., 2015). Several other individual characteristics which are significant to their choice of learning partners have not been considered from their own perspective in the matching process such as willingness to communicate, motivation, and personality as well as learning styles. Recent studies (Potts et al., 2018; Prabhakar, Spanakis, and Zaïane, 2017) focus on providing recommendations on study partners. Nevertheless, the matching criteria used are chosen either without a research basis or merely based on learners' competency and preferences regarding specific course topics. Moreover, students' attitudes towards the recommendations have not been explored.

2.5.2 Potentials

As previously discussed in subsection 2.4.4 and illustrated in Figure 2.2, there exists potential for employing in the current work the advances of different areas, including Automatic Group Formation (AGF), Learning Analytics (LA), and visualisation. Firstly, previous studies in AGF have revealed various students' characteristics which are important to their engagement in collaborative activities. AGF work has also shown that students' preferences should be taken into account in the group formation process, which indicates the diversity and significance of learners' requirements when it comes to learning/working with others.

Secondly, Learning Analytics (LA), as discussed above, is a subject undergoing intense study. LA studies often apply various techniques including data mining, statistics, content analysis and many others in order to analyse rich sources of data about learners as well as learning environments. Thus, there exists great potential to utilise LA advances in retrieving information about students' characteristics from their online learning activities. Although the utilisation of LA with a full integration with external data sources is out of scope of the current project, the role which LA is likely to play in a characteristic-preference learning partner recommender system is crucial: a feature source of inputs for the recommender system.

Lastly, visualisation has been proven to be a powerful tool for improving data presentation, information exploration and pattern recognition. Moreover, it is asserted to be beneficial for improving awareness of social interactions and promoting collaboration amongst students in an online learning environment. In the current research, visualisation has a good prospect of facilitating students to quickly recognise of how they are matched with other peers in terms of significant characteristics and individual preferences.

Chapter 3

Methodology

3.1 Introduction

The purpose of this study is to promote the formation of students' informal learning communities in higher education. From the discussions in Chapter 2, it is suggested that positive social interactions are expected to occur amongst individuals with compatible characteristics; and positive social interactions are the key prerequisite for the formation of a learning community. The current work therefore aims to stimulate interactions amongst students in online learning environments by means of recommending learners to each other based on their individual characteristics and preferences. Reasonably, the research involves building a system which generates recommendations for compatible study partners in order to support better student collaboration.

This chapter describes the research methodology that will be used to guide this research. A range of different methodologies exists. It is therefore important to select one that is suitable for this research so that the research could be systematically designed, structured and conducted. Section 3.2 discusses the research question in detail. Section 3.3 presents research methodology which covers research paradigm, Design Science as the chosen approach to conduct the study, research design, and identified phases of the project. The last section gives a summary of the research methodology of the current study.

3.2 Research Question

As presented in the previous chapter, the formation of students' online learning communities is a challenging task in the current context where learners' face-to-face interaction has decreased due to the remarkable growth of online learning. The present work aims to improve the situation through creating a system which can assist students in finding suitable peers to conduct their learning. The main research question has been identified as:

Can a learning partner recommender system help promote effective informal Online Learning Communities in higher education settings?

A set of eight sub-questions were devised to help breaking down the main research question, dealing with different aspects including: a conceptual model of a learning partner recommender system; development of the proposed system; evaluation of the developed system along with lessons learnt; and investigation of barriers to students' adoption.

Firstly, the first three sub-questions deal with the process of building a conceptual model of a recommender system which provides students with suggestions on compatible study partners. The recommendations generated are based on characteristics possessed by students and what they prefer to find in their peers in order to maximise the compatibility. As a result, it is a crucial task to identify which students' features to use as criteria for recommendations, which is the focus of sub-question 1:

SQ1. What characteristics do students consider important when choosing learning partners?

Moreover, since the research goal is to encourage effective OLCs, measures of an effective OLC need to be specified in order to guide the design of the proposed recommender system. Hence, sub-question 2 is as follows:

SQ2. Which measures can be used to assess the effectiveness of an Online Learning Community?

Next, it is required that the proposed system is modelled to reflect the key constructs of the system:

SQ3. How can a Learning Partner Recommender System (LPRS) be modelled to match students with compatible characteristics?

Secondly, the next three sub-questions concern the development of the proposed system regarding system input, process, and output. As for system input, sub-question 4 investigates utilisable data sources which can provide required data for the system:

SQ4. What data sources are available for an LPRS and can be used to collect the information needed to match partners according to the identified list of characteristics?

The next sub-question concerns the system process, aiming to make a decision about an approach to generate recommendations for compatible study partners:

SQ5. Which matching algorithms can be employed to generate matching scores based on important characteristics and their significance level?

With regard to system output, different approaches to present recommendation results are considered so that students can quickly gain a clear picture of their matching results and connections with other peers in the learning environment. Sub-question 6 focuses on presentations of recommendations generated by the system:

SQ6. How can matching results be presented to learners in a meaningful and engaging way?

Thirdly, the developed recommender system needs to be subsequently evaluated to determine whether it is suitable for the intended purpose, which is to stimulate positive social interaction amongst students. Therefore, sub-question 7 is stated as follows:

SQ7. What is the impact of the partner matching system in creating and increasing positive interactions amongst students?

It should be noted that iterative refinements of the proposed learning partner recommender system are likely to occur during development and evaluation steps according to inputs from students, who are the target audience of the current work. Multiple iterations are required in order to gain better understandings of students' needs in the specific context of the current work, and to improve system usability for the targeted users. Finally, the target audience of the current study are students in higher education; and the nature of the system use is entirely voluntary. Therefore, it is of great importance to understand factors which have an impact on students' decision to use or disregard a newly developed non-mandatory application.

SQ8. What are the factors influencing students' adoption of voluntary applications for learning purposes?

The research methodology used to answer these questions is described in the following section.

3.3 Research Methodology

This section covers the discussion on the research methodology of this project. The research paradigm applied for the current work is presented in subsection 3.3.1, leading to the choice of Design Science Research (DSR) which is discussed in subsection 3.3.2. After that, the research design employed to conduct the project is elaborated in subsection 3.3.3. Finally, subsection 3.3.4 presents the project phases from a practical perspective.

3.3.1 Research Paradigm

Research paradigm is considered as a "net that contains the researcher's epistemological, ontological, and methodological premises" (Denzin and Lincoln, 2005, p.13). This subsection discusses the ontological, epistemological and methodological stance of the current work. The discussion serves as a justification for the choice of Design Science Research as the approach employed to conduct this study.

Ontology is the study that explores the nature of reality (Denzin and Lincoln, 2005; Levers, 2013). There are two opposing perspectives: critical realism and relativist. Critical realism contends that there is a single reality and it exists independently of human minds whether the reality is recognised or comprehensible or not. Relativist ontology, on the other hand, argues that there are multiple realities and no reality exists outside of human thoughts (Levers, 2013).

Epistemology is the study of knowledge which investigates the relationship between the inquirer and knowledge. It raises questions such as "on what does knowledge depend and how can we be certain of what we know?" (Vaishnavi and Kuechler, 2004, p.8). Two opposing epistemological stances are objectivism and subjectivism (Levers, 2013). Objectivism holds that meaning is independent of human subjectivity and knowledge is universal because the reality does not change regardless of observers. On the contrary, subjectivism recognises that knowledge emerges from mutual influence of the observer and the observed (Levers, 2013; Vaishnavi and Kuechler, 2004).

The current work aims to promote informal OLCs amongst students in higher education through building a recommender system which attempts to give suggestions for compatible study partners. With the goal established, this study advocates a constructivist perspective: ontological contextual critical realism and epistemological subjectivism. In the current context of higher education where there is an increase in online learning and decrease in students' face-to-face interactions, online learning communities, with their proven benefits, need to be more strongly promoted. From the gaps and potentials identified in the literature, the current research proposes a learning partner recommender system aiming to stimulate students' interactions which can potentially result in the emergence of informal OLCs amongst students. However, it is acknowledged that the context in which the current research is conducted (technology, resources, educational institution, and participants' perspectives) can have important influences on adaptions which the recommender system must undergo. Thus, changes and adjustments in conducting the current work are expected; while the core goal remains as to obtain a better understanding of students' needs regarding learning communities and the complicated learning environment in order to promote informal OLCs.

Methodology focuses on the question "how do we know the world or gain knowledge of it?" (Denzin and Lincoln, 2005, p.12). In the context of the current work, it refers to approaches to conducting the project so that knowledge can emerge through creating a system to address the research problem identified. It is required that the system development is iterative with inputs from students, the target users, in order to obtain better understandings of the research problem, the system creation process, and existing as well as unexpected issues in the development and evaluation process. Therefore, the approach applied in the current work is exploratory, constructive, iterative, and developmental.

In summary, by identifying that it is challenging to form meaningful informal OLCs amongst students in higher education, the work presented in this thesis aims to improve the situation. By employing technologies, there are opportunities for data regarding students' characteristics and preferences on learning partners to be collected and analysed; and recommendations on compatible peers to form learning communities outside of classroom scope to be generated. Moreover, appropriate visualisation approaches can be utilised for matching results to be presented to students in a meaningful, understandable and engaging way. An approach to promote informal OLCs is proposed which involves the design, development and evaluation of the learning partner recommender system which provides students with suggestions on compatible peers for collaboration. With the epistemological, ontological and methodological standpoints of the current work presented above, Design Science Research (DSR) is remarked as a suitable research paradigm for the present project to be conducted.

3.3.2 Design Science Research

Design Science Research (DSR) (Hevner et al., 2004; Venable, 2006) is applied to conduct this present project. Design Science (DS) refers to the epistemological basis for the study of the design of artefacts, artificial (man-made) objects and phenomena, designed to achieve certain desired purposes (Dresch, Lacerda, and Antunes, 2015; Vaishnavi and Kuechler, 2004). Design Science Research (DSR) is defined by Hevner and Chatterjee (2010) as follows:

> "a research paradigm in which a designer answers questions relevant to human problems via the creation of innovative artefacts, thereby contributing new knowledge to the body of scientific evidence. The designed artefacts are both useful and fundamental in understanding that problem." (p.5)

Thus, the defining feature of DSR is "learning through building artefacts" (Vaishnavi and Kuechler, 2004, p.6). In DSR, a pragmatic research paradigm is supported to promote the creation of artefacts to solve real-life problems (Prat, Comyn-Wattiau, and Akoka, 2014). Artefacts here include "constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices), and instantiations (implemented and prototype systems)" (Hevner et al., 2004, p.77).

DSR has been discussed in the literature as a paradigm rather than a separate methodology (Baskerville, Pries-Heje, and Venable, 2009). DSR is conceptualised by Vaishnavi and Kuechler (2004) as having "multiple, contextually situated" ontology and "iterative, knowing-through-making" epistemology. From that, DSR researchers believe in a single stable underlying reality but acknowledge the influences of contextual factors. Knowledge in DSR is revealed through the construction of an artefact and its description including models, design principles, and/or design theories (Gregor and Hevner, 2013).

3.3.3 Research Design

Since 1980 a number of methods have been proposed to operationalise DSR (Dresch, Lacerda, and Antunes, 2015) including system development research process (Nunamaker Jr, Chen, and Purdin, 1990), Design Science Research cycles (Hevner, 2007), and Design Science process (Peffers et al., 2007). The DSR Process Model, as shown in Figure 3.1, proposed by Vaishnavi and Kuechler (2004) is chosen to guide the current work since this model focuses on the DSR methodology used in the creation of artefacts to solve problems and emphasises knowledge generation in the process of artefact creation.

3.3.3.1 DSR Process Model

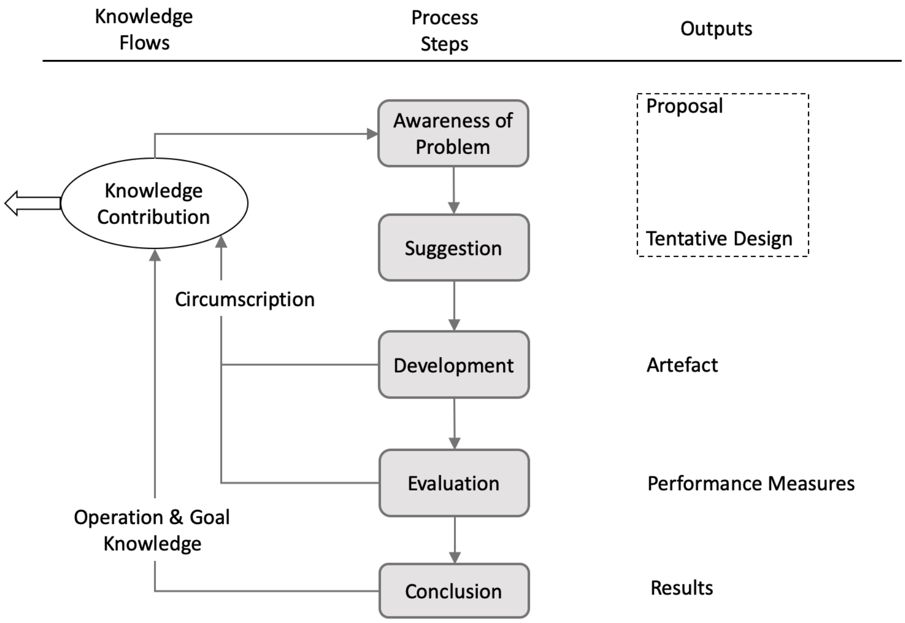


FIGURE 3.1: DSR Process Model, adapted from Vaishnavi and Kuechler, 2004

The first step in the DSR Process Model is *Awareness of Problem*. In this step, the problem is identified and understood. The output of this stage includes a proposal and preliminary performance requirements for the proposed artefact in order to meet the desired goal.

The second step immediately follows afterwards where a solution (or a number of solutions) is suggested to improve the identified problem, hence it is called the *Suggestion* phase. At this stage, there is a demand for both creativity and employment of prior knowledge. A tentative design is the output from this step.

The third step is *Development* where the tentative design is developed and implemented. There are many forms of artefacts ranging from instantiations to constructs, models, technological rules to design theories with the increasing degree of abstraction, completion, and maturity of knowledge (Gregor and Hevner, 2013). Therefore, the implementation techniques vary accordingly based on the nature of the designed artefacts (Vaishnavi and Kuechler, 2004).

The fourth step is *Evaluation* where the developed artefact is evaluated against the performance requirements suggested in the proposal in step one. As Vaishnavi and Kuechler (2004) remark, it is rare that in DSR the initial hypothesis regarding the functionality of the artefact completely holds up. Supplementary information from the development step and results from the evaluation stage are fed back to step one and two so that better understanding of the research problem and improved suggestions can be obtained (illustrated by the circumscription arrows in Figure 3.1).

The last step is *Conclusion* where results of the research effort are presented. Knowledge gained from the research can be categorised as either "firm ends" or "loose ends". The former refers to learnt facts and repeatable results; while the latter category refers to deviant behaviours of the developed artefact which can serve as a subject of further research. Communication is greatly significant in order for the research findings to be shared with other researchers and interested parties (Peffers et al., 2007).

3.3.3.2 DSR Applied in the Current Work

Using the DSR Process Model (Vaishnavi and Kuechler, 2004), the research design of the current project is shown in Figure 3.2. The first step is *Awareness of the Problem*. By reviewing literature on OLCs, the gaps related to facilitating informal OLCs are identified. Moreover, there exists the potential of LA, RSs and visualisation for collecting data regarding student's characteristics and preferences, performing analysis, and presenting compatible learning partners to students. A research proposal is then established which involves building a learning partner recommender system aiming to encourage positive social interactions amongst students. The set of eight research sub-questions are devised to handle different aspects of the main question.

In the *Suggestion* stage, by addressing the first three sub-questions (regarding identification of learners' characteristics used as matching criteria, measures of OLC effectiveness, and modelling LPRS), a tentative design of the recommender system, which is the conceptual model of LPRS, will be created. The design will include the identified characteristics used as criteria for generating recommendations, proposed approaches to collecting the required data, and key components of the system.

The third step is the *Development* of the proposed recommender system where a working prototype of LPRS will be implemented. Feedback from students, the target users of the system, is essential for a better understanding of the research and possible improvements of the system. Next, in *Evaluation* step, LPRS will be evaluated in a real-life context in terms of its impact on students' interactions and sense of community. Moreover, a subsequent investigation of students' adoption of voluntary technology is important for greater insights into students' decision-making process in order to improve the chance of success of non-mandatory technologies.

Details on planned method, evidence and intended output generated in the process of tackling each sub-question are demonstrated in Table 3.1.

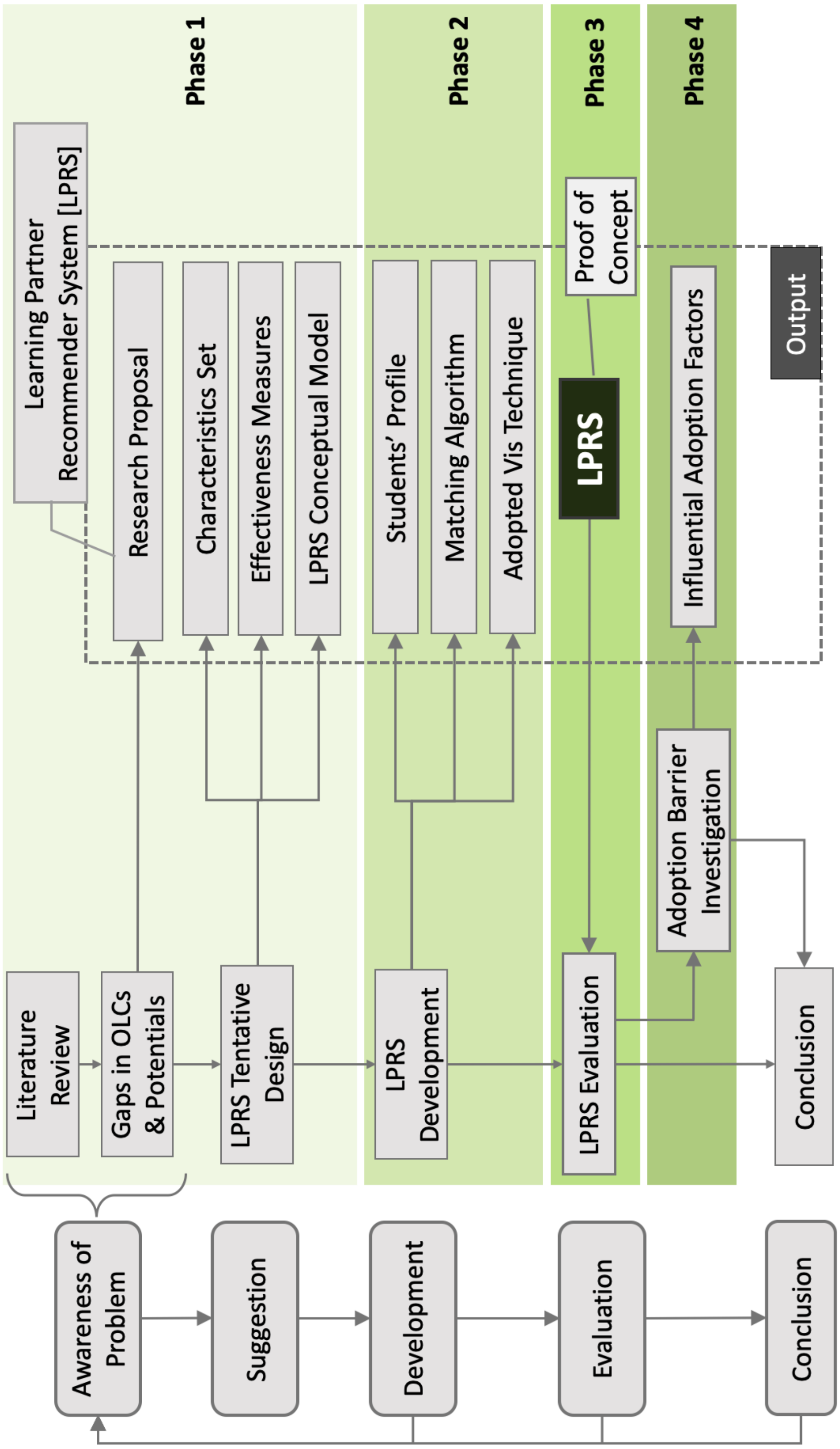


Figure 3.2: Research design for the current project

Research Question	Activity/Task/Method	Evidence Data (Indicators)	Output/Result
SQ1: What characteristics do students consider important when choosing learning partners?	• Literature Review • Data Collection & Analysis (survey & interview)	Integration of literature & students' perspective	A set of characteristics used as factor categories for the matching system
SQ2: Which measures can be used to assess the effectiveness of an OLC?	• Literature Review • Data Collection & Analysis (survey & interview)	Research on OLC evaluation & students' perceived benefits obtained	Indicators/metrics indicating an effective OLC
SQ3: How can a Learning Partner Recommender System (LPRS) be modelled to match students with compatible characteristics?	Initial model of proposed LPRS and modifications	Collection of factors, identified data sources, preliminary constructs of the LPRS model	LPRS conceptual model
SQ4: What data sources are available for an LPRS and can be used to collect the information needed to match partners based on the identified list of characteristics?	Collecting data about students' characteristics through questionnaires	Data about students' individual characteristics & preferences on partners	Students' profile & preferences
SQ5: Which matching algorithms can be employed to generate matching scores based on important characteristics and their significance level?	Available matching algorithms in literature	Potential algorithms	Adopted matching algorithms
SQ6: How can matching results be presented to learners in a meaningful and engaging way?	Presentation approaches in literature	Potential presentation approaches	Adopted interactive visualisation approaches
SQ7: What is the impact of implementing the partner matching system in creating and increasing positive interactions amongst students?	• Keep track of users' interactions to analyse the nature of interactions • Self-report assessment	Data about students' interactions & perceived sense of community	Evaluation results of students' interactions & perceived sense of community
SQ8: What are the factors influencing students' adoption of voluntary applications for learning purpose?	• Technology adoption theories & models in literature • Data collection with educators and students	Literature Review & Interview data	Factors influencing students' adoption of voluntary educational technology

TABLE 3.1: Research question handling

3.3.4 Project Phases

Considering the research in a practical view, four key phases of the project have been established as illustrated in Figure 3.3.

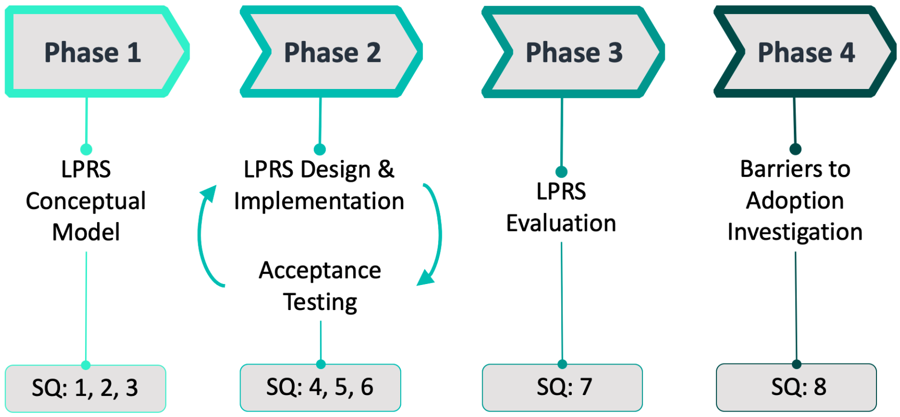


FIGURE 3.3: Research project phases

Phase 1: LPRS Conceptual Model – involves tackling the first three research questions during the first year of the project. From the synthesis of literature on Collaborative Learning (CL), Online Learning Communities (OLCs) and Group Formation (GF) in combination with an investigation of students' perspectives, a collection of learners' characteristics will be identified to be employed as criteria to matching students (SQ1). A model of LPRS will then be proposed suggesting approaches to collecting and identifying some of the characteristics through students' activities in online learning environments (SQ3, part of SQ4). The preliminary evaluation plan of an effective OLC is based on the elements of Sense of Community (SoC) - membership, influence, fulfilment of needs and shared emotional connection (McMillan and Chavis, 1986) (SQ2).

Phase 2: LPRS Design & Implementation. The focus is on the next three sub-questions in the second year of the project. Primary data sources for collection of students' characteristics and preferences are determined including self-report data through students' completion of characteristic quizzes (SQ4). Matching algorithms and visualisation approaches to present recommendations will be studied and chosen (SQ5 and SQ6). An initial user acceptance testing using focus group approach will be conducted to explore the target users' opinions on the developed system. Feedback from this second data collection will be revised and adopted for modifications to be made to the system.

Phase 3: LPRS Evaluation A pilot test and then a system deployment on a larger scale with a greater number of students are planned to be conducted in order to investigate its usability and potential impact, identify issues, and suggestions for improvements (SQ7).

Phase 4: Study of Barriers to Students' Adoption of Technology for Learning Purpose in Voluntary Settings. The low buy-in from students during phase 3 has led to the necessity of an investigation of factors which influence their decision to adopt or reject LPRS. Phase 4 focuses on a study of a non-mandatory application for learning purpose, with LPRS as a case study.

3.4 Summary

Given that the present research goal is to promote informal online learning communities amongst students; and the project scope involves building a learning partner recommender system, Design Science Research has been adopted to conduct the study. This chapter describes how the DSR process model will be adopted in the context of the current study. The four project phases, along with their primary goals, were identified in order to address the research sub-questions.

Chapter 4

Phase 1: The Process of Building LPRS Conceptual Model

4.1 Introduction

Chapter 4 focuses on the process of building the conceptual model of the Learning Partner Recommender System (LPRS), aiming to address the first three research sub-questions regarding students' characteristics used as matching criteria; measures of OLC effectiveness; and LPRS modelling. The content of this chapter belongs to phase 1 of the research project, aligning with the *Suggestion* step of DRS process model (as in Figure 4.1)

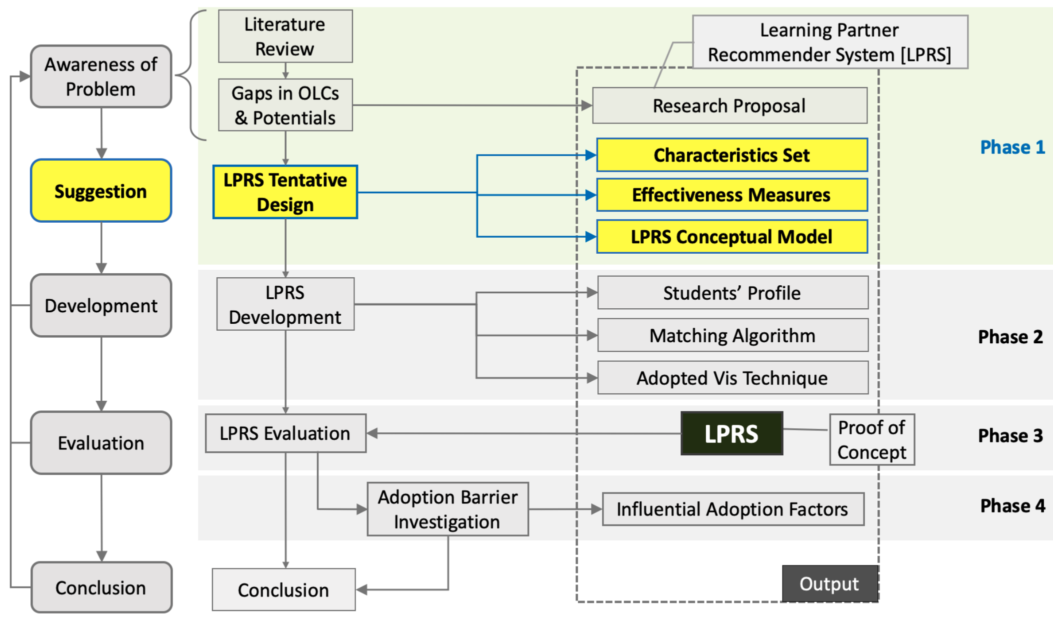


FIGURE 4.1: Chapter 4 content in the research design of the project

The general design pattern applied for building the LPRS model, or any computing system, consists of three main activities: input, processing, and output. Moreover, a database is required for such a recommender system in order to efficiently manage user data. Therefore, in general, the key components of the LPRS include *input*, *process*, *storage*, and *output*. Figure 4.2 demonstrates the four general components of LPRS model.

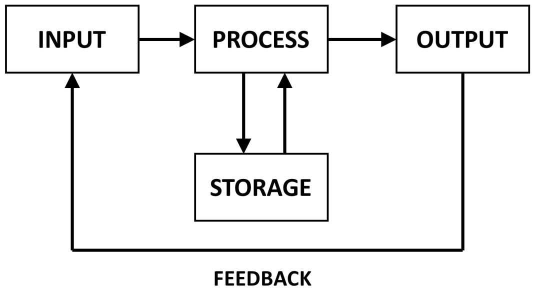


FIGURE 4.2: General components of LPRS model

Input here accounts for what is required to retrieve data about students' individual characteristics and preferences on learning partners. Process involves some actions such as modifying and storing the inputted data as well as retrieving data from the database, performing analysis, and generating recommendations. Storage refers to how processed data are organised and stored in the database. Output focuses on how the matching results are presented to users.

Firstly, in terms of the input component, since the primary goal of the research is to promote informal OLCs amongst students through suggesting learning partners with compatible characteristics, it is crucial to identify which characteristics of students could be used as matching criteria. Moreover, with students being the target users of the LPRS, it is required that attempts are made to obtain students' perspectives on the matter of interest. The process of identifying characteristics used as matching criteria in the model involves (1) literature review to synthesise students' characteristics to be used as matching factors (covered in Section 4.2) and (2) investigation of students' attitudes to LCs and perceived important characteristics (presented in Section 4.3).

Secondly, the other three components of the model – storage, processing, output – are briefly discussed in Section 4.4. The conceptual model of LPRS is presented afterwards with highlights regarding which parts of the model are influenced by results from the first data collection. The primary deliverable of this phase is the conceptual model of the proposed recommender system.

4.2 Identification of Students' Characteristics Conducive to OLCs

This section covers the identification of students' characteristics which were found to be important to collaborative learning and the formation of OLCs (subsection 4.2.1). Suggested data sources to collect data of the characteristics are provided afterwards in subsection 4.2.2.

4.2.1 Collection of Students' Individual Characteristics

From the literature review on CL, OLCs and Group Formation as discussed in Chapter 2, a collection of students' characteristics that are considered to be important for their participation in collaborative activities and the development of sense of community in online environments were identified. These characteristics were categorised into two groups: (1) academic aspects, which include factors such as educational level, academic interests, experience/skill, learning styles, learning pattern, and achievement goals; and (2) socio-psychological aspects, which include culture, pattern of socialisation, perception of self as being connected or separated, hobbies/interests, personality traits, and preferred communication media. Table 4.1 gives information about these characteristics. Factors in a blue shade are those of the academic group, while ones in a pink shade belong to the socio-psychological category. Also, factors with an asterisk (*) attached are students' characteristics whose data would be collected using questionnaires developed in literature.

Factor	Description	Supporting studies	Data sources & Questionnaire
Motivation *	"The disposition of a student to approach success. It was used to explain the activated state of a student to get a high standard in his academic performance" (Bekele, 2006, p.64)	Rienties et al. (2009) Graf and Bekele (2006) Duncan and McKeachie (2005)	Academic Motivation Scale or MSLQ Quiz (Motivation subscale)
Self-efficacy*	"Subjective judgement of one's level of competence in executing certain behaviours or achieving certain outcomes in the future" (Shea and Bidjerano, 2010, p.1724)	Graf and Bekele (2006) Dascalu et al. (2014)	MSLQ Quiz (Self-efficacy Subscale)
Skills/ Experiences	Individual's knowledge about / ability to perform tasks regarding some certain domains	Spoelstra et al. (2013) Mehennaoui et al. (2014) Moreno, Ovalle, and Vicari (2012) Gabriel (2004) Dascalu et al. (2014)	Self-report data LA (completed units & grades)
Educational Level	Data regarding degree, major, year	Brook and Oliver (2003)	Profile data
Learning Styles*	Preferences a student has for how to gather information, how learning material is presented, how to process information and how to internalise information (Bernard et al., 2017) (Felder and Silverman, 1988)	Alfonseca et al. (2006) Mehennaoui et al. (2014)	Felder-Silverman questionnaire
Learning Patterns	Students' preferred working schedules – online timetable, to address time compatibility issues	Gabriel (2004) Stodel, Thompson, and MacDonald (2006)	Tracking data (LMS)
Academic Interests	The liking/disliking the student developed towards certain areas	Lin, Huang, and Cheng (2010) Dascalu et al. (2014) Yannibelli et al. (2016)	Self-report data Tracking data

Continued on next page

Table 4.1 – continued from previous page

Factor	Description	Supporting studies	Data sources & Questionnaire
Hobbies	General interests/hobbies for initially social interaction purpose	Liu (2010)	Self-report data
Self-perception of being connected / separated*	"Recognition of membership in a community and the feelings of friendship, cohesion, and satisfaction that develop amongst learners" (Rovai, 2002b, p.322)	Rovai (2002d) Brook and Oliver (2003)	Classroom Community Scale (CCS)
Preferred Communi -cation Media	Student's preferred approaches to communication / collaboration with peers	Brook and Oliver (2003) So and Brush (2008)	Self-report data
Demographic	General demographic information including age, gender, nationality	Brook and Oliver (2003) Economides (2008) Holmberg (2019) Ounnas, Davis, and Millard (2009)	Profile data
Willingness to communicate (WTC) *	"The degree to which a student is inclined to initiate communication with different people in various social settings" (Cho et al., 2007, p.311)	Cho et al. (2007)	WTC questionnaire
Personality Traits*	Internal enduring characteristics possessed by a student which influences the individual's pattern of behaviours (network, learning performance, learning styles, collaborative contribution)	Graf and Bekele (2006) Spoelstra et al. (2013) Srba and Bielikova (2015) Chen and Caropreso (2004)	Personality questionnaire

TABLE 4.1: Students' characteristics conducive to OLCs

The following subsections 4.2.1.1 and 4.2.1.2 discuss the importance of each characteristic in the two categories, academic and socio-psychological aspects. Subsection 4.2.1.3 briefly explains the role of students' preferences for study partners.

4.2.1.1 Academic Aspects

The first characteristic in the academic group is motivation. Motivation is defined as the "disposition of a student to approach success" (Bekele, 2006, p.64). This characteristic, according to Bekele (2006), is the driving factor that influences a student to be proactive in their study. Motivation has been used as a key characteristic in several studies to examine factors which have a significant impact on learners' level of success (Chang and Chang, 2012; Duncan and McKeachie, 2005; Kerr, Rynearson, and Kerr, 2006) as well as their collaboration with peers (Rienties et al., 2009), and as a group formation criterion (Abnar, Orooji, and Taghiyareh, 2012; Graf and Bekele, 2006). Data about learners' motivation are commonly obtained using motivation questionnaires such as Academic Motivation Scale (Vallerand et al., 1992) or MSLQ Motivation subscale (Pintrich et al., 1991).

The second characteristic, self-efficacy, is described as students' "subjective judgement of one's level of competence in executing certain behaviours or achieving certain outcomes in the future" (Shea and Bidjerano, 2010, p.1724). In other words, this refers to students' self-belief in their own ability to conduct actions in order to accomplish tasks in their study. This factor has been proven to have important influence in learners' achievement as well as collaborative learning activities (Graf and Bekele, 2006; Klassen, Krawchuk, and Rajani, 2008; Shea and Bidjerano, 2010; Wang, Lin, and Sun, 2007; Zimmerman, 2000a). A commonly used approach to retrieve data regarding this factor in a learning context is the Self-efficacy subscale of MSLQ scales (Duncan and McKeachie, 2005).

Next, learners' skills or experience is another important factor contributing to the formation and development of a learning community. In this research, this characteristic refers to students' knowledge about and/or their ability to perform tasks regarding some certain domains. Several studies in the group formation area have employed this factor as a key criterion to assign students into a team (Dascalu et al., 2014; Mehennaoui et al., 2014; Moreno, Ovalle, and Vicari, 2012; Spoelstra et al., 2013). Skills and experiences also ensure mutual benefits which all members of a learning community can share with and learn from each other (Gabriel, 2004).

The educational level of students is another characteristic which is believed to influence community development (Brook and Oliver, 2003). Research on collaborative learning and group formation has been commonly conducted in the context of students being in the same courses and/or taking similar subjects. This factor plays a non-trivial part in the formation of a learning community; however, it has not been emphasised explicitly in literature. Also, a student who looks for study partners would tend to find a peer who enrols in the same course or takes similar units (or subjects). In a system which aims to provide recommendations on learning partners, the educational level should be employed as a matching factor (Prabhakar, Spanakis, and Zaïane, 2017).

Learning style is one significant criterion in previous studies which attempt to find a solution to grouping students into teams (Abnar, Orooji, and Taghiyareh, 2012; Mehennaoui et al., 2014; Ounnas, Davis, and Millard, 2009). The basis for the use of learning styles in education is that students' learning can be improved if they are categorised into different preferred styles of learning and taught accordingly; however, this use of learning styles has been suggested in the educational field as a neuromyth (Dekker et al., 2012; Newton and Miah, 2017). Although the use of learning styles in education has been a controversial topic, the current work does not emphasise classification of learners into distinct groups. Rather, learning styles refer to learners' preferences for some certain activities and preferences for how materials are presented (Felder and Silverman, 1988). These preferences can be as flexible as needed for different topics/areas which the students are studying. Moreover, as Alfonseca et al. (2006) asserts, learners with different study preferences would hold different perspectives on approaches to collaborating with other peers. Therefore, students' learning styles can play an important role when collaboration amongst students is meant to be encouraged.

The sixth factor in Table 4.1 is learning pattern. In some studies, the term "learning pattern" was used interchangeably with "learning styles" (Marambe, Vermunt, and Boshuizen, 2012; Vermunt, 2005). However, in the context of this research, learning pattern simply refers to learners' preferred or common work schedule. Although online learning provides great convenience, flexibility and personalisation, it is considered important by online learners that their co-learners share a compatible work schedule as well as timely responses (Gabriel, 2004; Stodel, Thompson, and MacDonald, 2006).

The last factor when attempts are made to promote a learning community is students' academic interests. This refers to a liking for certain areas and/or topics which students develop during their learning journey. Students' interests regarding certain topics in a course have been used as one criterion in attempts to build collaborative learning teams in previous research (Dascalu et al., 2014; Lin, Huang, and Cheng, 2010; Yannibelli et al., 2016). As Yannibelli et al. (2016) remark, different studies in the literature have found that grouping students based on academic interests can facilitate promotion of positive discussion and interactions during collaboration, improvement of social connections amongst students, and enhancement of learning experiences.

4.2.1.2 Socio-psychological Aspects

The first factor in the socio-psychological group is hobbies. Similar hobbies can help trigger conversations and facilitate the initial bonding relationship amongst students (Liu, 2010). There have been social network systems which employ hobbies as the matching key criterion to help people with common hobbies find companions (Schoenberger, 2007). The learning process involves social interactions amongst learners; therefore, it is worth taking into account this factor when building a recommender system which aims to provide students with suggestions on learning partners.

The next factor in the socio-psychological category is students' self-perception of being connected/separated. This refers to "recognition of membership in a community and the feelings of friendship, cohesion, and bonding that develop amongst learners as they enjoy one another and look forward to time spent together" (Rovai, 2002b, p.4). Lack of a sense of connectedness might lead to students' non-involvement in collaborative activities with other peers, which can result in feeling of isolation, motivation loss, low achievement, and even dropout (Rovai, 2002d). This factor, according to an OLC design framework by Brook and Oliver (2003), is also one important characteristic of students that has an impact on the supporting condition for formation of LCs.

One factor which appears to have a non-trivial impact on learners' communication and collaboration is preferred communication media. A key factor of a communication medium is social presence – "the degree to which a person is perceived as 'real' in mediated communication" (Richardson and Swan, 2003, p.70). Differences in several communication media might have influence on the nature of interactions; and learners tend to choose media in order to fit their communication purpose. In online learning contexts, students' preferred communication channels play a more important role in facilitating the formation and maintaining interactions and social presence (So and Brush, 2008).

The fourth factor of the socio-psychological group is demographics, which involves dimensions such as gender, age group, and cultural background. It is believed that these factors are likely to have an impact on community development (Brook and Oliver, 2003; Prinsen, Volman, and Terwel, 2007; Rovai and Baker, 2005). Reported attempts in literature to form student groups have also taken into account the demographic aspects (Holmberg, 2019; Ounnas, Davis, and Millard, 2009). This is because these aspects not only are associated with learners' need/purpose of communication but also have an impact on their preferences regarding peers whom they work with.

The next factor in the group of socio-psychological aspects is Willingness to Communicate (WTC). This is defined as the likelihood that an individual would choose to communicate when they are free to do so (McCroskey and Baer, 1985). Students with high WTC tend to be more likely to initiate, maintain and develop social relationships with other peers, while those with low level of WTC tend to be reluctant in communicating (Cho et al., 2007). In the context of attempts being made to encourage formation of OLCs, this characteristic of learners plays an inevitably critical role.

The last characteristic listed in Table 4.1 is personality. This factor is indeed one factor that poses critical influence on online knowledge sharing, discussion and collaborative activities amongst students (Chen and Caropreso, 2004; Matzler et al., 2008). A substantial amount of research in group formation has employed this characteristic to optimise team formation towards increased productivity, higher learning outcomes and improved students' satisfaction (Abnar, Orooji, and Taghiyareh, 2012; Graf and Bekele, 2006; Srba and Bielikova, 2015).

4.2.1.3 Students' Preferences for Learning Partners

Besides individual characteristics, students' preferences need to be taken into account in attempts to promote informal online learning communities. Previous work on formation of student groups shows that students' preferences are taken into account in the group formation process; yet only on projects or activities they would want to work in (Meyer, 2009; Spoelstra et al., 2013; Srba and Bielikova, 2015). This is sensible since students nowadays are encouraged to be transforming towards more self-directed and intrinsically motivated learners (Calhoun and Green, 2015; Goodyear and Retalis, 2010). They have been gaining skills to self-regulate their studies and they have their own requirements/preferences on choosing who to learn with. Therefore, in recommending compatible learning partners to students, it is reasonable for their preferences to play an important role.

In summary, from the literature review on CL, OLCs and GF, a collection consisting of 13 learners' characteristics was compiled. These characteristics were found to have influence on students' communication and collaboration with other peers and consequently on the formation and development of OLCs.

4.2.2 Suggested Data Sources

Initial investigation of data sources suggested three main sources including student information repository, learning management systems (LMS), and characteristic questionnaires. The first source keeps track of students' information regarding educational level, demographics and academic interests. LMSs provide tracking data of learners' learning activities in online environments that can provide information about students' academic interests and skills (for instance, based on their posts in discussion forums, grades, and material engagement related to different areas). Characteristic questionnaires which have been used widely in previous research can be employed to retrieve values of students' several characteristics such as motivation, self-efficacy, learning styles, WTC and personality. Others, including hobbies and preferred communication media, can be obtained directly through some self-reported form where students enter the values explicitly.

The identification of the characteristic set and suggested data sources contributed to the input component (Data Retrieval stage) of the LPRS model design (see Figure 4.3).

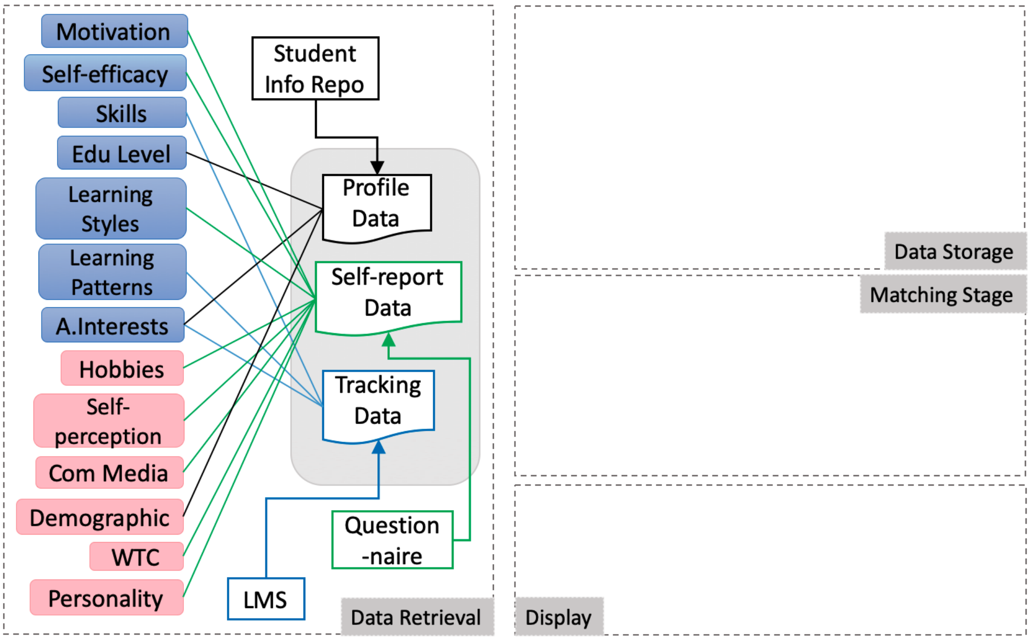


FIGURE 4.3: General components of LPRS model: data retrieval stage

The next section presents the process of confirming these factors through investigating students' attitudes towards learning communities and their perception of the importance of the compiled characteristics.

4.3 Investigation of Students' Perspectives

This section presents an investigation of students' views on learning communities and factors influencing the formation and maintenance of an effective LC. The first four subsections 4.3.1 to 4.3.4 discuss objectives of the investigation, participants, data collection instruments, and procedure applied. The process of analysing the survey and interview data is presented in subsection 4.3.5, followed by the findings regarding factors important to an effective OLC and valued characteristics from students' perspectives in subsection 4.3.6. Moreover, students' feedback on the proposed LPRS is summarised in subsection 4.3.7; and influences of this investigation on the LPRS design are highlighted in subsection 4.3.8.

4.3.1 Purpose of the Investigation

Interaction amongst learners is a primary determinant of the creation and development of an LC; and how students perceive LCs and experience the interactions is conducive to their participation and engagement in collective learning activities with others. Therefore, an investigation was conducted to identify learners' perception of LCs, the current context of LCs, and which characteristics students value in learning partners which according to them, would facilitate the formation and improvement of a healthy LC. Moreover, the inquiry also aims at addressing the first sub-question of this research project, which is **"What characteristics do students consider important when choosing learning partners?"**.

A list of learners' perceived significant factors is expected to emerge and be affirmed from analysis of collected data, which formed the fundamental criteria used for the design of the proposed learning partner matching system in this project. In addition, this investigation could help provide insights into what is considered as fundamental for the creation and maintenance of an LC from learners' perspectives, difficulties that they have encountered when learning with peers, and their expectations of an effective LC.

This inquiry is conducted using a qualitative approach from a constructivist perspective, that is "understanding the complex world of lived experience from the point of view of those who live it" (Schwandt, 1994, p.221). Online survey and semi-structured interviews are employed on undergraduate students to obtain insight into their perception of the investigated matter.

4.3.2 Participants

The inquiry aimed at obtaining a better understanding of students' perception of LCs, their needs and expectations for an effective LC, and what they value in learning peers. Convenience sampling was employed to recruit students as participants for the investigation. Undergraduate students who were studying at the Faculty of Information Technology at Monash University were selected to be participants for the inquiry since working in teams to solve complex problems is a common requirement for those who study IT-related degrees. Moreover, the investigation targeted at those who were in second year because they were likely to have some experience on group work and LCs in general.

Four units[2] in the faculty with a large number of students enrolled were chosen for an online survey invitation to be sent out in order to maximise the response rate. The four units were IT Professional Practice, Systems Development, IT Project Management, and Industry Experience Studio Project which were taught in semester one in the year 2017. The online survey was available to be taken for one month. Moreover, students who took the online survey were invited to a follow-up interview. Detail of the online survey and the interview is presented in the following subsection.

[2] Note that a unit, at Australian universities, is "a subject that runs for one semester. Units are the building blocks of a course. Most undergraduate courses are made up of eight units per year" (Monash University, 2017).

4.3.3 Data Collection Instruments

The instruments of this round of data collection included an online survey and semi-structured interviews.

4.3.3.1 Online Survey

With the aim of exploring students' perspectives on current LC context, perceived benefits which could be obtained through participation in an LC, obstacles of LC participation and characteristics that students look for in learning partners, an online survey was designed consisting of three main sections as follows.

The first section attempts to investigate students' experiences on three forms of LCs. The three forms are task-based, practice-based and knowledge-based as discussed in the work of Riel and Polin (2004) (see also subsection 2.3.4). Aspects examined for each LC form consist of (1) factual details such as communication channels used and meeting frequency; (2) subjective assessments including perceived influence of activities on one's learning experience, comfort level amongst LC members, one's perceived influence of self on the LC and one's overall satisfaction level with one's participation in the LC.

The second section explores persistence of LCs, students' perceived benefits through their participations in an LC and obstacles when it comes to working with others. Persistence of LCs, in the survey, refers to students' preferences for working with either the same set of peers or different partners. As for perceived benefits and obstacles of LC participation, several advantages of LCs and common reasons for non-involvement retrieved from literature were available for participants to choose, alongside an "other" option where respondents can provide their own answers.

The third section aims to determine the collection of factors which students find important in learning partners when they work in a group. Since learning is viewed as a social process and an LC covers both social and academic aspects of learners, several features are categorised into two areas – social and academic. Respondents are asked about their preferences on learning partners' characteristics and the perceived significance level of those characteristics in the form of five-point Likert scale. For each item, respondents specify how important the corresponding factor is to them where one denotes "Not at all important" and five means "Very important". For example, questions about learning partners' personality consists of a pair – (1) "Do you think your partner's personality is important?" where students can rate on the scale from 1 to 5 as mentioned; and (2) "Do you prefer your partner to have similar/different personality?" with options being "Similar", "Different", and "Does not matter".

The three forms of LCs are retrieved from Riel and Polin (2004) which include (1) Task-based, (2) Practice-based and (3) Knowledge-based LCs. These three forms have been discussed in Chapter 2. Survey questions regarding students' self-reflection about of their participation in those communities are based on Sense of Community theory of McMillan and Chavis (1986).

A pilot test was conducted on four students to refine survey questions, eliminate ambiguity and improve understandability. Based on testers' comments, modifications were made in order for the questions to be more concise and comprehensible. The changes included the order of some questions about partners' characteristics, the way questions were being asked, more options in questions for respondents to choose, and use of intuitive graphics for better description of some concepts (such as forms of LCs and learning styles). The full version of the online questionnaire is provided in Appendix A.1.

4.3.3.2 Interview

Respondents of the online survey could optionally provide their contact information (email) if they were willing to participate in a follow-up interview session. The goal of the interview was to obtain deeper insight into (1) students' attitudes towards learning communities in which they were joining or had joined, (2) a collection of important characteristics that students look for/value in learning partners, and (3) the need for a learning partner recommender system.

A semi-structured interview approach was employed with main topics being covered and probing questions utilised as the interview progressed to enquire about more specific and in-depth information from interviewees. Questions about students' perception of LCs were designed based on Sense of Community components presented in McMillan and Chavis (1986) which consist of membership, fulfilment of needs, influence and personal connections with other members in the LC. For instance, questions under the "Fulfilment of Need" section seek to explore the purpose of LC participation and benefits obtained, with a probing question asking about disadvantages they think they have had.

Past experience on working with other peers was also discussed to explore difficulties in forming and maintaining a learning group. Questions which aimed to invite students to openly talk about their stories were utilised, such as "Tell me about the most memorable experience you had when you were learning with other students in the learning community", and "When working with other peers, tell me about the time when it went well and when it did not go well". More importantly, most valued social and academic characteristics in peers from students' perspectives were investigated with questions such as "According to you, what are the most important characteristics that you look for in a learning partner? Can you list and rank them in order?"

In terms of the proposed learning partner recommender system, a visualisation of a basic model was presented in order for interview participants to have a clear understanding of the system – its goal, processes and expected deliverables. Questions asking for their comments on, expectations of, and suggestions for the systems were posed afterwards.

Questions included in the interview were revised before the interviews by an independent PhD candidate who was doing educational research. A number of suggestions were provided regarding question rephrasing and word changes so that there are no leading or misleading questions present and bias is guaranteed to be eliminated. The full version of the interview questions is provided in Appendix A.2.

4.3.4 Procedure

Since this data collection was conducted involving human data (students as respondents; and data enquired being their opinions, ideas and perspectives on the investigated matter), ethics aspects such as integrity, respect for participants, participant consent, research merit and safety were taken into account. Ethics application for conducting this inquiry was submitted and approved by The Monash University Human Research Ethics Committee (MUHREC) before the data collection started. Approval certificate of Ethics application is attached in Appendix A.3.

The survey announcement was posted on the Moodle[3] site for each selected unit with the academics' support and assistance. The explanation of objectives of the project as well as a survey link were provided so that students could choose to do the survey voluntarily.

[3]Moodle is the LMS used at Monash University.

Participants of the interview were recruited from those who had completed the survey and voluntarily provided contact details and indicated that they wished to participate in an interview session. All interview participants signed a consent form. The interviews were audio recorded with the participants' consent and transcribed non-verbatim with fundamental content being conserved. Grammatical errors were corrected, spoken fillers and repetitions were removed so that the statements were presented in a succinct manner. The interview transcripts were then sent to the interviewees in order for them to review, amend and expand as they wished so that they felt satisfied with their ideas and opinions being expressed the way they had meant.

4.3.5 Data Analysis

For a one-month duration when the online survey was available, 35 students took the questionnaire (25 males; 10 females); however, only 33 completed all parts of the survey. Over 50% of the survey respondents are between 20 and 25 years of age, followed by those under 20 who account for around 30% of the participants; the rest are 26 years old and above. Of the 35 survey respondents, 8 students accepted the interview invitation and agreed to participate in the interview session. The interview participants (6 males; 2 females) were undertaking a Bachelor of Computer Science, Bachelor of Information Technology or Master of Business Information Systems.

4.3.5.1 Survey Data

In investigating what factors were considered by students as important when they choose/work with learning peers, 14 pairs of questions asking about several factors were given. For example, two questions regarding personality factor included a 5-point Likert scale item asking "Do you think your partner's personality is important?" and a multiple choice question "Do you prefer your partner to have similar/different personality?" with three options "similar", "different", and "does not matter". Figure 4.4 demonstrates the significance of different factors reported by survey respondents according to the Likert scale data.

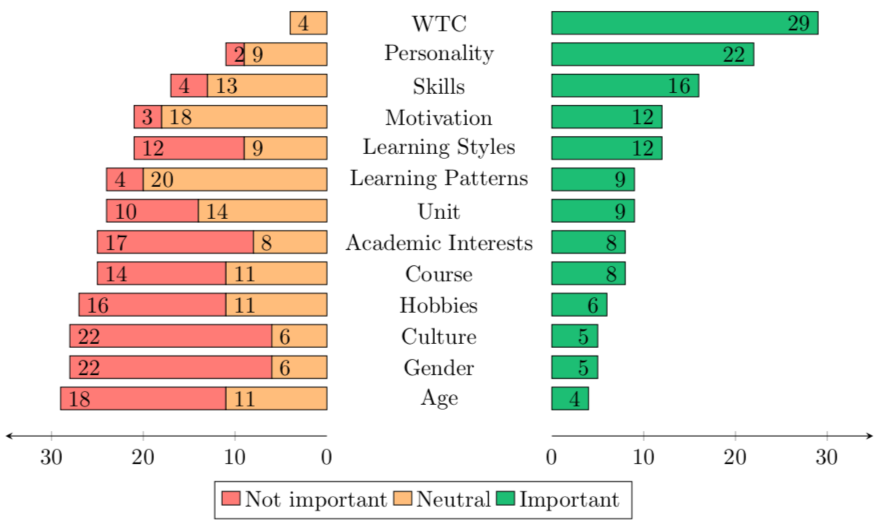


FIGURE 4.4: Perceived significance of several characteristics in learning partners

As can be seen in Figure 4.4, learning partners' characteristics which were considered valuable according to students include willingness to communicate (WTC), personality and academic experience/skills. Social characteristics including age, gender, culture, and hobbies appeared to be remarked as trivial by students. Two other factors belong to academic aspects, namely motivation and learning styles, were perceived as moderately significant by most respondents. The other factors received varied ratings from students, including learning patterns, common courses or units, and academic interests.

Qualitative data was also collected via an optional question asking students to rank one or more of the characteristics based on their perceived importance. Twenty-five students answered this question. Figure 4.5 illustrates the ranked factors based on the frequencies of the factors in participants' responses.

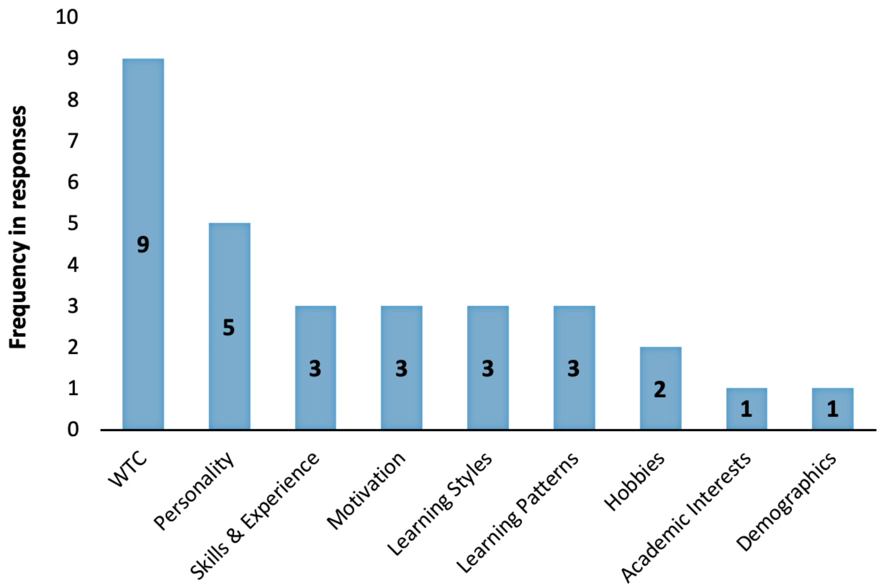


Figure 4.5: Ranked factors according to respondents' perception

In the same vein with results obtained from 14 pairs of questions, WTC was ranked the highest amongst all (by 9 responses), followed by personality (by 5 responses). Other factors including skills, motivation, learning styles, and learning patterns appeared to be less important to students in comparison with the first two mentioned factors. Other factors which were mentioned as significant by fewer students (1 or 2 responses) included academic interests, hobbies and demographics. According to survey respondents, communication between partners was the most fundamental factor conducive to group success – collective work was unlikely to happen if members were not communicating. The reason given for the importance of the personality factor was that it greatly facilitated discussion, engagement and communication amongst all participants.

From the above, two factors were consistently stated as important by participating students when working with other peers: WTC and personality. Other factors including skills, motivation, learning styles, learning pattern, and hobbies received varying degrees of significance as rated by the participants; while demographics and academic interests did not appear to be as important as the aforementioned characteristics. This feedback from students could inform the decision of which factors would need to be integrated in the to-be-developed recommender system.

4.3.5.2 Interview Data

The method used for data analysis of interview transcripts was thematic analysis (open coding and theme identification). The analysis process began with the collection of data in the set of transcripts based on the interview protocol. The initial themes according to the interview questions included: students' perception of LCs, difficulties in creating and maintaining learning groups, valued characteristics in learning partners as well as potential, expectations and challenges of the proposed learner matching system.

The transcripts were read. Keywords were highlighted. Comments and notes were created to record key ideas and interesting information which were relevant to the initial themes. Repeated concepts mentioned by the participants were grouped into a more comprehensive theme. Two main themes emerging from data collected through both the survey and interviews are presented in the following section (subsection 4.3.6). The themes include factors conducive to LC formation and maintenance from the learners' perspective, and valued characteristics in learning partners. Interviewees' quotations were utilised in the report in order for their opinions to be presented in a preservable manner. Deidentified information about interviewees is used to maintain their anonymity. The students who participated in the interview sessions are referred to as S-1, S-2 and so on.

4.3.6 Key Findings

This section presents two main findings from the investigation of students' perspectives. The first finding is about factors that are perceived by students as significant to the creation and maintenance of an effective LC. The second finding is about characteristics which students value in their learning partners.

4.3.6.1 Factors Conducive to Creating and Maintaining an LC from Learners' Perspective

From data obtained from the interviews, combined with results retrieved from the survey, factors which are perceived as conducive to the formation and maintenance of healthy LCs emerged. In the current work, a characteristic of an LC called "healthy" is emphasised, referring to (1) its positive influence on learners' learning experience, and (2) a supporting environment where learners are comfortable to learn, contribute and express themselves without fear of being judged. In terms of LC formation, interviewees either explicitly stated the most critical (also most difficult) aspects in the creation of a group (S-1, S-2, S-5) or explained the reason why they did not take part in some communities (S-1, S-4). Factors which facilitate the creation of LCs emphasise generation of stimuli for learners' needs and the wish to take part in collective activities. Moreover, a sense of knowing (or an awareness of) that they are welcomed into the group is one critical factor for learners' willingness to participate.

Regarding maintenance of an LC, elements which are fundamental to nurturing the community once it has been formed emerged from students' answers to questions asking about their experiences when actually working with other peers in a group (Section II, Appendix A.2). Eight participants described when collaboration amongst learners functioned well, as well as when collective learning was perceived as an unpleasant experience. Figure 4.6 illustrates a set of factors perceived as conducive to LC creation and development, which emerged from interviews with students. The inner ellipse contains aspects contributing to LCs formation, and the outer ellipse includes factors considered as important by students for the effective maintenance of an LC.

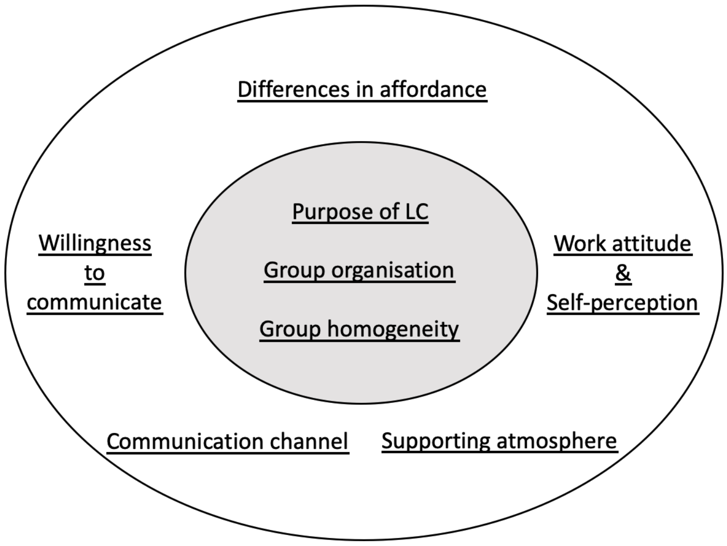


FIGURE 4.6: Factors conducive to LC creation and maintenance from learners' perspective

Creation of LCs

The inner darker ellipse of Figure 4.6 demonstrates what learners perceive as fundamental factors which contribute to the creation of an LC – purpose of the LC, group organisation (especially for a task-based LC), and homogeneity within the LC.

Purpose of LC: Students are likely to be willing to join in a collective activity if they can see benefits they can obtain through their active participation. Consequently, while their expectation is to learn something new, if the purpose of an LC aligns with their needs, there is a high chance that the LC can draw learners' attention and interest. S-4 stated that communities of students are encouraged in the university; however, they do not fit this interviewee's needs. S-4 shared that *"I have signed up for some [groups] but I don't really attend their meetings because it is just actually just coffee and I do not really go for that"*. On the contrary, when benefits are recognised, students would eagerly engage in these activities. S-1, a second year IT student, participated in PASS (peer assisted study session) sessions in the first year, admitting that study techniques and better understandings of several concepts being taught in some units were some of the expectations when joining. S-4 attended a boot camp outside of university since the program promised skills and learning outcomes that are of S-4 interests. S-5 participated in open source platforms where source code of various programs and systems are available for open collaboration. As S-5 indicated *"you can contribute to [those open source platforms], you can learn from their coding styles, depending on your interest"*. Thus, in order to engender the need for participating in an informal LC, the purpose of the LC should be made clear and suitable for learners' needs.

Group organisation: Since LCs in formal educational settings are mainly task-based where students are required to carry out group assignments as a part of the course, group organisation regarding group structure and members' roles are necessary for the group to be established. S-2 asserted that *"I think the hardest part of any group work is establishing organisation and making sure that people know what they have to* *do and by when"*. S-5, amongst the three types of LC, also favoured the project-based form since as S-5 explained *"I prefer the project-based because each group member would have a proper role, they know what they are going to do"*. In a similar vein, S-7 asserted that a group would function well when all members fitted into the role that they had been given. Role assignment provides LC participants with an expectation of what they would obtain through participation and a sense of contribution to the community.

Group homogeneity: Homogeneity within a group facilitates group interactions. When learners recognise peers with similar characteristics such as interests or learning goals and purpose, it is more likely that they want to communicate and get connected with these peers. As S-1 remarked on the potential of people with compatible characteristics, *"they are more willing to work with each other"*, and the significance of similar thoughts and views to be met, *"I think the most difficult thing about forming learning communities is finding like-minded individuals"*. Similarities act as a bonding force which can help create a social setting where participants find others with shared traits, which stimulates interactions amongst them. S-5 commented on common academic interests as well as hobbies: *"I think firstly people start with hobbies within the field; and then they will communicate. If they're not interested, then they won't communicate"*. Learners who want the same thing and have similar learning and achievement goals are usually willing to come and work towards the same target. S-6 explained,

> *"I think we should want the same thing. In a project, if one person just wants to pass the unit and another one just wants to get HD or something, it will be difficult to collaborate."*

Therefore, similarities shared amongst LC members are crucial. They act as the starting point where students find common traits in others, which helps put their mind at ease in order to take the first step in expressing themselves and communicating with others. As McMillan (1996) suggested, a place for people to be themselves is assumed to be created once they have found others who share a similar way of thinking, viewing, feeling and being.

There are some implications for the current work from the discussion above. Firstly, it is important that students are made aware of benefits they might receive when joining in a learning community. Only when there are benefits perceived by students, would they be willing to take part in a non-mandatory activity. Secondly, it is required that there exists a certain degree of homogeneity regarding the motivation level and academic interests amongst participants of a community in order to stimulate initial communications. Thirdly, students' expectations for the group organisation suggests that it is likely that attracting students to participate in an informal LC outside of a classroom might be challenging because they need to be completely in charge of what role to take in that community.

Maintenance of LCs

The light grey outer ellipse in Figure 4.6 shows factors which are perceived by students as crucial for the maintenance of a learning group. Those factors include willingness to communicate, communication channels, differences in affordance, work attitudes and self-perception, as well as shame-free atmosphere.

Willingness to communicate: Communication plays a vital role in learners' information sharing, meaning making and intellectual development process. In order for communication amongst LC participants to take place effectively, it takes both learners and tools into account. All students who took the interview session believed that willingness to communicate is one of the most essential characteristics that they value in co-learners. As S-2 explained what is expected from other peers: *"if someone is not doing something well, they will ask for help or they can ask to do something else if they cannot do it"*.

The degree to which one is willing to initiate a conversation and communicate with others is critically affected by their personality (McCroskey and Baer, 1985). However, several situational factors also have a great impact on learners' inclination to perform communication. Those situational factors can include the degree of familiarity between members, the formality level of the situation and/or the topics of interest (MacIntyre et al., 1998). The notion of effective communication amongst LC members is therefore tightly connected with the supporting atmosphere which is discussed below.

Communication channels: Communication channels employed are also perceived as vital for the maintenance of a successful learning group. Face-to-face meetings are still perceived as the best way of interaction and discussion. One thing to note was that interviewees often linked back to their experiences on working with peers for group assignments which are a mandatory requirement of the units. Moreover, the context of this inquiry is a blended learning environment which involves both face-to-face learning activities (lectures and tutorial sessions occurring in classrooms) and online components (such as learning materials posted on Moodle sites of the units, discussion forums, and reflective blogs). In this setting where group work affects learners' learning outcomes (grades), physical meetings are expected.

Although in-person meetings are viewed to be the most effective means of communication, internet-based communication tools are greatly utilised for an efficient way of interaction amongst LC members. Tools used should facilitate timely response and interactive spontaneity. S-1 recognised that

> *"...I think if there is a dedicated instant messaging group, it is a lot easier to contact group members. Since I find in the past if the group had a Facebook chat, it's easier. But sometimes it's all done by email and it is hard to get back."*

S-4 also considered group chat as a useful channel of communication, but for a group with small number of participants. S-2 also suggested: *"...discussion forums or groups where you have past conversations, look at what people suggested... It should be more permanent than just a messaging system"*. S-2 also appreciated the availability and archival repository feature of online communication tools and groups. Thus, online channels, in order to enable effective communication amongst learners, should facilitate constant availability, timely responses, and ability to retrieve past conversations.

Supporting environment: An environment where members feel safe to freely communicate their ideas and opinions without the fear of humiliation is perceived as vital for a healthy LC to be developed. Survey respondents who claimed that they have not joined in any learning communities asserted that the major reason for not participating was a lack of a shame-free environment where they can express themselves without being judged. S-3 explained this with an example that if there were some friends in a group or a comfortable environment was available, learners would feel welcomed in a group and be willing to be themselves and contribute to the group activities. As S-7 stated, *"...you feel more comfortable talking to someone you know and asking questions since you know they're not going to judge you"*. The idea of shame-free climate points back to the notion of homogeneity within group which has been discussed above. As McMillan (1996, p.321) discussed: "shame drives people to search for similarities".

Differences in affordance: As an LC develops, differences in affordance amongst members become of greater significance. Affordance here denotes one's skills, experiences, ideas and/or opinions which one is willing to share with others and contribute to the collective learning. S-6 shared a past experience on a group project: *"For our project, we needed to do programming. But I'm not studying programming, so the others had to do that part"*. One's own knowledge which can benefit the group as a whole is greatly appreciated by others, which engenders satisfaction in their learning process. S-4 elaborated by giving previous work as an example:

> *"One of the key team members, he's a web developer, so he made the website and it is a really good thing because it is a good way of presenting the assignment, so his knowledge and experience came handy."*

Learners come together with the expectation of obtaining understandings from different perspectives, of learning from others' experience and knowledge, of sharing their own ideas and contributing to the development of others. Consequently, diversity in disciplinary experience and knowledge is desired for a fair "trading" to occur amongst learners.

Work attitudes & self-perception: Other major matters retrieved from the interviews with students was about attitudes and self-perception. There is a whole collection of desired characteristics which learners expect their group peers to possess so that the collective work can be conducted effectively. The most desired features include motivation, self-efficacy, and open-mindedness. S-2 and S-5 shared the same view on the significance of being motivated by achievement goals. According to S-2, *"generally characteristics like wanting to do well – that's really the main thing... Even if they're not the best at what they do"*. Similarly, all other interviewees contended that motivation or achievement goal is the most important feature that they value when working with other peers.

Moreover, when it comes to a group of learners, different opinions and thoughts are involved, so being open to discussions, negotiation and understanding of views from diverse perspectives is required, as S-3 expressed: *"The first and foremost that is really important I think is to understand each other and to be able to listen to the others and understand their opinion"*. Willingness to listen to different opinions, to take ideas from others, to discuss and negotiate is not only advantageous to learners' social skill development but also beneficial to their enrichment of knowledge.

There are some suggestions that emerged from the discussion on factors influencing the maintenance of LCs. Firstly, effective communications amongst members is of great importance in maintaining a healthy community. The effective communications require both the participants' willingness to communicate and media to facilitate their communication. Secondly, an atmosphere where learners can feel safe, valued, and supported is desirable in order for them to continue the participation and contribution. These aspects need to be taken into account in an attempt to promote LCs, and in the development of the LPRS in the context of this project.

4.3.6.2 Valued Characteristics in Learning Partners

Learning, especially collaborative learning in a community of learners, involves both social-psychological and academic aspects. This theme of findings from the data collection and analysis process presents various characteristics in learning partners which are appreciated from the students' views.

Learning and working with other peers in a group involves factors regarding both academic and social aspects; and this was reflected in the data obtained from both the survey and interviews conducted. According to survey results, it appears that academic factors received lower perceived significance from the learners' view. However, students who participated in the interview sessions asserted that peers' academic characteristics also play a critical part in making ideal learning partners, which consequently facilitate the creation and maintenance of a healthy learning community.

Academic aspects

The characteristic that was highly appreciated by students participating in the interviews is ***Motivation***. Motivation here refers to achievement goals and learning goals. Although this factor was perceived in a diverse range of significance by survey respondents, analysis of interview data demonstrates that a learning partner with high motivation tends to be greatly desirable. As S-5 explained, in the group work context where the group was supposed to last for a long time period, motivation residing in members was more crucial than skills possessed, since motivated learners would strive to find a solution to issues encountered and keep on equipping themselves with skills need to accomplish their work. Motivation in an academic context can be divided into intrinsic and extrinsic motivation with varying level (high – low) and orientation of motivation (intrinsic – extrinsic) (Ryan and Deci, 2000). However, in this research, motivation is viewed in a general sense, which is "to be moved to do something" (Ryan and Deci, 2000, p.54).

The second most mentioned characteristic in a co-learner from the students' perspectives is ***Self-efficacy***. This feature refers to a feeling of self-confidence that one has the ability to overcome difficulties and/or accomplish a task. As S-6 recognised, it is difficult to assign tasks to group members when each individual lacks self-efficacy and hesitates to take charge of the assigned work. S-4 gave a reason for ranking self-efficacy as the most important characteristic in a partner:

> *"You need to be confident that you can do the task. If you're not, then you put down the other team members. Even if you don't think you can, you need to build your skills along the way and try your best instead of keeping feeling that you wouldn't get the task done. You need to be positive and you need to think 'I can do it'."*

Another feature in learning partners which is considered valuable is ***Skills*** (or Experiences) to contribute to collective work and group learning. This factor was previously discussed in "Differences in Affordance" of Theme 1 in subsection 4.3.6.1. As can be seen in Figure 4.4, experiences and skills of a co-learner, especially when those experiences are in different areas of knowledge, are highly ranked by the majority of students who participated in the survey, as well as interviews. Although S-4 – when being asked to rank the list of factors based on perceived significance, weighed experiences/skills as the least important amongst the seven academic factors, the interviewee did demonstrate high appreciation of peers' experiences which greatly contributed to the work of the whole group. S-2 ranked experiences and skills as four out of seven, presumably due to the respondent's preferred learning approach, as explained: *"I prefer to gaining an understanding of what I'm doing before I engage in a group scenario just because I like to know what I'm doing really"*. Having a different view on this characteristic, S-8 emphasised the potential for obtaining knowledge from others thanks to the diversity of experiences brought by LC members, *"who have different areas of knowledge and they can help grow other areas of knowledge in other students"*. In general, this feature in learning partners enjoyed great merit perceived by students.

Socio-psychological aspects

The characteristic in learning partners which received a consistent consensus about its utmost significance from both the survey respondents and interview participants was ***Willingness to Communicate (WTC)*** (see Figure 4.4 and Figure 4.5). WTC refers to the degree in which one is inclined to initiate and/or continue with a conversation with different categories of people in various settings (McCroskey and McCroskey, 1988). In the context of an LC, this attribute has been proved to play an important role in learners' tendency to explore new network connections, which is likely to result in effective collaborative learning (Cho et al., 2007). According to the participating students, a learning partner with high WTC is expected to be able to talk about both group and individual issues (related to collective learning), to be open to asking for help and support when needed. Expressing the recognised virtue of peers' willingness to communicate outweighing other features, S-2 believed that *"... if they've got good communication skills or they learn to communicate, so it doesn't really matter so much like where they come from or whatever"*. Moreover, low WTC is remarked as a critical obstacle to productive collective learning. As S-8 shared about an experience where group members did not communicate their problematic matters, which led to failure in the group work. S-2 held a similar view, *"I think the biggest obstacle is if someone's not trying to solve the things they should and try to talk to them about doing a better job"*.

The second most important feature of a partner recognised by students was ***Personality***, in which greatly appreciated characteristics include (1) open-mindedness and (2) responsibility. Firstly, an LC ideally is formed by individuals with diverse knowledge areas, experiences as well as opinions. Consequently, differences in thoughts and views are expected. In the worst-case scenario, where members lack open-mindedness and resist taking ideas from various perspectives, conflicts are likely to occur and are hardly resolvable. S-3 asserted that being open to new ideas is one of the fundamental attributes of a most wanted partner:

> *"The first and foremost that is really important I think is to understand each other and to be able to listen to the others and understand their opinion and then work together towards what the purpose of the community is."*

Secondly, a state of being responsible for individual work as well as for the group as a whole is highly acknowledged amongst learners. S-1, S-6, and S-7 shared some of their experience on encountering partners with a lack of responsibility, which caused delay or unwanted hardship for the collective work. As S-7 demonstrated,

> *"He thought this assignment was due a week before it was, he was like 'ok guys, I've done my part. The rest is up to you. Good luck. I'm going out for tonight. See you later' ... he'd done barely anything compared to what we were doing, and it was really frustrating."*

The issue concerning a paucity of responsibility is related to "social dilemma" situations, which have been studied by psychologists, economists and sociologists. These situations refer to circumstances in which collective failure may be caused by individual pursuit of self-interest, which result in phenomena such as free-rider, social loafing and sucker (Kerr, 1983). Lack of responsibility issue in collective learning is tightly connected with learners' academic motivation (or achievement goal). More information about the "social dilemma" topic can be found in the work of (Kerr, 1983; Stroebe and Frey, 1982).

4.3.7 Students' Views on the Proposed LPRS

With an aim of exploring the prospects of the proposed learning partner matching system in terms of target users' willingness to use it, some questions were asked to enquire students' opinions. From the analysis of data retrieved from the survey and interviews, three main aspects regarding the proposed matching system according to participative students are presented including potentials, user expectations, challenges and suggestions. Appendix A.4 provides the quotes from the students participating in the interviews regarding the three aspects.

4.3.7.1 Potential Benefits of LPRS

Survey data
Three questions were asked at the end of the online survey, one of which was concerned with learners' view on whether matching students with compatible characteristics and preferences could facilitate effective collective learning. The other two questions directly focused on the degree to which students are willing to try out a system which provides them with recommendations on peers who are likely to work/learn well with them. 33 students responded to question one; and 29 responses were made to question two and three. The three questions and corresponding responses are presented as in Figure 4.7

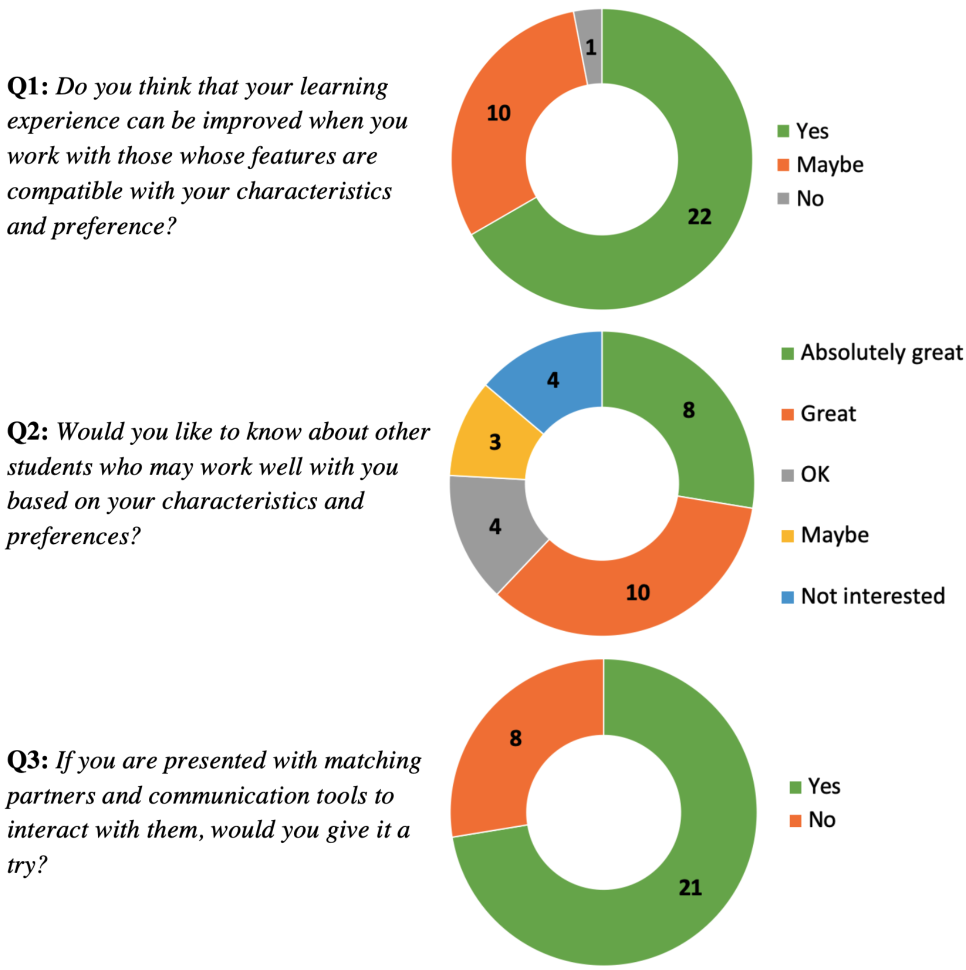


FIGURE 4.7: Questions and responses regarding the proposed LPRS

Thus, the majority of investigated students (32 out of 33 responses) contended that compatible characteristics amongst learners could help improve (or had possibilities in improving) their learning experience. Besides that, results of the two last questions demonstrated that there existed a need amongst learners for finding about peers who possess favourable features and make connection with those peers.

Interview data

Interview participants also provided their positive comments on the potential of the proposed partner matching system. The main opinion on the proposed recommender system demonstrated that students believed such a system could facilitate matching learners with compatible characteristics (such as similar interests, complementary experience and favourable personalities) and fitted individual preferences; and from that, they could get connected with ones who they can learn/work with in a comfortable setting. Appendix A.4 presents details of responses given by the interviewees.

4.3.7.2 Primary User Needs

With regards to target users' expectations for the proposed system, all eight students contended that the user interface (i.e., visualisation of recommended learning partners) should be simple, *"easy to see the results"* (S-1) and easy to understand.

Communication tools expected to be integrated into the system should, from students' perspectives, provide timely responses for them to be able to quickly contact the recommended peers. S-7 was aware that there was a messaging feature provided by the existing Learning Management System (LMS) employed within the university (i.e., Moodle); however, the feature was "barely used" by students. Also, S-2 expressed the need for features which support forming a group messaging system and making past conversation available to users.

In terms of information about suggested co-learners, opinions vary amongst interviewees. Most of the interview respondents agreed that only basic information about recommended study partners would be sufficient. As S-2 explained

> *"because people know who they are, so you don't really need like... this person prefers this type of people... I don't think you would need a whole lot of data because once you put people in a group, they'll figure it out pretty quickly for themselves."*

Only S-3 asserted that it would be useful if as much detailed information as possible was provided.

4.3.7.3 Challenges & Suggestions

From students' perspectives, challenges for the proposed LPRS as well as suggestions for a more effective and satisfactory system were explored. In terms of challenges raised by interviewees, the main concerns included (1) negative effects of members with similar hobbies (S-2), (2) implication of impractical practice in working with others (S-4), and (3) difficulties in collecting objective evidence of learners' individual characteristics (S-6).

In respect of suggestions on improving the proposed matching system, several ideas were given during the interview sessions. Regarding better outcomes of learners being matched together, S-1 put forward that contrasting personalities in a group could help enhancing learning experience amongst learners. Another idea demonstrated by S-7 was about allowing users of the system to find compatible learning partners based on either similar or complementary traits. As for setting up students' profile data, S-5 asserted that data retrieval of learners' individual characteristics and preferences should be conducted effectively and efficiently at the beginning of Data Retrieval stage.

4.3.8 Influences of the First Data Collection on Data Retrieval Component of LPRS Conceptual Model

Results from the first data collection and analysis prompted modifications to the design of LPRS model. There were two main implications emerging regarding valued characteristics in learning partners, according to the results from the data collection. Firstly, some characteristics were perceived as more fundamental than others by students when choosing learning partners to collaborate. Secondly, several characteristics of partners received varied ratings of significance level. This second implication engendered a demand for personalisation where individual preferences can be met.

The aforementioned implications emerging from the data collection suggested an idea for assigning weights to characteristics in determining the compatibility level of two arbitrary learners. A result of how much a student is matched with different peers would be presented to users in some form of compatibility scores. Different significance levels of the characteristics implied that more substantial factors should carry greater weight than the others when generating the matching scores.

Figure 4.8 shows the refined design of the Data Retrieval stage of LPRS conceptual model. The highlighted part in the yellow box demonstrates the change made to the model design influenced by the investigation of students' perspectives.

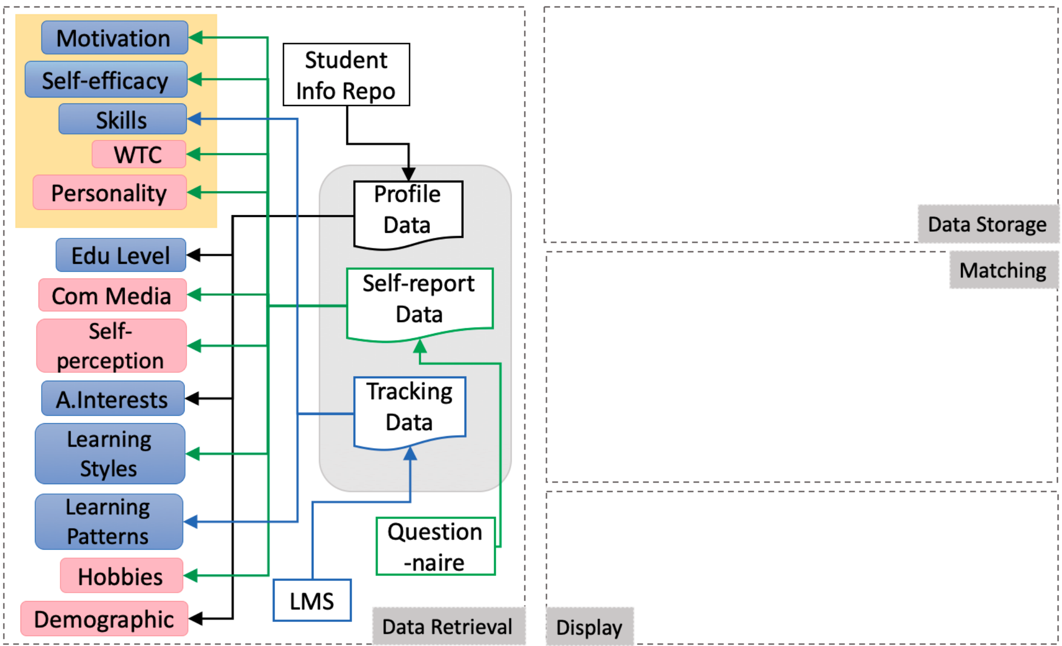


FIGURE 4.8: Change made to the LPRS conceptual model: data retrieval stage

Results from the investigation of the students' perspectives suggested different characteristics were perceived with varying level of significance by students. This resulted in changes to the system design. On the left of the model in Figure 4.8, a collection of learners' characteristics is presented. Boxes in pink shade denote social-psychological factors; and those in blue shade represent factors relating to the learning domain. There are 13 factors in total, with the five listed on the top are the ones that received the greatest perceived significance according to the data collection results. The other eight factors are those with varying importance level perceived by students. Without students explicitly assigning significance levels to characteristics, the five top factors would have greater influence on the matching score, followed by the other eight factors.

There were studies conducted to automatically identify students' characteristics such as personality traits (Amichai-Hamburger and Vinitzky, 2010; Ghorbani and Montazer, 2015b), or learning styles (Bernard et al., 2017; Chang et al., 2009; Özpolat and Akar, 2009) based on students' interactions in LMSs. However, those studies had to resort to corresponding questionnaires to evaluate the performance and accuracy of the automatic approaches. Furthermore, data regarding the top five factors were expected to be collected with a degree of precision as close as possible to students' true characteristics; therefore, these factors are planned to be retrieved directly from students via questionnaires (WTC, personality, academic motivation, self-efficacy). The questionnaires chosen would be those which were validated instruments in the literature. Although there was an awareness that users would have to be involved more in the data retrieval phase of the system, for the purpose of quality data, self-report questionnaires are planned to be employed.

4.4 Storage, Process and Output Components of LPRS Model

Process involves both (1) transformation of users' inputted data which encompasses (a) evaluating questionnaire responses in order to determine characteristic values of the students, and (b) converting raw data from input forms into cleaned, validated and ready-to-use format; and (2) performing matching algorithm to generate matching scores between any two students and create a ranking list of compatible peers. Task (1) is about taking input data from users to store in the storage; while task (2) concerns retrieving data from the storage, applying a selective matching algorithm from literature to produce system outputs.

Storage takes care of storing, structuring and managing data about students' characteristics, preferences and the weights of these factors. It also facilitates easy data retrieval for the matching process. Note that the weights of the factors being stored and managed was influenced by results from the first data collection. The weights are referred to as factor significance level (FSL) (see Figure 4.9 with highlight in Data Storage stage of LPRS model)

Matching stage of the model (task 2 of the Process component of the model, discussed above) generates inputs for the Output component, referred to as *Display* stage in LPRS model. *Display* focuses on approaches to present recommendation results to students. At this stage, visualisation has good potential for presenting the results in a way so that students can easily understand the reason for the generated recommendations.

4.5 LPRS Conceptual Model

The process of designing the conceptual model of LPRS was performed through different steps. The first stage (input or data retrieval) of the proposed model was specified through literature review and the first data collection to explore students' perspectives on learning communities and important characteristics which can be

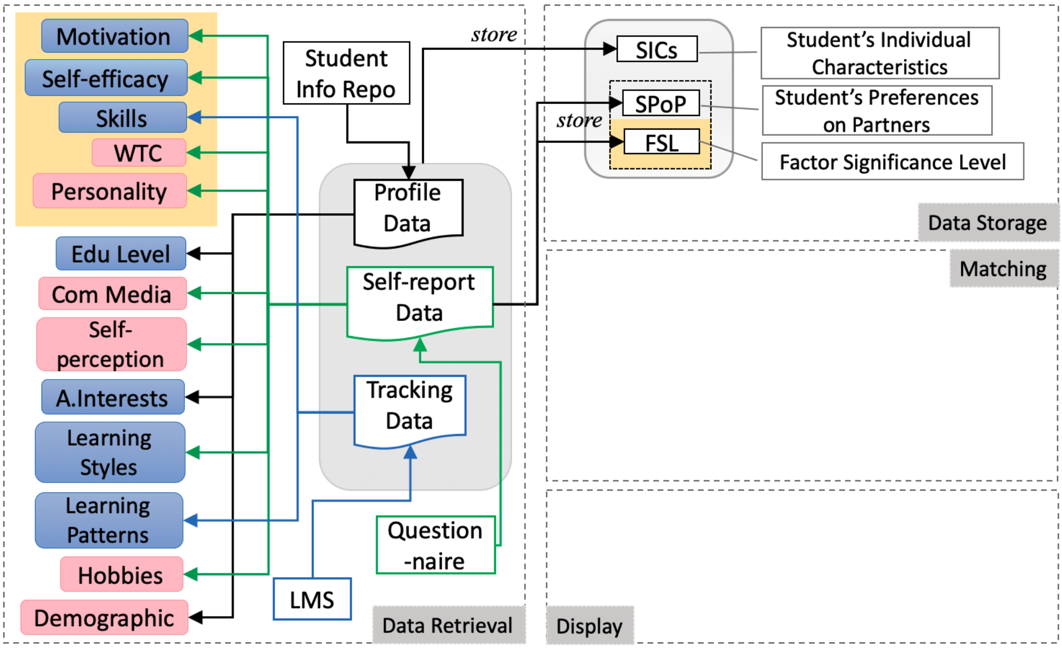


FIGURE 4.9: LPRS conceptual model in progress: data retrieval stage and data storage stage

used as matching criteria in a learning partner recommender system. The preliminary design of the other three components of the model – process, storage, and output – was also presented.

Figure 4.10 illustrates the proposed LPRS conceptual model design. Specific parts of the model which were influenced by results from the first data collection are highlighted.

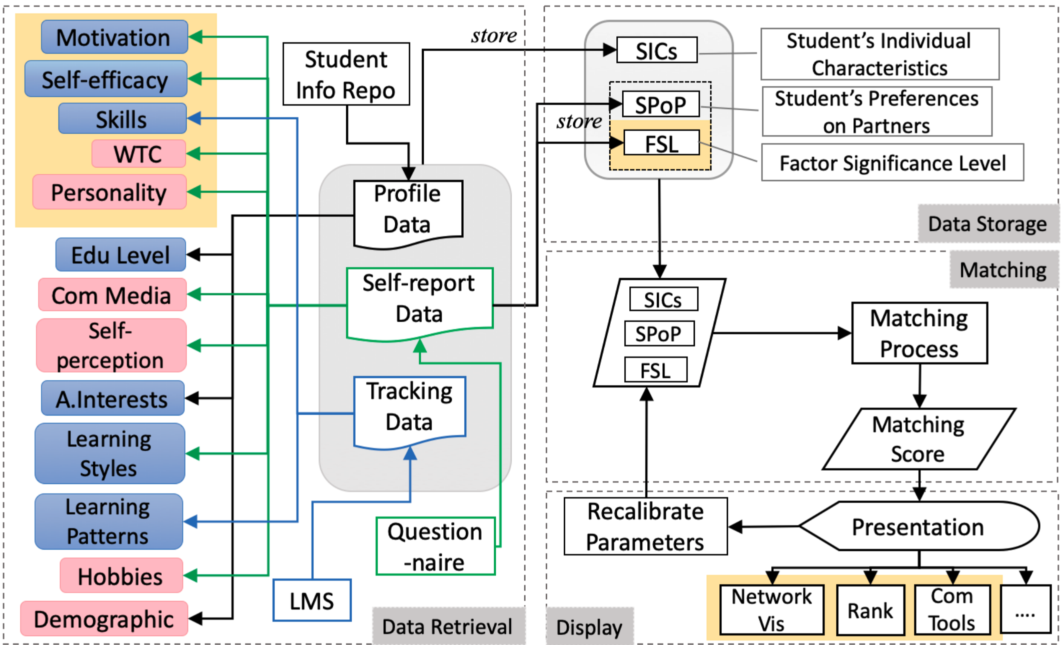


FIGURE 4.10: Basic LPRS Model Design

The proposed system comprises of four main stages: *Data Retrieval*, *Data Storage*, *Matching*, and *Display*. The first stage, *Data Retrieval* involves a process in which data about students' individual characteristics and preferences regarding learning partners of the respective students are collected. Preliminarily identified categories of data to be required as well as corresponding suggested data sources include (1) Profile Data (PD) where data are retrieved from a student information repository, (2) Tracking Data (TD) with data being extracted from the existing LMS, and (3) Self-report Data (SRD) which cover evidence of factors being collected through online characteristic quizzes.

The second phase, *Data Storage*, refers to the design and management of a database (DB) of collected data employed by the proposed system. Fundamental classification of data to be stored consists of (1) student's individual characteristics (SICs) which keep track of each student's data regarding factors used as criteria for matching other peers, (2) student's preferences on partners (SPP) where data about characteristics in learning partners that each student values are maintained, and (3) factor significance level (FSL) which indicates the importance degree of each factor when choosing learning partners according to each student's subjective evaluation. In a higher level of classification, data stored in the DB would be composed of two main components – student's profile and student's preferences on partners.

The last two stages are Matching and Display. In *Matching* stage, input consists of data about SICs, SPP and FSL. The matching process involves retrieving data from the database, performing analysis, calculating the degree of compatibility between any two users of the system, and generating a ranking list of compatible peers for each user. Compatibility degree suggests the two-way nature of the recommendations generated. A recommendation has to take into account the individual characteristics and preferences on learning partners of both the student who receives the recommendation and the peer who is recommended.

Once the matching process is completed, results are presented to the user, hence *Display*. Students participating in the interview sessions have demonstrated what they expect to be provided by such a recommender system. The user interface (i.e., visualisation of recommended learning partners) is expected to be simple, easy to see the results, and easy to understand. Communication tools expected to be integrated into the system should, from students' perspectives, provide timely response for them to quickly contact the recommended peers. There is also a need for features which support forming a group messaging system and making past conversations available to users. However, those features are beyond the scope of this project.

4.6 Evaluation of Effective OLCs

Attempts to address the second sub-question about how to assess the effectiveness of an OLC involve a combination of previous literature and results from the first data collection. As discussed in Chapter 2, subsection 2.3.9, several measures can be involved when a learning community has emerged in an online environment. Different aspects can be of interest to researchers when investigating the formation or development of an OLC, such as students' active engagement in both social and academic activities, willingness to share and contribute to meaning making (Palloff and Pratt, 2007), connectedness and learning (Rovai, 2002d),and learning achievement and communityness (Ke and Hoadley, 2009). The current work aims to contribute to efforts to overcome obstacles due to a mismatch in students' characteristics when they look for study partners. By suggesting peers with compatible factors, it is expected that a supporting situation could be created where students would feel comfortable to share ideas, encourage and support each other. Literature review suggested that sense of community is a multidimensional construct, comprising several key components such as membership, influence, fulfilment of needs and social bonds (McMillan and Chavis, 1986). Moreover, in a learning context, those components should be specific for the setting where the goal of the community members' (students') is learning. Amongst several instruments proposed to measure sense of community, Classroom Community Scale (CCS) designed by Rovai (Rovai, 2002c) fits the requirement of the current work in terms of grasping an overall situation of community amongst students.

In subsection 4.3.6.1, theme 1 emerging from the first data collection revealed which factors were considered important by students to the creation and development of a healthy learning community. These factors can be employed to investigate the specific aspects of a learning group in order to obtain a better understanding of the group well-being. One thing to note is that the present work does not place focus on the academic side of a learning community. That means investigation of an impact of the research on academic achievement such as grades or assignment submissions is out of scope.

4.7 Summary

This chapter described the process of building the conceptual model of the learning partner recommender system (LPRS), attempting to address the first three research questions regarding: students' characteristics which can be used as matching criteria, how to evaluate the effectiveness of an online learning community, and how to model the recommender system. The process involved literature review and data collection. Previous studies on Collaborative Learning, Learning Communities, and Group Formation were analysed in order to compile a collection of students' characteristics which have been either remarked as significant in students' participation in collaborative activities or used as grouping criteria in several studies. After that, confirmation of the characteristic set was conducted through investigation of students' perspectives using online survey and interview approach.

In summary, phase 1 of the research (1) identified a collection of characteristics to be used as matching factors in the learning partner recommender system, (2) planned the approach to assess the effectiveness of an OLC, and (3) created the conceptual model of the Learning Partner Recommender System.

Chapter 5

Phase 2: System Design & Implementation

5.1 Introduction

Chapter 5 focuses on the development of the Learning Partner Recommender System (LPRS), which is the primary aim of the *Development* step in the Design Science Research process (as demonstrated in Figure 5.1). This chapter aims to address three research questions regarding available data sources (SQ4), an approach to generating recommendations (SQ5), and result presentation approach (SQ6). The conceptual model presented in the previous chapter is employed as the base for building an instantiation which manifests itself as the working system developed. Moreover, from the practical view on the project, this chapter describes steps taken to conduct phase 2 of the research project.

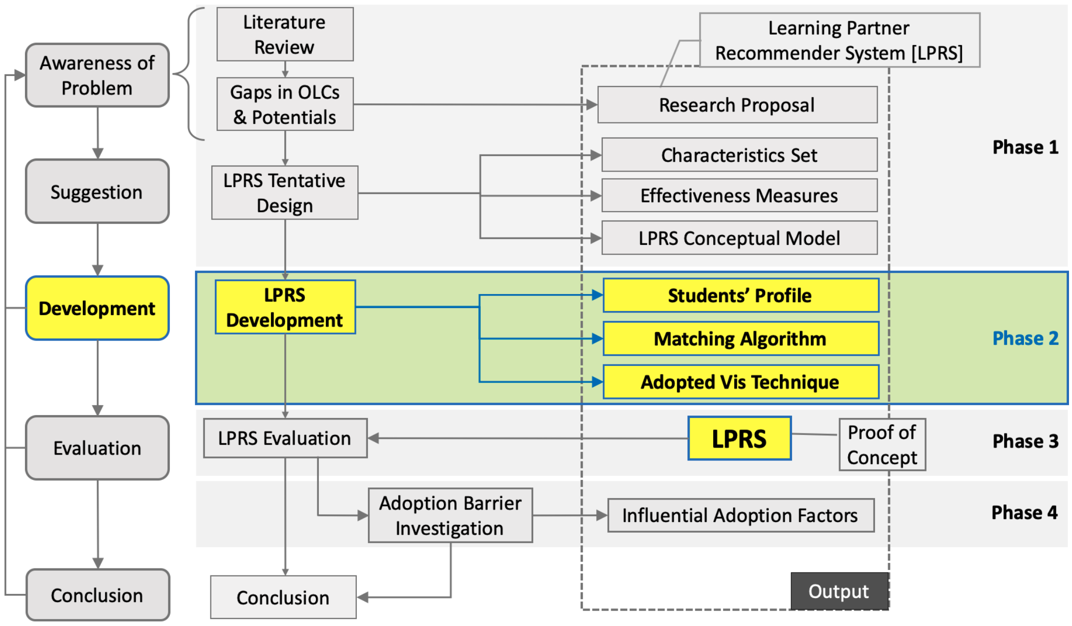


FIGURE 5.1: Chapter 5 content in the research design of the project

The sections in this chapter are organised as follows. Firstly, the system goals and requirements are stated in Section 5.2. Next, adjustments in the implementation are discussed in Section 5.3. After that, Section 5.4 presents in detail the process of how LPRS was designed and implemented. Thereafter, Section 5.5 describes an initial user acceptance test conducted using a focus group approach after basic required features of the system had been implemented. Refinements based on feedback from the focus group were made to improve the system usability.

In summary, by the end of this chapter, a working learning partner recommender system is presented. Key features implemented include collecting and managing students' profile and preferences data, generating recommendations of learning partners, and utility tools for students' initial contact.

5.2 System Goals and Requirements

The proposed LPRS attempts to facilitate students in finding peers with whom they can learn and work in an online learning environment. Taking students' characteristics and preferences into account when generating recommendations is expected to help stimulate positive interactions amongst learners, resulting in the creation of online learning communities.

The primary goal of the system involves the generation of recommendations on learning partners based on students' individual characteristics and their preferences regarding characteristics possessed by their co-learners. Grouping students into teams has been a vibrant topic of research in the computing education area. However, those studies have mainly focused on the creation of a globally optimised situation where the grouping solution aims to satisfy the grouping criteria which were established based on specific tasks or projects.

This project does not attempt to maximise the number of students who get recommended and receive recommendations; rather, it **aims at the generation of high quality recommendations where a number of students would receive close-to-perfect matches; while others might get recommendations with lower compatibility scores**. There are two reasons for this key decision. Firstly, an attempt to maximise the number of students involved in learning groups and to create a globally stable situation is an aim of studies in the area of Automatic Group Formation. This aim is desirable in formal learning contexts which are unit-specific and task-oriented, whereas the current study focuses on promoting informal learning communities beyond the boundaries of a specific subject. Therefore, a global stability is not of great importance in the context of the research. Secondly, by using the Learning Partner Recommender System (LPRS) students are investing their time and effectively committing themselves to some activities. They are encouraged to voluntarily join in by recognition of benefits from their participation. Creating a globally stable setting where many students are not satisfied with the provided recommendations would drive away even enthusiastic learners.

Three key aspects of the system consist of (1) data input, (2) matching process & recalibration, and (3) recommendation presentations. Data come from students' self-report data and characteristic questionnaires. Matching between two students is done taking into account features and preferences of both parties. In the matching and recalibration stage, with data being changed (explicit updates made by students or characteristic questionnaires retake), recommendations are adjusted. Finally, visualisation techniques are employed to present the list of recommended learning partners to students in a meaningful way in order to support them in making decision on contacting the suggested peers. Moreover, utilisation tools such as messaging, voting and connecting with peers are provided to facilitate initial contact amongst students.

5.3 Revisions based on Students' Feedback

As presented in Section 4.5, LPRS conceptual model, the recommender system was proposed with 13 students' characteristics which are suggested to be taken into account when giving students recommendations for learning partners. Six out of the 13 characteristics were chosen as key matching factors in the to-be-implemented system for two main reasons. The first reason is about system feasibility. Using all 13 factors for generating recommendations would require users to provide a large amount of information, leading to a lengthy process before they could receive recommendation results. Therefore, for the purpose of proof of concept, more significant characteristics are selected to be used as matching criteria. The second reason is a selection of factors based on their significance according to both students and previous research. Five factors including willingness to communicate (WTC), personality, motivation, self-efficacy, and skills emerged as most influential perceived by students according to results from the first data collection conducted in phase 1 (subsection 4.3.6.2). Moreover, students' characteristics such as learning styles, personality and skills were also reported as important grouping criteria which have been widely used in previous studies in group formation area. Because of these two reasons, six characteristics were selected including: willingness to communicate (WTC), personality, motivation, self-efficacy, skills and learning styles. Other characteristics are used as recommendation filtering conditions including demographics, education information, and academic interests.

Also in Section 4.5, three data sources were suggested to be employed including a student information repository, a learning management system (LMS) in use, and characteristic questionnaires. Online learning systems were included since there have been studies in the literature which attempt to automatically identify students' characteristics using their online learning data such as learning styles (Bernard et al., 2017; Chang et al., 2009; Jena, 2018), skills (Beheshti and Desmarais, 2014) or motivation (You, 2016). It had been initially planned that some characteristics could be retrieved from an external source (e.g., Moodle or Alexandria[4] in the context of the current research) in order to utilise Learning Analytics (LA). However, an initial investigation suggested that the amount of LA data which could be used in the project was less than anticipated. There were two main reasons for this adjustment. Firstly, it was crucial for the proposed recommender system to collect data about students' characteristics and preferences because recommendations for study partners would not be generated without these data. Secondly, the highest priority in this phase of the project is to establish the proof of concept, have it functioning, and investigate the matching process before investing significant effort in integrating LA in the system implementation. Thus, LA from external sources is ultimately one of primary data sources, but not a feature data source in this research project. Integration of LA data into the system has been remarked as further research. In view of the foregoing, values of students' characteristics are going to be collected through questionnaires and self-rating forms.

5.4 LPRS System Design and Implementation

This section covers the design and implementation of the learning partner recommender system (LPRS). The four main design blocks are introduced in subsection 5.4.1,

[4]An educational resource repository used by Monash University to facilitate authoring, sharing, discovery and publishing of high-quality, interactive, media-rich learning modules and ebooks.

followed by the types of data required by LPRS in subsection 5.4.2. The selected approach to generate recommendations for learning partners and to present the generated results are presented in subsection 5.4.3 and 5.4.4. The last two subsections provide brief descriptions of the integrated utility tools and the technical infrastructure of LPRS.

5.4.1 Design Blocks

The system is comprised of four main design blocks including profile, preference, recommendation, and utility, as shown in Figure 5.2. The four quarters show the user-centric view of the system consisting of four fundamental blocks. The attached boxes list the key tasks in each block which the system is responsible for in the background.

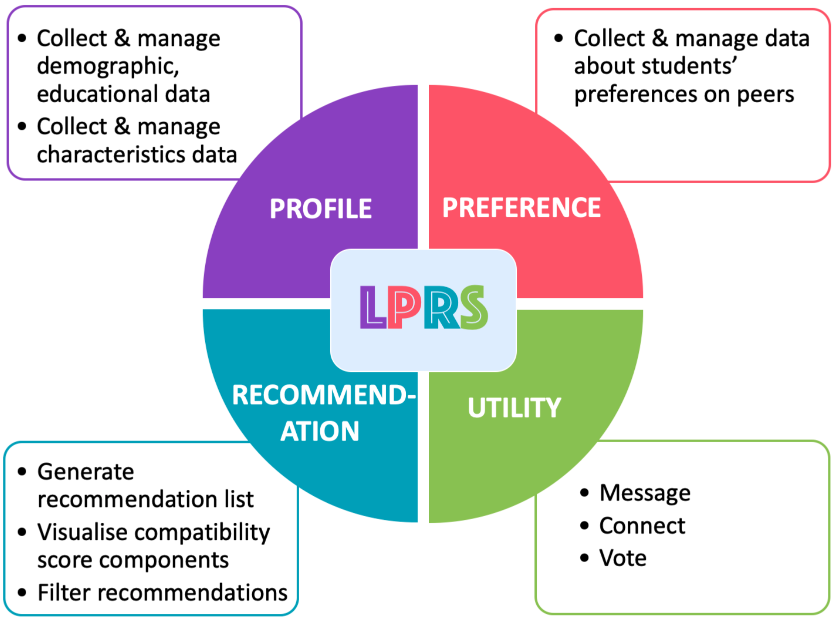


FIGURE 5.2: LPRS design blocks

Block 1, *Profile*, involves system features which deal with collecting and managing data of the students' profile including (1) demographics and educational data as well as (2) values of their characteristics. Demographical information collected by LPRS includes gender, age group, and nationality; educational data refers to those regarding degree, major, the year they are in, and campus location which they are based at. Values of characteristics refer to students' results of characteristic questionnaires. Thus, block 1 involves all forms designed to collect the kinds of data aforementioned, functions to process the raw data, and database to store and structure the processed data.

The second block, *Preference*, keeps track of what students look for in preferred learning partners regarding the six factors used as matching criteria. Also, influenced by the results from the first data collection, different factors can be assigned with different weights by a student (to indicate different levels of significance indicated by the student). This kind of information can be obtained through a form, then be preprocessed and saved into the database. Subsection 5.4.2 focuses on the data required by the system for recommendation generation, which covers the system functions needed for both *Profile* and *Preference* design blocks.

Block 3, *Recommendation*, takes care of the calculation of compatibility scores for any two learners in the system, generation of a ranking list of compatible peers as well as presentation of recommendation results generated from the matching process. This particular block requires the implementation of (1) a matching algorithm to determine the compatibility degree of any pair amongst the users of the system, and (2) presentation techniques in order to present results of learning partner recommendations in a user-friendly and engaging way. Subsection 5.4.3 and subsection 5.4.4 present the process of generating the ranking list of compatible peers for students and the presentation approach which utilises visualisation techniques to display compatibility score decomposition, respectively.

The fourth block, *Utility*, aims to facilitate initial contact amongst students as well as future evaluation of the system. Tools to be provided include message box, connecting with peers, and voting connected peers. Given the significant number of available communication applications, the message box feature integrated in LPRS aims to provide a simple channel to support initial interactions with minimal features. "Connecting with peers" feature allows users to create connections with whom they find compatible. Two connected users can get access to more detailed information about each other. "Voting connected peers" provides a way for students to give feedback on the connections they have. The voting data can be employed to improve the personalisation characteristic of generated recommendations as well as provide a data source for evaluation of recommendation quality. Subsection 5.4.5 briefly introduces the utility features integrated into LPRS.

5.4.2 System Data

This subsection focuses on the data required by the system to generate recommendations, which include (1) students' six characteristic values and (2) students' preferences on study partners regarding the six factors. The approach to collecting these data includes characteristic questionnaires and self-report forms. Thus, the implemented system features which are presented in this section cover two design blocks – profile and preference (as shown in Figure 5.2)

5.4.2.1 Types of Required Data

As previously presented in Section 5.3, while 13 characteristics were recommended to be used as matching criteria in the proposed LPRS conceptual model, six out of the 13 have been selected to integrate into the implemented system for the purpose of proof of concept. The six factors employed to perform the calculation of compatibility scores amongst students are: willingness to communicate (WTC), personality, motivation, self-efficacy, learning styles, and skills. Table 5.1 summarises the six characteristics, along with students' preferences, used as matching criteria in the implemented system, their data types and the approach to collecting these data.

Data about four characteristics (WTC, personality, self-efficacy, and learning styles) are collected through questionnaires. Data regarding students' motivation is retrieved in a form of self-rating on a scale from zero to ten where students rate themselves in terms of being motivated in their study. Students' skills data are obtained using a basic information form when they sign up with the system and create their profile. Finally, data regarding students' preferences on learning partners are collected through a preference form where students would specify what they prefer to find in peers in terms of the six factors. Also, students can rank or weigh these characteristics based on the level of importance they assign to each factor. By "rank", students can

Factor	Data Type	Collection Approach
WTC	Ordinal	Questionnaire
Personality	Categorical	Questionnaire
Self-efficacy	Ordinal	Questionnaire
Motivation	Ordinal	Self-rating
Skills	Categorical, multi-value	Basic information form
Learning Styles	Categorical	Questionnaire
Preferences	Value & weights of factors	Preferences form

TABLE 5.1: System data

place the six characteristics in their preferred order. In this case, each characteristic will receive a default weight assigned by the system as 35 (out of 100) for the most important factor, followed by 25, 20, 10, 5, and 5. By "weigh", students can explicitly assign a weight to a factor. Weights assigned to the six characteristics must add up to 100.

5.4.2.2 Choice of Characteristic Questionnaires

Out of the six characteristics used as matching criteria in LPRS, data about four factors are collected through questionnaires – WTC, personality, self-efficacy, and learning styles. For each characteristic, there are different instruments which have been proposed in the literature. Therefore, it is required that suitable questionnaires are selected so that there is a balance between the attempt to capture data about students' characteristics and the time students would have to spend on completing the forms. The process of choosing the instruments involve: collecting available questionnaires which have been widely recognised with a favour for those with reasonably short questions, removing attention check items in order to make questions more concise, rewording some of the questions to improve clarity and better fit the context of the research. Table 5.2 lists the questionnaires used to collect values of the four characteristics.

Factor	Adopted Questionnaires	# of Questions
WTC	WTC scale (McCroskey, 1992)	12
Personality	BFI-10 (Rammstedt and John, 2007)	10
Self-efficacy	Self-efficacy sub-scale (MSLQ questionnaire) (Pintrich et al., 1991)	8
Learning Styles	Felder-Silverman questionnaire (Felder and Silverman, 1988)	22

TABLE 5.2: Questionnaires used to collect characteristics

Willingness to Communicate (WTC) has been defined as the likelihood that an individual would choose to communicate when they are free to do so (McCroskey and Baer, 1985). In the context of this research, WTC refers to the degree to which a student is willing to communicate with others, and their peers in particular. The questionnaire used to retrieve the value of a student's WTC index is based on the WTC scale (McCroskey, 1992). The original quiz is composed of 20 items, asking respondents to indicate on a scale of 0 to 100, how willing they would be to talk (communicate) with people in different situations. WTC scale has been used in several studies and demonstrated to have high reliability (Cao and Philp, 2006; Donovan and MacIntyre, 2004). Eight out of the 20 questions are filler items used to distract respondents' attention from the scored items; only 12 items are used to generate the final results (McCroskey, 1992; McCroskey and Richmond, 2013). Therefore, the eight questions are removed from the WTC quiz used by the system. Some sample items used are: "present a talk to a group of strangers", "talk in a large meeting of acquaintances", and "present a talk to a group of friends". The WTC questions which are integrated into the system can be found in Appendix B.1.

As for the second factor in Table 5.2, personality, the Big Five model (or Five Factor Model of personality) is a widely accepted framework for describing five different aspects of an individual's personality. The model, along with its constituting dimensions, "is currently the dominant paradigm in personality research, and one of the most influential models in all of psychology" (McCrae, 2009, p.148). The five dimensions include extraversion, agreeableness, conscientiousness, neuroticism and openness. A number of instruments – with questionnaires being the most commonly adopted approach – have been developed to measure an individual's five aspects, such as the 240-item NEO-Personality-Inventory Revised (NEO-PI-R) (Costa and McCrae, 2008), the 100-item Trait-Descriptive Adjectives (TDA) (Goldberg, 1992), the 60-item NEO Five Factor Inventory (NEO-FFI) (Costa and McCrae, 2008), the 44-item Big-Five Inventory (John, Donahue, and Kentle, 1991). However, those questionnaires are not suitable to be used in the system due to the time limit which users would be willing to spend on each characteristic quiz. Short questionnaires, such as BFI-S (Lang et al., 2011), BFI-10 (Rammstedt and John, 2007), and TIPI (Gosling, Rentfrow, and Swann Jr, 2003), which take less time to complete have been built on the base of well-proven instruments, retaining the best correlating items from the original ones (Vinciarelli and Mohammadi, 2014). In the current project, BFI-10 (Rammstedt and John, 2007) is employed in the system to obtain the value of users' personality index since despite its briefness, the instrument has been proven to be able to stand as a proxy measure for lengthier Big-Five questionnaires (Hahn, Gottschling, and Spinath, 2012; Rammstedt and John, 2007). BFI-10 is a short version of the 44-item BFI and only consists of 10 items, each of which is associated to a 5-point Likert scale. Each dimension of the Big-Five is examined using two items, one positive-coded and one negative-coded. For instance, two items used to examine the neuroticism dimension are "I see myself as someone who is relaxed, handles stress well" and "I see myself as someone who gets nervous easily". The BFI-10 questionnaire can be found in Appendix B.2.

In terms of self-efficacy, in the context of this research, it refers to one's belief in one's capabilities to carry out the actions needed to successfully perform a task (Bandura, 1993; Puzziferro, 2008). It is considered as one of the most influential factors for academic performance (Klassen, Krawchuk, and Rajani, 2008; Zimmerman, 2000b). The instrument adopted to measure this index is the 8-item Self-efficacy subscale of the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al., 1991). MSLQ (including both the entire instrument and its subscales) has been employed intensively in previous work across research areas and target populations (Duncan and McKeachie, 2005). Also, Pintrich et al. (1993) have demonstrated that MSLQ has robust scale reliability, good factor structure and reasonable predictive validity. Since the current study does not focus on unit-specific or task-based learning groups, terminology in the eight items are replaced to reflect students' self-perceived academic self-efficacy in their courses instead of in one particular class as in the original questionnaire. Some sample items in the adapted self-efficacy questionnaire are: "I believe I will receive an excellent grade in my course", and "I expect to do well in my course". LPRS users would rate themselves on a 7-point Likert scale with indicators from 1, which means "not at all true of me" to 7, which means "very true of me". The self-efficacy subscale can be found in Appendix B.3.

Regarding learning styles, there are a number of different learning style models in the literature, each of which has proposed a different classification of learning styles. Noticeable work includes (Honey and Mumford, 1992), (Kolb, 1984), and (Felder and Silverman, 1988). In the current research, Felder and Silverman's learning styles model, FSLSM, and the associated questionnaire are employed to retrieve data about two out of four dimensions of students' learning styles. Instead of categorising learners into groups, Felder and Silverman (1988) suggested to examine learners' learning styles in terms of four dimensions – sequential/global, visual/verbal, sensing/intuitive, and active/reflective – and their preferences on these dimensions. FSLSM is remarked as "most appropriate for hypermedia courseware" when research which aims to examine learning styles in web-based learning contexts is conducted (Carver, Howard, and Lane, 1999; Graf et al., 2007). The questionnaire used by LPRS consists of a subset of the original 44-item questionnaires, covering questions about sequential/global and active/reflective aspects. The two dimensions are chosen to be integrated into the system since they indicate students' preferences in terms of their approaches to retaining and understanding information (active/reflective) and gaining understanding of a matter of interest and solving problems (sequential/global). These aspects are found to be relevant and have an impact on students' collaboration and their performance in online learning (Battalio, 2009). Two sample questions are: "I understand something better after I (a) try it out or (b) think it through" (for the active/reflective dimension); and "Once I understand (a) all the parts, I understand the whole thing or (b) the whole thing, I see how the parts fit". The subset of the FSLSM questionnaire can be found in Appendix B.4.

Table 5.3 provides the details of data types of the six factors used as matching criteria in the system and how these data are stored in the database.

Factor	Data Type	Description	Questionnaire results –>Values stored in DB
Willingness to communicate	Ordinal	The degree to which a student is willing to communicate with different categories of people.	[1...3] → "lower" [4...5] → "average" [6...7] → "upper"
Personality	Combination of Categorical	There are 5 dimensions constituting the value of this factor. Score for each dimension is [1...5]. 3 groups for each dimension: [1...2], [2.5...3.5], [4...5] 2 users are considered to fall into the same personality category if they are in the same group for 4 or more out of 5 dimensions.	Extraversion score → e_score [1...5] Agreeableness score → a_score [1...5] Conscientiousness score → c_score [1...5] Neuroticism score → n_score [1...5] Openness score → o_score [1...5] Group identification is performed during matching process
Self-efficacy	Ordinal	The degree in which a student is confident about their ability in doing their study	[1...3] → "lower" [4...5] → "average" [6...7] → "upper"
Motivation	Ordinal	Self-rating form from 0 to 10	
Skills	Categorical, multi-value	Academic skills that a user is confident about, including technical & soft skills.	
Learning Styles	Categorical	There are 2 dimensions (Active/Reflective and Sequential/Global). For each dimension, there are 6 groups (3 for each dimension in a scale: mild, moderate, strong). A/R [1...3], A/R [5...7], A/R [9...11] S/G [1...3], S/G [5...7], S/G [9...11] 2 users are considered to have similar learning styles if they are in the same group for both dimensions.	Active/Reflective score → ar_score [1...11] Sequential/Global score → sg_score [1...11] Group identification is performed during matching process

TABLE 5.3: Data types of factors

5.4.2.3 System Data Input Flow & Input Forms

This section discusses the steps which a user needs to take to complete the data inputs required by the system. Forms used to collect the required data are presented with explanations afterwards.

Data input flow

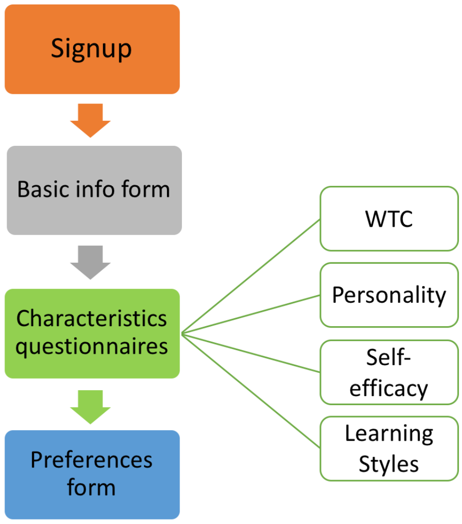


FIGURE 5.3: System data input forms

Figure 5.3 demonstrates the basic input flow which a user is guided through when interacting with LPRS. The main steps include: signup → basic information form → characteristic questionnaires → preferences form. In the signup step, the user provides their email address and password. A confirmation email will be sent to the registered email address with an account verification link attached which the user needs to use in order to complete the account creation.

After signing up, the user needs to fill in a form with their basic information. Collected information include demographics (age group, gender, and nationality), educational data (degree, major, year, and campus), skills (both technical and soft skills) they are confident about, academic topics which they are interested in, and communication channels they prefer to use when communicating with others.

The next step is to determine the user's values of five characteristics including WTC, personality, self-efficacy, learning styles and motivation. Data about the first four factors are collected through questionnaires as shown in Table 5.2. The value of the user's motivation is obtained in a self-rating form on a scale from zero to 10 (as presented in subsection 5.4.2.1).

The last form in the data input stage is about the user's preferences on study partners. With this "Preferences" form, the user indicates what they would want to find in their recommended peers regarding the six characteristics used as matching criteria. Importantly, the user needs to specify the significance level of the six factors by ranking them in descending order of importance or giving them a weight (or score).

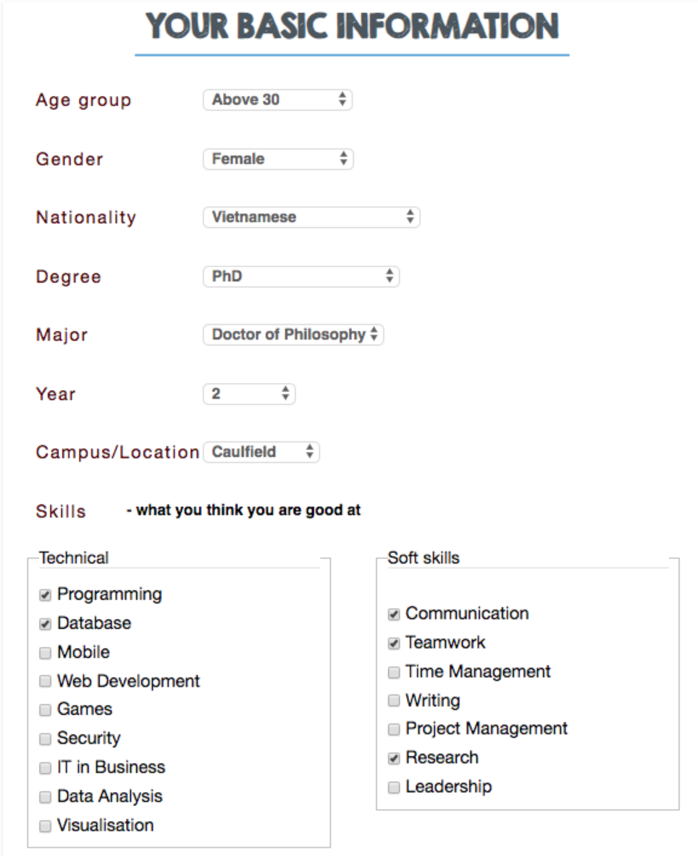
Input forms

This section presents input forms for data collection of a student's profile (Figure 5.4) and preferences (Figure 5.5). Figure 5.4 provides screenshots of different forms for system data inputs including "Basic Information form", characteristic questionnaire forms (WTC, personality, self-efficacy, learning styles, and motivation), and display of the profile information.

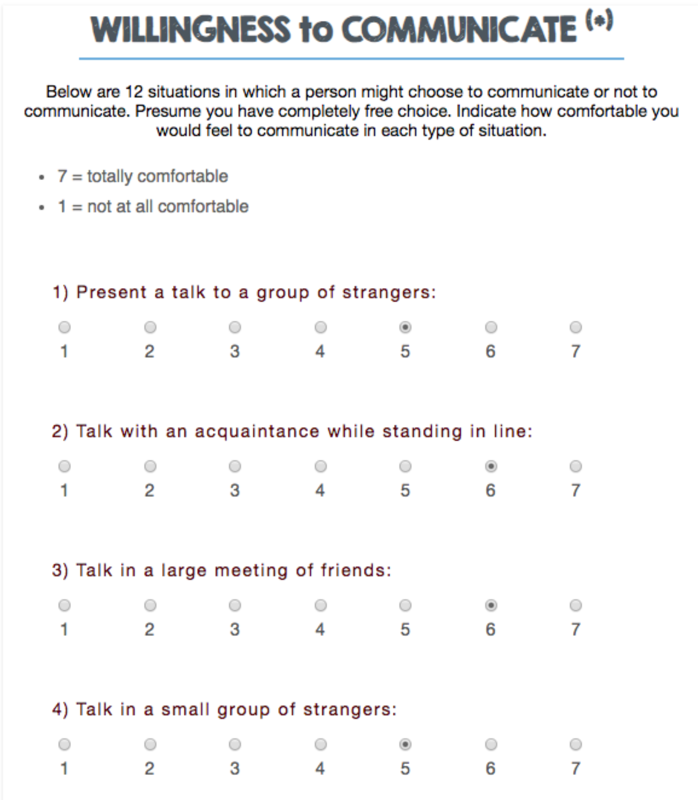
As shown in Figure 5.4a, the basic information form collects data about students' education, demographics, skills, academic interests, and preferred communication channels. Characteristic questionnaire forms (Figure 5.4b to 5.4e) are the implementation of the four questionnaires in order to obtain values of students' corresponding characteristics. Results from these forms constitute students' profile, which can be viewed and edited by the students (as shown in Figure 5.4f).

Figure 5.5 shows the form to collect data regarding a student's preferences on study partners regarding the six matching criteria (Figure 5.5a) and display of the preference information (Figure 5.5b). In the preferences form, the user needs to specifically indicate values of three factors which they would want the suggested peers to have including skills (from a provided list), personality (similar or different) and learning styles (similar or different). Preferred values of the three other factors – WTC, self-efficacy, and motivation – are automatically (implicitly) set by the system with the values equal to or higher than the student's values of corresponding factors. For example, if a student's WTC value is 4 (average group), the system will automatically record the student's preferred value of WTC for their recommended peers as 4 and higher.

Also, in this form (Figure 5.5a), the student needs to specify the importance levels of the matching criteria by ranking/weighing them. The meaning of rank and weigh was discussed in subsection 5.4.2.1. Information about their preferences is displayed to the student and it can be edited as required (as shown in Figure 5.5b).

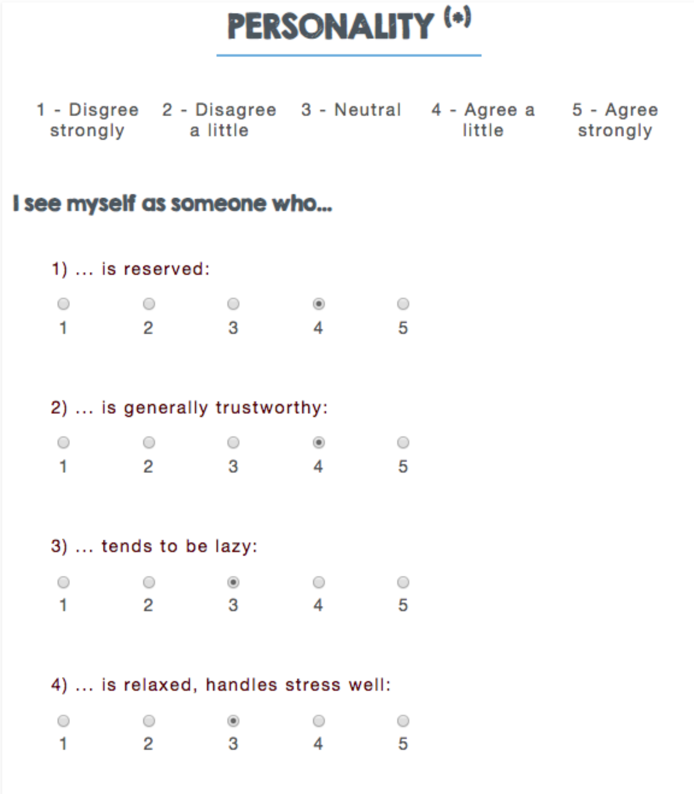


(a) Basic Information form

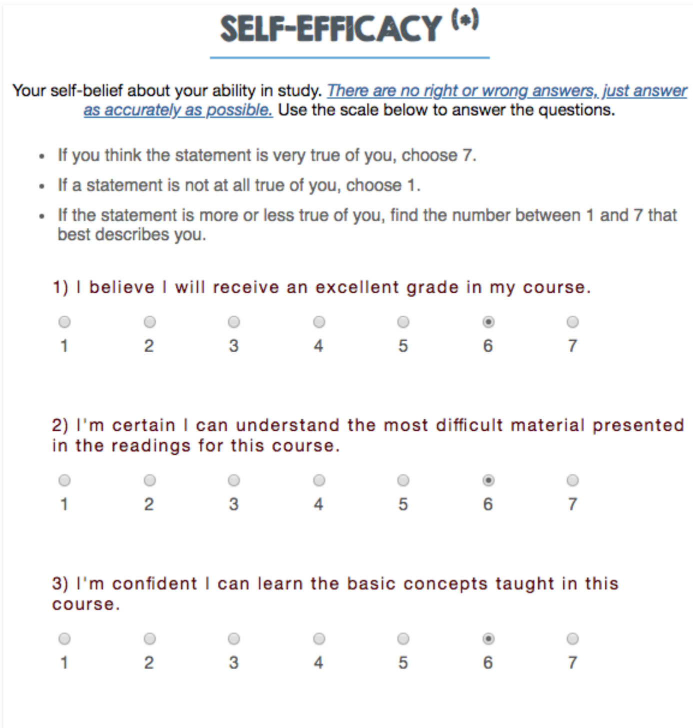


(b) Willingness to Communicate form

FIGURE 5.4: Profile forms and result display

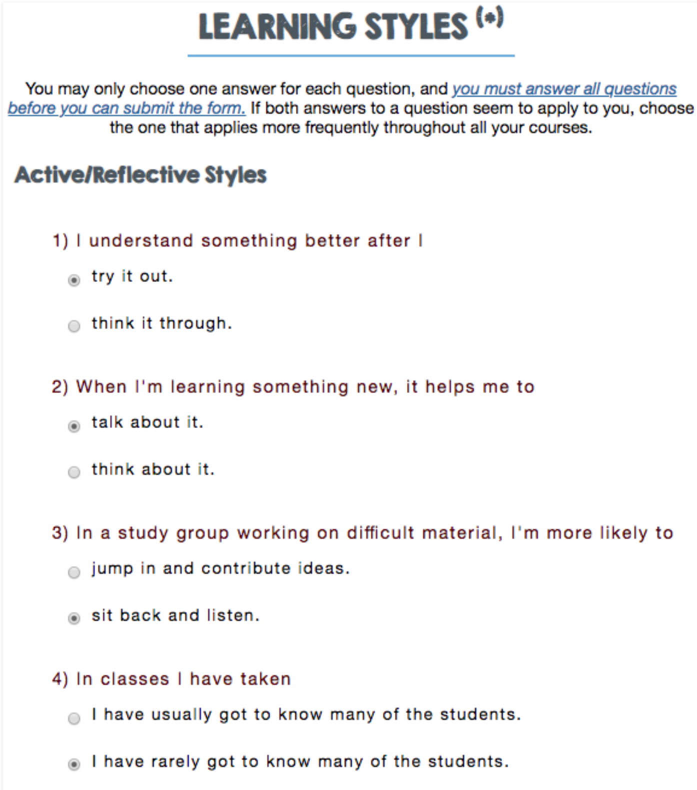


(c) Personality form



(d) Self-efficacy form

Figure 5.4: Profile forms and result display (cont.)



LEARNING STYLES (*)

You may only choose one answer for each question, and *you must answer all questions before you can submit the form.* If both answers to a question seem to apply to you, choose the one that applies more frequently throughout all your courses.

Active/Reflective Styles

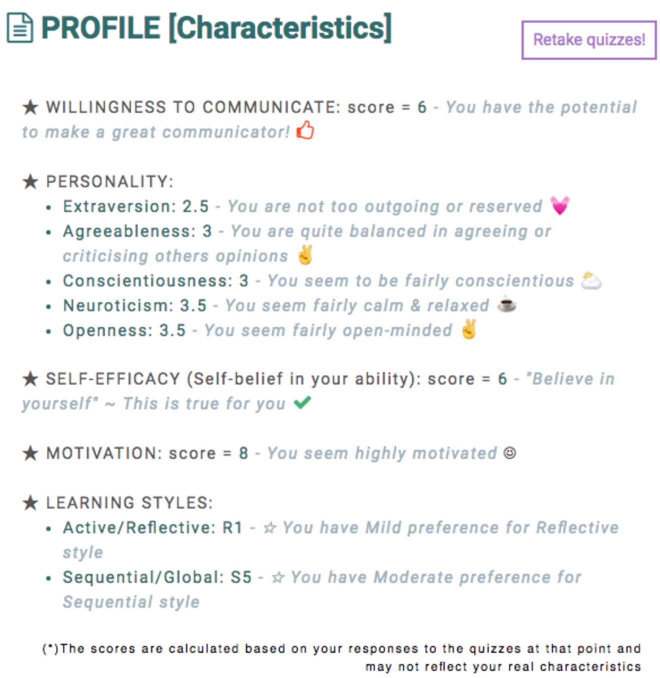
1) I understand something better after I
- try it out.
- think it through.

2) When I'm learning something new, it helps me to
- talk about it.
- think about it.

3) In a study group working on difficult material, I'm more likely to
- jump in and contribute ideas.
- sit back and listen.

4) In classes I have taken
- I have usually got to know many of the students.
- I have rarely got to know many of the students.

(e) Learning styles form



PROFILE [Characteristics]

Retake quizzes!

★ WILLINGNESS TO COMMUNICATE: score = 6 - *You have the potential to make a great communicator!*

★ PERSONALITY:
- Extraversion: 2.5 - *You are not too outgoing or reserved*
- Agreeableness: 3 - *You are quite balanced in agreeing or criticising others opinions*
- Conscientiousness: 3 - *You seem to be fairly conscientious*
- Neuroticism: 3.5 - *You seem fairly calm & relaxed*
- Openness: 3.5 - *You seem fairly open-minded*

★ SELF-EFFICACY (Self-belief in your ability): score = 6 - *"Believe in yourself" ~ This is true for you*

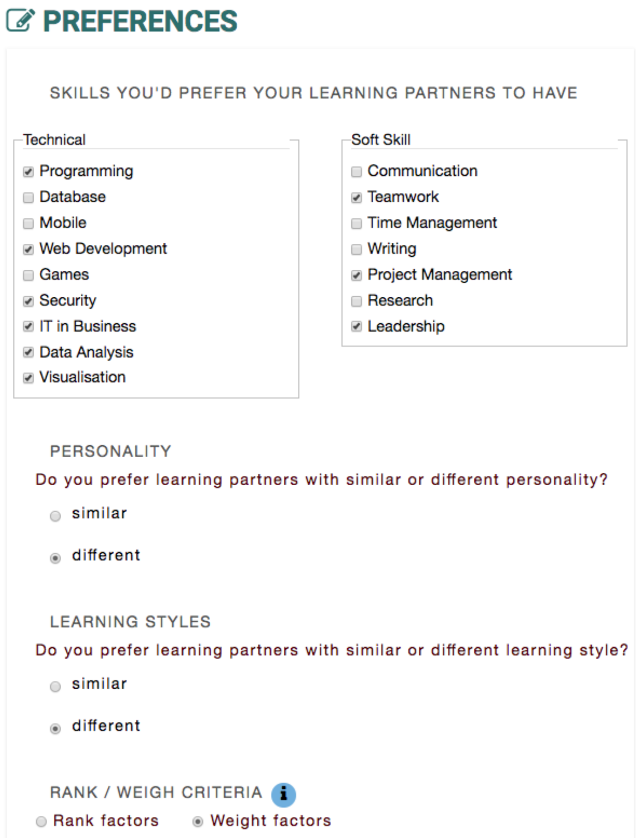
★ MOTIVATION: score = 8 - *You seem highly motivated*

★ LEARNING STYLES:
- Active/Reflective: R1 - *☆ You have Mild preference for Reflective style*
- Sequential/Global: S5 - *☆ You have Moderate preference for Sequential style*

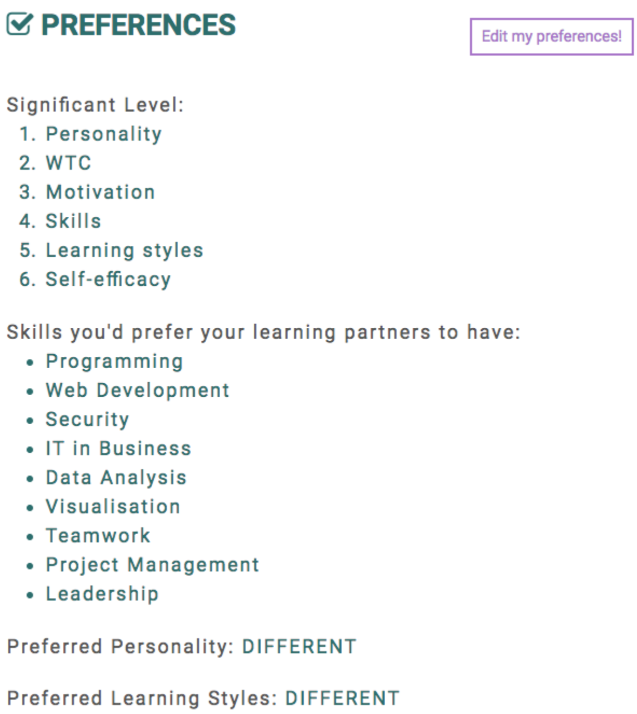
(*)The scores are calculated based on your responses to the quizzes at that point and may not reflect your real characteristics

(f) Profile - Display of characteristic results

FIGURE 5.4: Profile forms and result display (cont.)



(a) Preferences form



(b) Preferences display

FIGURE 5.5: Preferences form and display

5.4.3 Matching Approach & Implementation

Given the data required have been collected (which includes data about students' profile and their preferences on learning partners regarding the six matching criteria), the process of generating recommendations starts. This section presents the chosen matching approach and how it is implemented. The implementation of generating a ranking list of compatible peers for system users performs the first key task of the recommendation block as shown in Figure 5.2. Note that the term "target user" refers to a student who receives recommendations on study partners which is used in explanations of the system features.

5.4.3.1 Matching Approach

In reciprocal recommendation, there are two main approaches: Content-based versus Collaborative filtering. Content-based recommends targeted users with people having similar attribute values to those with whom the targeted users have connected (Pizzato et al., 2010). In terms of collaborative filtering (CF), it can be item-based CF (assumes that if many of A's connections are connected to B, then A may like to connect to B too) or user-based CF (assumes that similar users are likely to be pleased to connect with the same people) (Krzywicki et al., 2015).

A content-based approach is applicable when users' interaction data is available, which is not the case at an early stage of the system (Potts et al., 2018; Prabhakar, Spanakis, and Zaïane, 2017). Collaborative filtering is done through using similar users' opinions which tend to be more social network oriented; whereas the project focuses on students' individual characteristics and preferences and how these characteristics impact their collaboration with other peers and participation in learning communities.

Thus, neither content-based nor collaborative filtering approach is suitable to be employed in the current project. As a consequence, a decision has been made regarding the choice of approach to generating recommendations on learning partners. Within the scope of the PhD, a profile-preference matching approach was employed to generate compatibility scores amongst students. This is along the same line with remarks made by Potts et al. (2018) and Prabhakar, Spanakis, and Zaïane (2017). Initial data required for the matching process comes from the self-reported forms (the profile forms as in Figure 5.4 and the preferences form as in Figure 5.5). Matching is performed through calculating a two-way matching score between two users. Here, the factors which have effect on adjustments of recommendations involve: (1) updated values of students' characteristics through retaking characteristic quizzes, modified education/demographic information, and/or updated skills; (2) students' availability status; and (3) students' voting activities.

A content-based recommendation approach can be applied once a certain number of users' interactions have occurred. Interactions include those which can be tracked by the system: sending messages, making connections and voting peers. Further research can employ machine learning where user models can be created, and users' activities can be learnt to provide more highly personalised recommendations. This is not included in the scope of the current research.

5.4.3.2 Implementation

This section presents the implementation of the profile-preference matching approach. The matching process is explained, followed by a demonstration of the process with sample data.

Matching process

The matching process is presented as follows. A user's data in LPRS is composed of two main categories: the user's profile (the user's values of the characteristics which are used as matching criteria) and preferences (the values of corresponding characteristics that the user prefer their learning partners to have).

$U = \{V, Pref\}$ (U: user data, V: characteristic values, $Pref$: preferences)

$V = \{V_{C1}, V_{C2}, ..., V_{Cn}\}$ (V: user's characteristic values)

$Pref = \{V_{Pref}, W\}$ ($Pref$: user's preferences, V_{Pref}: preferred values of characteristics, W: weights of characteristics)

$V_{Pref} = \{V_{PrefC1}, V_{PrefC2}, ..., V_{PrefCn}\}$ (V_{Pref}: user's preferences for different characteristics)

$W = \{W_{C1}, W_{C2}, ..., W_{Cn}\}$ (W: significance level (weight) of characteristics which the user considers when looking for learning partners)

$n = 6$ (six characteristics used as matching criteria in LPRS)

For each pair of two users (referred as users A and B), firstly one-way matching scores ($score_{(B \to A)}$ which indicates how user B's characteristics fit user A's preferences and $score_{(A \to B)}$ which indicates how user A's characteristics fit user B's preferences) are calculated. It is to be noted that the calculation of one-way matching scores takes into account the weight (significance level) of factors which were assigned by the user. The calculation of $score_{(B \to A)}$ can be formulated as:

$$score_{(B \to A)} = \sum_{i=1}^{N} fit(V_{C_i(B)}, V_{PrefC_i(A)}) * W_{C_i(A)}$$

N is the number of characteristics used as matching criteria ($N = 6$ in the implemented system). $V_{C(B)}$ is user B's values of a specific characteristic C. $V_{PrefC(A)}$ is the value of the characteristic C which user A would want to find in learning peers. $W_{C(A)}$ is the weight user A has assigned to the characteristic C.

The harmonic mean (Pizzato et al., 2010) of the two scores is then generated to obtain the compatibility score between two users. The recommendation list for a user consists of peers being arranged in descending order in terms of the compatibility scores.

Demonstration

Suppose that there are nine users in the system. Sample data regarding the users is presented in Table 5.4.

	Skills																Moti-vation	WTC	Learning styles		Personality					Self-efficacy
User	Prog	DB	Mob	Web	Game	Sec	BizIT	DA	Vis	Com	Team	Time	Wrt	PM	RS	Lead			A/R	S/G	E	A	C	N	O	
																	0 – 10	1 – 7								1 – 7
PROFILE DATA																										
1	x			x						x			x				6	4	A5	S6	2	3	3	3	4.5	3
2		x				x		x		x				x		x	8	5	A3	G6	4	2	4	1	4	5
3	x		x	x				x	x		x	x	x			x	9	6	R3	S3	3	2	5	1	4	7
4	x					x					x						5	4	A6	G3	4	4	2	2	2	5
5							x	x		x	x	x	x	x	x		7	6	R6	G5	2.5	2	4	2.5	4	6
6	x	x								x	x				x		8	6	R1	S5	2.5	3	3	3.5	3.5	5
7	x		x			x		x	x	x	x	x					8	6	A3	S1	3.5	3	4.5	2.5	3.5	7
8				x	x		x	x			x	x			x	x	5	3	R2	S7	1	1	4.5	1	2	5
9		x					x	x	x	x	x	x	x		x		9	5	R7	G3	2	2	4	1.5	4	4
PREFERENCES DATA																										
1		x			x	x								x		x	>= 6	>= 4	diff		diff					>= 3
2	x								x								>= 8	>= 5	similar		diff					>= 5
3						x				x							>= 9	>= 6	diff		similar					>= 7
4	x		x												x		>= 5	>= 4	similar		similar					>= 5
5	x								x	x							>= 7	>= 6	diff		diff					>= 6
6	x		x			x			x	x							>= 8	>= 6	diff		similar					>= 6
7	x	x													x		>= 8	>= 6	diff		similar					>= 6
8			x	x		x			x								>= 5	>= 3	diff		similar					>= 5
9	x					x					x						>= 9	>= 5	similar		diff					>= 4

TABLE 5.4: Sample: Profile data of nine users, user 6 is the target user.
Prog: Programming, DB: Database, Mob: Mobile, Web: Web programming, Game: Game Design, Sec: Security, BizIT: Business Information Technology, DA: Data Analysis, Vis: Visualisation, Com: Communication, Team: Teamwork, Wrt: Writing, PM: Project Management, RS: Research, Lead: Leadership

Table 5.5 shows the significance level of the six matching criteria. As presented in subsection 5.4.2.1, the significance level of a factor is represented by a weight which was explicitly assigned by a student (in case the student chose to weigh the factors) or automatically assigned by the system (in case student chose to rank the factors).

User	Rank/ Weigh	WTC	Person -ality	Self-efficacy	Learning Styles	Motiva -tion	Skills
1	Weigh	0.2	0.6	0	0	0.1	0.1
2	Rank	0.35	0.25	0.05	0.05	0.2	0.1
3	Weigh	0.2	0.2	0.1	0.1	0.3	0.1
4	Rank	0.25	0.2	0.35	0.05	0.1	0.05
5	Weigh	0.3	0.2	0.1	0	0.2	0.2
6	Weigh	0.1	0.3	0	0.1	0.1	0.4
7	Weigh	0.1	0.2	0	0.3	0.1	0.3
8	Weigh	0	0.6	0	0.2	0	0.2
9	Rank	0.05	0.25	0.05	0.1	0.35	0.2

most important … least important

TABLE 5.5: Sample: Significance level data for nine users

Given the profile and preference data, one-way matching scores are calculated. Take user1 and user2 for instance, $score_{(user1 \rightarrow user2)}$ (how much user1's characteristics fit user2's preferences) is calculated using the formula below:

$$score_{(user1 \rightarrow user2)} = \sum_{i=1}^{6} fit(V_{C_i(user1)}, V_{PrefC_i(user2)}) * W_{C_i(user2)}$$

Fitting scores of the factors, which represent how much user1's characteristics fit user2's preferences regarding specific factors, are demonstrated in Table 5.6.

Factor	Weight	user2's characteristics	user2's preferences	user1's characteristics	Factor's fitting score
WTC	0.35	5	$>= 5$	4	$0 * 0.35 = 0$
Personality	0.25	E: 4 A: 2 C: 4 N: 1 O: 4	different	E: 2 A: 3 C: 3 N: 3 O: 5	$1 * 0.25 = 0.25$
Self-efficacy	0.05	5	$>= 5$	3	$0 * 0.05 = 0$
Learning Styles	0.05	A3 G6	similar	A5 S6	0
Motivation	0.2	8	$>= 8$	6	$0 * 0.2 = 0$
Skills	0.1	Programming Security Data Analysis Communication Project Mgt Leadership	Programming Visualisation	Programming Web Communication Writing	$0.5 * 0.1 = 0.05$
				$score_{(user1 \rightarrow user2)}$	**0.3**

TABLE 5.6: Sample: Demonstration of how to calculate one-way matching score ($score_{(user1 \rightarrow user2)}$)

Applying this method to calculate the one-way matching score for any two users within the nine sample users, Table 5.7 shows the one-way matching score matrix. The scores in Table 5.7 can be translated row-wise. For instance, row 1 shows how user1's characteristics satisfy the preferences of user2, user3, user4 and so on.

User	1	2	3	4	5	6	7	8	9
1	x	0.3	0.15	0.392	0.333	0.21	0.45	0.15	0.317
2	0.98	x	0.4	0.7	0.467	0.36	0.4	0.25	0.167
3	0.92	0.7	x	0.733	0.733	0.49	0.5	0.25	0.583
4	0.82	0.35	0.15	x	0.267	0.26	0.45	0.25	0.55
5	0.92	0.675	0.55	0.717	x	0.28	0.4	0.2	0.467
6	0.92	0.9	0.3	0.733	0.833	x	1	0	0.483
7	0.92	0.975	0.45	0.733	1	1	x	0.35	0.55
8	0.64	0.3	0.05	0.467	0.2	0	0.3	x	0.117
9	0.92	0.6	0.65	0.392	0.533	0.36	0.55	0.85	x

TABLE 5.7: Sample: One–way matching score matrix for nine users, matching score for user1 and user2 is highlighted

Given one-way matching scores for two users are calculated, the compatibility score for the two users is generated using harmonic mean. Harmonic mean is used because "it is desirable to favour low compatibility scores over high scores when two users have distinctly different levels of compatibility" (Pizzato et al., 2011, p.6).

The general formula of harmonic mean is:

$$H = \frac{n}{\frac{1}{x_1} + \frac{1}{x_2} + ... + \frac{1}{x_n}} = \frac{n}{\sum_{i=1}^{n} \frac{1}{x_i}}$$

Take user1 and user2 for example:

$$score_{(user1 \rightarrow user2)} = 0.3$$

$$score_{(user2 \rightarrow user1)} = 0.98$$

Using arithmetic mean:

$$score_{(user2 \leftrightarrow user1)} = \frac{0.3 + 0.98}{2} = 0.64$$

Using harmonic mean:

$$score_{(user1 \leftrightarrow user2)} = \frac{2}{\frac{1}{0.3} + \frac{1}{0.98}} = 0.459$$

Thus, in comparison with arithmetic mean, harmonic mean tends to moderate the impact of the higher one-way matching score and aggravate the impact of the smaller one. This fits well for reciprocal recommendations since a balanced situation is required with regard to preferences on learning partners from both parties of a recommendation.

Applying harmonic mean, compatibility scores for nine users are demonstrated in Table 5.8.

User	1	2	3	4	5	6	7	8	9
1	x	0.459	0.258	0.53	0.489	0.342	0.604	0.243	0.472
2	0.459	x	0.509	0.467	0.552	0.514	0.567	0.273	0.261
3	0.258	0.509	x	0.249	0.628	0.372	0.474	0.083	0.615
4	0.053	0.467	249	x	0.389	0.384	0.558	0.326	0.458
5	0.489	0.552	0.628	0.389	x	0.419	0.571	0.2	0.498
6	0.342	0.514	0.372	0.384	0.419	x	1	0	0.413
7	0.604	0.567	0.474	0.558	0.571	1	x	0.323	0.55
8	0.243	0.273	0.083	0.326	0.4	0	0.323	x	0.206
9	0.472	0.261	0.615	0.458	0.498	0.413	0.55	0.206	x

TABLE 5.8: Sample: Compatibility scores for nine users, highlighted are the 100% and 0% matching scores

Testing the process of calculating compatibility scores was done with target user6. Sample data was entered with a purpose of generating a perfect match with user7 (100% matching) and a lowest score with user8 (0% matching). As shown in Table 5.8, the compatibility score between user6 and user7 is 1 (out of 1); while the compatibility score between user6 and user8 is 0 (out of 1).

As a summary, algorithms used to calculate compatibility scores for users in LPRS include the calculation of one-way matching score (Figure 5.6), calculation of compatibility scores (Figure 5.7) and creation of ranking list of compatible peers for a user (Figure 5.8).

One-way matching score: $score(P_A, C_B)$

Input: Preferences of user A, Characteristic of user B

Output: one-way matching score showing how much user B's characteristics fit user A's preferences

begin

- initialise $score(P_A, C_B) = 0.0$
- identify the factors' weights: $w_{fi}(i \in N.N = [1 \ldots 6])$
- for each factor f
  - retrieve user A's preference regarding $f - (f(prefA))$
  - retrieve user B's value of $f - (f(B))$
  - calculate the similarity $- similarity(f(prefA), f(B))$
  - calculate factor's fitting score $- score(f) = similarity(f(prefA), f(B)) * w_{fi}$
  - accumulate $score(f)$ into $score(P_A, C_B)$
- return $score(P_A, C_B)$

end

FIGURE 5.6: One-way matching score calculation algorithm

Compatibility score: $score(A \leftrightarrow B)$

Input: Preferences of user A (P_A), Characteristic of user B (C_B),
Preferences of user B (P_B), Characteristic of user A (C_A)

Output: compatibility score showing how much user A and user B are compatible

begin
- initialise $score(A \leftrightarrow B) = 0.0$
- calculate $score(P_A, C_B)$
- calculate $score(P_B, C_A)$
- calculate compatibility score $- score(A \leftrightarrow B) = \frac{2}{(score(P_A,C_B))^{-1}+(score(P_B,C_A))^{-1}}$
- return $score(A \leftrightarrow B)$

end

FIGURE 5.7: Compatibility score calculation algorithm

Top-K recommended peers: $Rank@K$

Input: Preferences of user A, K,
all peers' characteristics and preferences ($peers = [\{C_p, P_p\}]$)

Output: User A's top-K recommended peers ($Rank@K$), $scores = [\{p, score(p)\}]$. $score(p)$ is compatibility score between user A and peer p.

begin
- initialise $Rank@K = []$
- for each p in $peers$ ($peers'length = m$)
  - $score(p) = 0$
  - if $p = A$ then
    - $score(p) = 0$
    - add score to scores: $scores \mathrel{+}= \{A, 0\}$
  - else
    - calculate compatibility score $- score(p)$
    - add score to scores: $scores \mathrel{+}= \{p, score(p)\}$
- sort $scores$ in descending order:
  - $scores = [\{p_1, score(p_1)\} \dots \{p_m, score(p_m)\}]: score(p_i) >= score(p_{i+1}) \forall i$
- generate $Rank@K = \{p_1, p_2, \dots, p_K\} \subset \{p_1, p_2, \dots, p_m\}$
- return ($Rank@K, scores$)

end

FIGURE 5.8: Ranking list of compatible peer algorithm

5.4.3.3 Summary

This section has presented the process of generating the compatibility score for any two users of the system. The approach employed is profile-preference matching due to the unavailability of students' interaction data at the early stage of such a recommender system (Potts et al., 2018; Prabhakar, Spanakis, and Zaïane, 2017). The detailed steps and algorithms used have been provided with demonstrations performed on sample data.

The result after the three algorithms (Figure 5.6 to 5.8) have been executed is a ranking list of compatible peers for each student. The next section discusses the approach to present recommendation results to students after all data inputs have been completed.

5.4.4 Presentation Approach & Implementation

With a generated list of recommended peers, results need to be presented to students in an accessible way. This section presents an approach which utilises visualisation techniques to display recommendation results to students. This performs the second key task of the recommendation block in the system design blocks as shown in Figure 5.2.

5.4.4.1 Recommendation Presentation Approach

Initially, given the learning partner recommendations for a target user resulting from the matching process (presented in subsection 5.4.3), the most basic way of presenting the results is to list the recommended peers in descending order of compatibility score, as demonstrated in Figure 5.9.

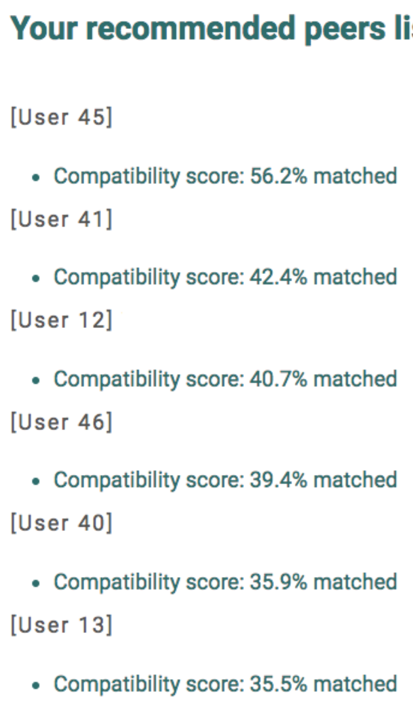


FIGURE 5.9: Initial display of compatible peer list for some example users

As in Figure 5.9, a modest amount of information is presented including the peers' display names and the percentage of how much the target user and the peers are compatible. However, this approach of showing the recommendation results is not easy to comprehend, and it fails to provide an informative presentation which can assist users in making decision to contact the recommended peers.

In order to provide explanatory information about how the target user and a particular peer are compatible, bar charts can be utilised to display the components which make up the final compatibility score of the two users. Figure 5.10 demonstrates how the score components can be presented. This presentation can facilitate the target user in making sense of how the user and a recommended peer fit in respect of each of the six matching criteria.

In Figure 5.10, the charts for the target user and the recommended peer are placed on the left and right, respectively. The order of the bars denotes the significance level (weight) which the users assigned to the six factors. The part of the bar in darker

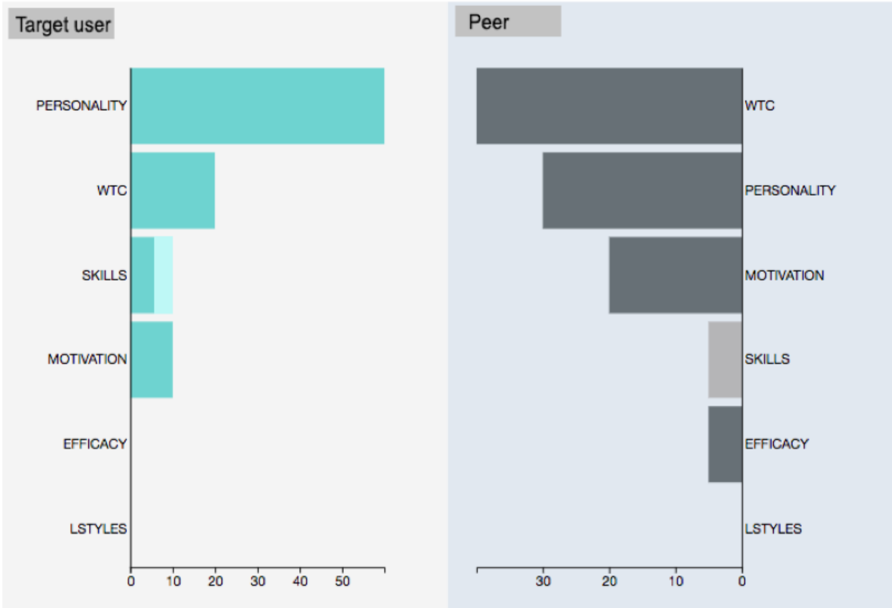


FIGURE 5.10: Presentation of a peer's compatibility score components

shade shows the matching proportion; while the one in lighter shade denotes how much the two users do not fit regarding the factor represented by the bar. For example, as can be seen in Figure 5.10, the target user gave weights to the six matching criteria in order as: personality (60) – WTC (20) – skills (10) – motivation (10) – self-efficacy (0) – learning styles (0); whereas the weights of the factors assigned by the peer are: WTC (40) – personality (30) – motivation (20) – skills (5) – self-efficacy (5) – learning styles (0). The target user's and the peer's characteristics fit quite well with each other's preferences. The only unmatched characteristic is skills – the target user does not have the skills which the peer expects their study partners to possess, while the peer partially fits the target user's expectation regarding this matching factor. The presentation of recommendation results which is demonstrated in Figure 5.10 can provide detailed information regarding how the target user and a peer are compatible in respect of each matching factor. Nevertheless, this approach fails to give the target user a quick grasp of all recommended peers' compatibility scores within a single viewport display.

With the aim to facilitate students' quick understanding of how different components contribute to the recommended peers' scores, as well as to support easy comparison for different peers, the presentation of recommendations needs to hold some features. These features are adopted from Gratzl et al. (2013). Table 5.9 gives a description of these basic features.

The presentation of users' recommendations is inspired by the work of Gratzl et al. (2013) about a visualisation technique which employs bar charts to create an interactive representation of multi-attribute ranking. Inline bar chart is employed in the implementation of recommendation visualisation in order to facilitate compatibility score decomposition in a single viewport. The following section details the visualisation implementation.

5.4.4.2 Recommendation Presentation Implementation

Figure 5.11 demonstrates the visual presentation of recommendation results for a student. Recommendation visualisation shows the ranking list of compatible peers

Feature	Description
Encode Rank	Users should be able to quickly grasp the rank of recommended peers
Encode Reasons for Rank	Users should be able to understand easily why the suggested peers are recommended to them
Support multiple attributes	Visualisation of recommendations should support the presentation of multiple characteristics in the decision regarding recommendations
Interactive refinement & visual feedback	Users should be able to add/remove/weigh matching criteria. It should be reflected immediately in the visualisation so that users can perceive how different matching criteria influence the recommendations

TABLE 5.9: Requirements of recommendation visualisation

who are suggested to the target user resulting from the matching process which was presented in the previous section.

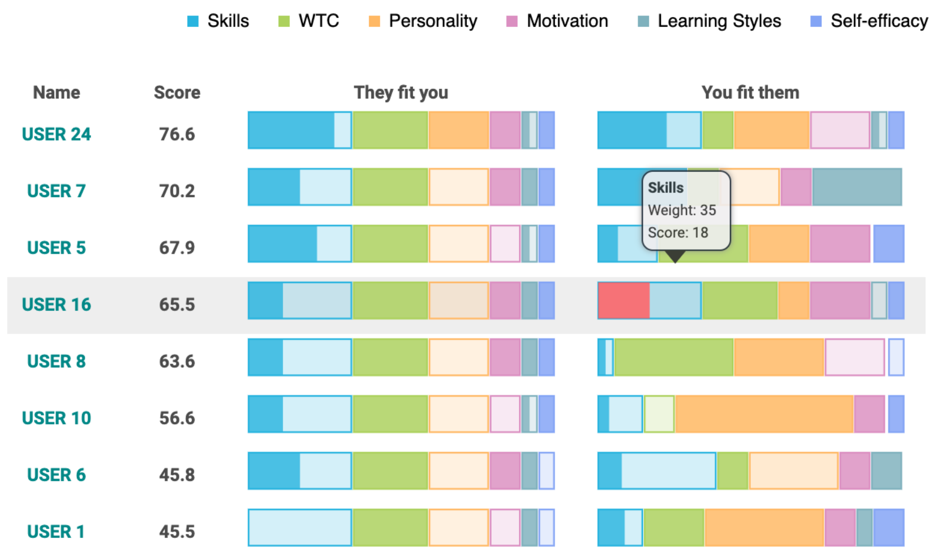


FIGURE 5.11: Recommendation visualisation: Compatibility score decomposition

There are four columns – peers' name, compatibility score, "They fit you" which shows how the recommended peers' characteristics fit the target user's preferences, and "You fit them" is the other way around.

The bars are colour-coded to represent different factors. The order of the coloured bars is based on how the target user ranked or weighed the importance level of the matching criteria. To illustrate, the target user (the student who receives the recommendations) ranked the characteristics as motivation, personality, skills, learning styles, WTC, and self-efficacy in descending order of importance. Therefore, stacked bars in both column three ("They fit you") and four ("You fit them") are arranged consistently in this order. The length of a bar in column three demonstrates the weight assigned to the corresponding factor by the target user; whereas the length of the bar in column four shows how the peers weighed or ranked the six matching criteria. As for the shades of a colour, the darker shade represents the matching proportion, while the lighter shade shows the unmatched portion regarding a particular factor. Also, tooltip is enabled on hovering over the stacked bars to show the weight of a factor assigned by the target user (column 3) and by the peer (column 4), as well as the fitting score regarding the corresponding factor.

For instance, in Figure 5.12, user 6 is the target user who receives the recommendation results. Considering the recommended peers in the first row, second row and last row, user 7 has the highest compatibility score of 100, user 2 scores at 51.4, and user 8 has the lowest matching score at 0 (out of 100). The compatibility scores represent how much the three users are mutually compatible with user 6 – the student who receives the recommendations.

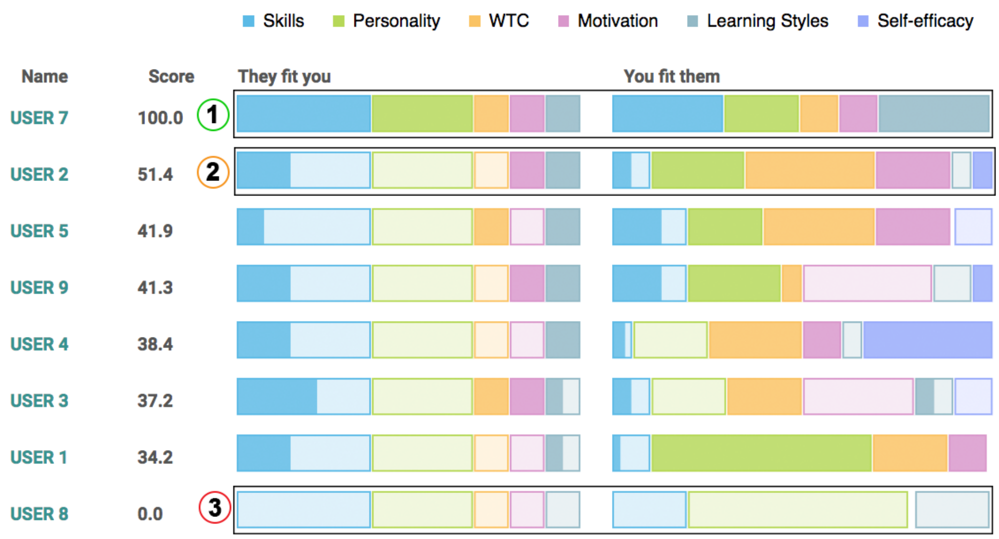


FIGURE 5.12: Recommendation results visualisation: Compatibility score decomposed

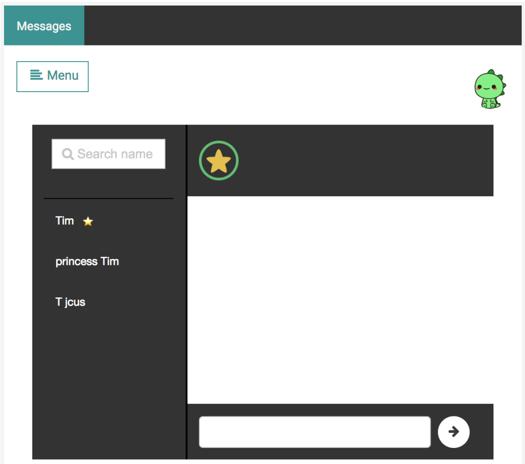
At ① in Figure 5.12, the target user's preferences regarding the six matching criteria are satisfied by peer 7's characteristics (as shown in column "They fit you", row 1). Similarly, as can be seen in column "You fit them", row 1, although peer 7 has different perception on the importance level of the six factors (skills and learning styles are perceived as most significant, followed by personality, then WTC and motivation based on the length of the stacked bars), the values of the target user's characteristics fit peer 7's preferences. This leads to the perfect fitting score of 100 out of 100.

At ② in Figure 5.12, the compatibility between the target user and user 2 is 51.4. The stacked bars in column 4 show that user 2 ranked the six factors in descending order of significance as WTC – personality – motivation – skills – learning styles – self-efficacy. Even though the target user's characteristics fit user 2's preferences quite well; the opposite is not true; which results in a medium matching score.

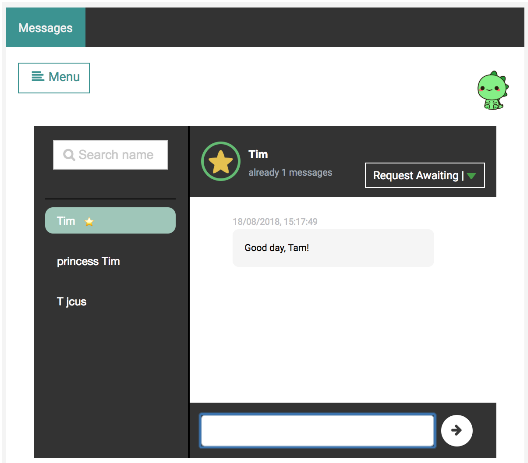
As can be seen at ③ in Figure 5.12, user 8 only considered three factors as important and assigned specific weights to them – personality at 60, skills at 20, and learning styles at 20. Note that this information can be viewed with the help of tooltips as demonstrated in Figure 5.11. In contrast to ① in Figure 5.12, regarding user 8, all stacked bars in both column 3 and 4 are in lighter shade, showing that the target user and peer 8's characteristics do not fit each other's preferences regarding the six factors.

5.4.5 Utility Tool Implementation

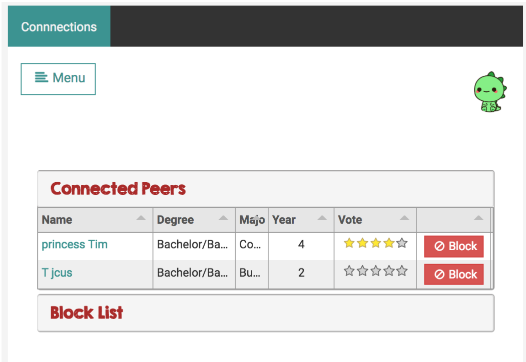
In order to facilitate students' initial contact and interactions within the LPRS environment, some utility features were implemented including message box, connecting with peers (with whom students have had messages with), and voting connected peers. Being presented with a list of recommended peers, users can choose to message a peer in the list. The message box feature allows users to manage all messages they have had (Figure 5.13a). Users can then choose to create a connection with any of the peers with whom they have communicated (Figure 5.13b). With the voting connected peers feature, users can give a remark on the relationship they have with the connected peers (Figure 5.13c).



(a) Message Box



(b) Connecting Peers



(c) Voting Peers

FIGURE 5.13: Screenshots of utility features of the LPRS

Since the key function of the system is to provide suggestions on study partners based on students' characteristics and their preferences on what they want to find in their peers, utility tools were developed with minimum features with an aim to support the first step of communications amongst students. Nevertheless, consideration for users' data privacy was considered important. Displayed names in the system are usernames which students chose when creating their accounts. Moreover, no personal information is exposed to other users. Contact information is exchanged voluntarily between students if they decide to connect with each other.

5.4.6 Technical Infrastructure

5.4.6.1 Database Design

MySQL[5] was employed to create the system database in order to store, structure and managed collected data. Tables composing the database are presented in Figure 5.14. The tables in the database are categorised into groups to manage data about (1) information of students' demographics, education, interests, and preferred communication channels, (2) students' characteristic values, (3) students' preferences on learning partners, (4) students' messages, connections, and voting, (5) students' login and recommendation views, and (6) other information.

[5] An open-source relational database management system (RDBMS). https://www.mysql.com/

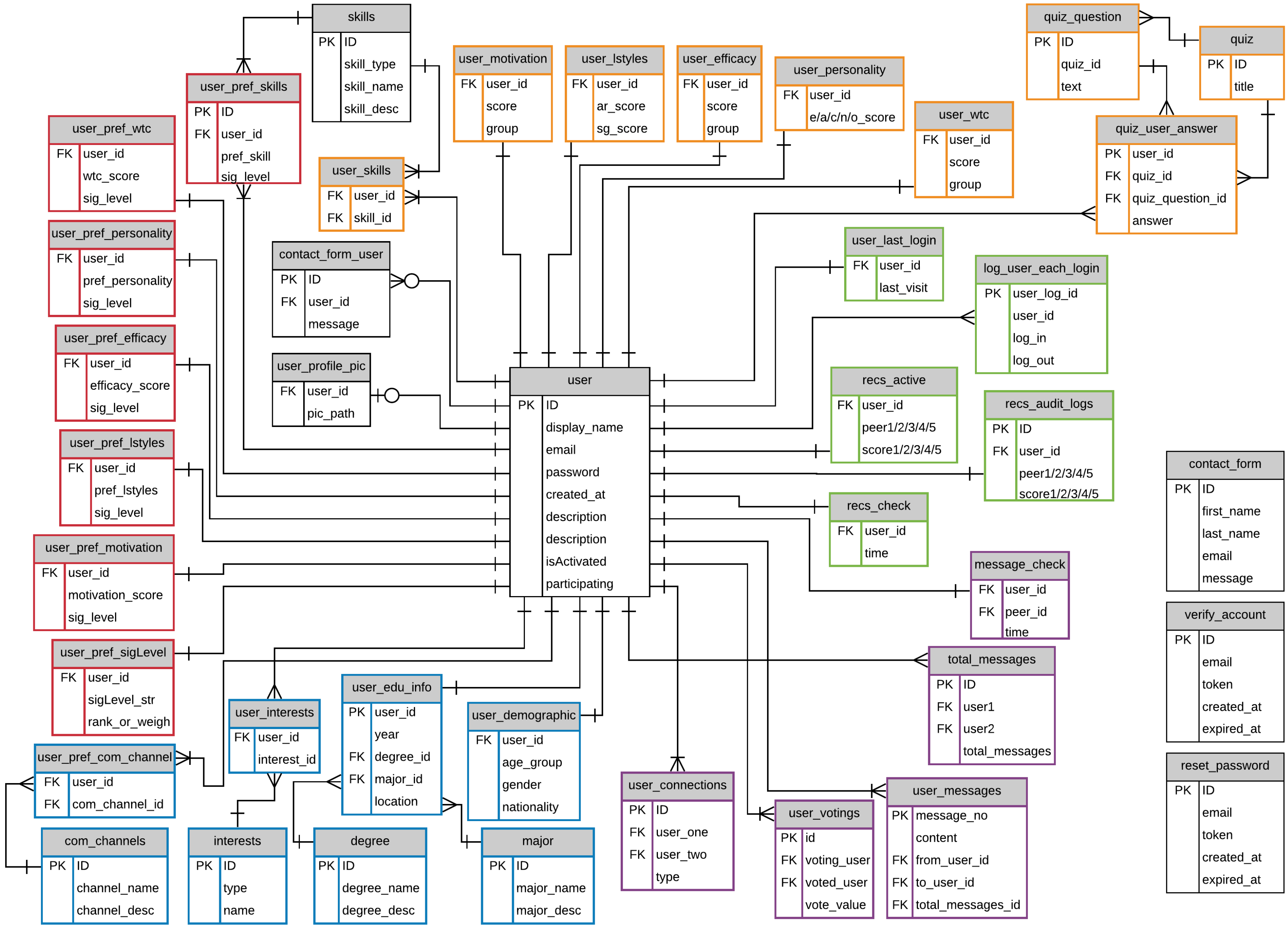


FIGURE 5.14: Database design of LPRS.
Blue: information of students' demographics, education, interests, and preferred communication channels; Orange: students' characteristics; Red: students' preferences on learning partners; Purple: students' messages, connections, and voting; Green: students' login and recommendation views; Black: other information

5.4.6.2 Technical Structure

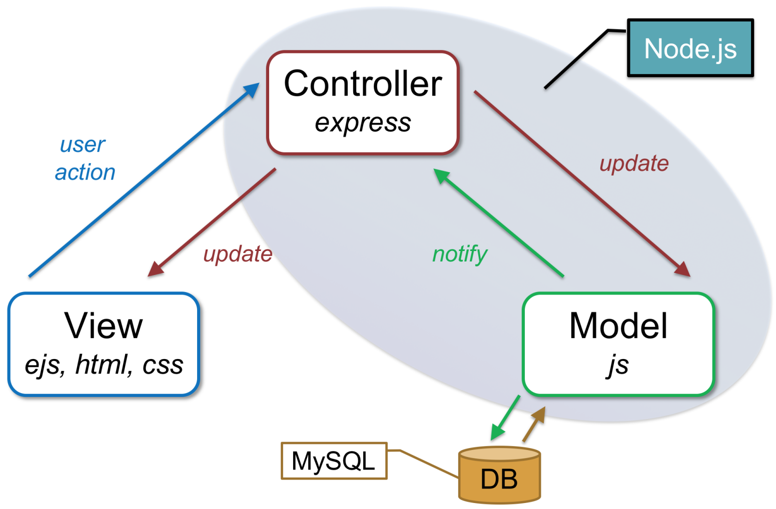


FIGURE 5.15: LPRS technical structure

As for the system technical implementation, LPRS was developed applying the Model – View – Controller pattern (Figure 5.15). Model takes care of functions which directly perform manipulations to data in the database, apply business logic and rules of the system. View visually represents information that Model manages. Controller works on both Model and View – it controls the data flow which is fed into Model and updates View when there are changes in data. Technologies employed include Node.js[6], Express.js[7], EJS[8], HTML[9], CSS[10] and MySQL.

5.5 User Acceptance Test & System Refinements

This section discusses the second round of data collection after the basic features of LPRS were implemented. In order to gather students' opinions of the developed system, a focus group was conducted.

5.5.1 Focus Group

After the preliminary design and development of the recommender system a focus group, the second round of data collection, was undertaken. Ethics application for conducting this inquiry had been approved by Monash University Human Research Ethics Committee (MUHREC) before the commencement of the focus group. Approval certificate of the Ethics application is attached in Appendix C.1.

The focus group was organised to initially investigate the target users' – the students' – opinions of LPRS. Advertisements were posted in the Moodle forum of four units in Faculty of Information Technology (FIT), Monash University briefly presenting the purpose of the research project as well as the working system prototype and inviting students to take part in the focus group activities. Eight students (5 males,

[6] A JavaScript runtime built on Chrome's V8 JavaScript engine. https://nodejs.org/en/
[7] A web application framework for Node.js. https://expressjs.com/
[8] A simple templating language that allows generation of HTML markup with plain JavaScript. https://ejs.co/
[9] Hypertext Markup Language.
[10] Cascading Style Sheets.

3 females) agreed to participate in the focus group which was conducted on the 31st of May 2018. Feedback from the focus group participants was reviewed, summarised and integrated in modifications and improvements of the system prototype in order to improve user experience and understandability of recommendation presentations. Also, based on students' comments, additional features were developed such as filtering recommended peers according to their information (demographic, education, skills, and interests), sorting peers based on characteristic components, and messaging.

5.5.2 Focus Group Activities

The focus group session lasted for approximately 70 minutes. During the session, participants were asked to go through activities including:

- Taking a short questionnaire regarding difficulties in finding study partners. This questionnaire can be found in Appendix C.2.
- Interacting with the system prototype (data inputs – basic information form, four characteristic quizzes, preferences form; system outputs – participants are shown their results of characteristic quizzes and recommendation presentations)
- Discussing topics such as: how the system functions, additional matching criteria which participants find necessary, features which are expected to be integrated in the system, changes which are expected to be made to improve user experiences. The set of prompting questions for the discussion can be found in Appendix C.3
- Taking a short questionnaire about system usability (usefulness, user-friendliness, user experience). This questionnaire can be found in Appendix C.4.

Note that during the focus group, the students were presented with three different versions of the recommendation display (see Figure 5.16) so that participants could give comments on how the results would be presented most effectively. As shown in Figure 5.16, version 1 (Figure 5.16a) showed only the recommendation list and the score indicating how much the students and recommended peers are compatible. Version 2 (Figure 5.16b) provided some information about the peers including degree, major and year that the peers were in. Version 3 (Figure 5.16c) was the visual presentation of recommendation with compatibility score decomposition as presented in subsection 5.4.4.

Recommendations - V1

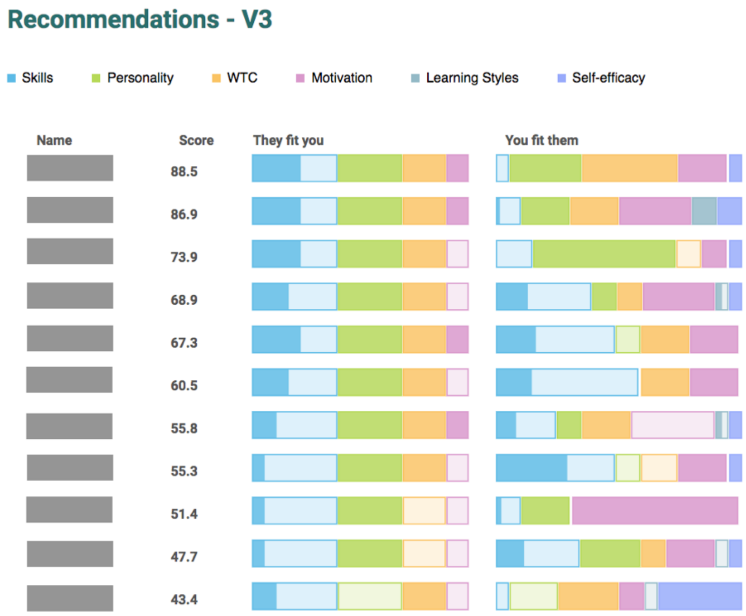
#	Peer name	Compatibility Score
1	[redacted]	88.5
2	[redacted]	86.9
3	[redacted]	73.9
4	[redacted]	68.9
5	[redacted]	67.3
6	[redacted]	60.5
7	[redacted]	55.8
8	[redacted]	55.3
9	[redacted]	51.4
10	[redacted]	47.7
11	[redacted]	43.4

(a) Recommendation display: version 1

Recommendations - V2

#	Peer name	Score	Degree	Major	Year
1	[redacted]	88.5	Bachelor	Computer Science	2
2	[redacted]	86.9	PhD	Doctor of Philosophy	6
3	[redacted]	73.9	Bachelor/Bachelor	Business Specialist and Information Technology	3
4	[redacted]	68.9	PhD	Doctor of Philosophy	1
5	[redacted]	67.3	Bachelor	Computer and Information Sciences	2
6	[redacted]	60.5	PhD	Doctor of Philosophy	2
7	[redacted]	55.8	Bachelor/Bachelor	Business and Information Technology	3
8	[redacted]	55.3	Masters by coursework	Masters of Information Technology	1
9	[redacted]	51.4	Bachelor	Computer and Information Sciences	2
10	[redacted]	47.7	Masters by research	Masters of Philosophy	2
11	[redacted]	43.4	Bachelor	Information Technology	1

(b) Recommendation display: version 2



(c) Recommendation display: version 3

FIGURE 5.16: Three versions of recommendation display used in the focus group session
(a) shows recommended peers and compatibility scores
(b) displays the peers' education information
(c) shows the visual presentation of compatibility score decomposition

5.5.3 Results & System Refinements

This section presents the results from the focus group and system refinements based on feedback from the participating students.

5.5.3.1 Focus Group Results

Based on the activities performed in the focus group session, three aspects explored were perceived difficulties that students encounter when finding study partners; LPRS usability; and participants' suggestions for improving the developed recommender system. Feedback from the focus group, the second data collection, supported the potential of the current research and showed positive prospects of the LPRS in encouraging the formation of learning groups through suggesting study partners. Details of the three aspects are presented below.

Difficulties in finding study partners: Mismatch in characteristics
When being presented with the question "Do you have any difficulties regarding collaboration in study or finding learning partners which you want to mention?", all participants agreed that there existed difficulties when they work or learn with others due to mismatch in characteristics such as personality, motivation level or work attitude. As mentioned by a participant, *"people learn differently and have different personalities, so it is hard to find a suitable study buddy"*. Other students also remarked on incompatibility of learning styles as well as attitudes, *"difference in learning styles and attitudes towards study and mark"* and *"it's hard to make sure that someone is as committed as you"*. Also, skills or experience level play an important part when students look for someone to work with – *"it's difficult to find a learning partner who is at a similar skill-level to me, not higher or lower, and has a similar motivation for study"*, as one student expressed concern.

These characteristics were elicited by the students before they started interacting with LPRS and completed data input forms for the first time. Hence, it seems that the choice of factors used as matching criteria in the developed system are aligned with the characteristics which students perceive as important when working with other peers.

System usability
As for system usability, positive feedback was given by the participants. All the students were in agreement about the potential of the system for helping students find informal learning partners with compatible features. As a participant remarked, *"there is no existing platform that allows students who are strangers to study together. Normally you can meet people at lectures and tutorials, but not people from other streams or timetables"*. This is a common situation with classes of a large size where students are assigned in different sessions, organised in different locations and at different time slots. LPRS is built with the aim to facilitate students' exploration of potential peers and alleviate the obstacles blocking the way of finding compatible learning partners.

Moreover, the majority of the participants (seven out of eight) found LPRS simple to use. They managed to get themselves familiar with the system without much effort or detailed instructions. On average, it took the students approximately 15 minutes to complete seven data input forms (one basic information form, four characteristic questionnaires, one self-rating form, and one preference form). Interestingly, participants also mentioned that the characteristic questionnaires used by the system seemed to generate similar results to ones which they had previously taken, particularly personality and learning styles quizzes.

In addition, the participating students showed their interest in the visualisation of recommendations. As a student commented during the focus group, *"I find the graph really interesting"*. Other participants also remarked that the inline bar chart (as in Figure 5.11) could help students make sense of the compatibility scores which were generated to indicate the degree to which they and other peers fit. Feedback from the students suggested that the graphical display of recommendation results tended to meet their expectations, with suggestions for improving its understandability which are discussed in the following.

Suggestions for improving LPRS user experiences

Importantly, a number of useful comments and suggestions emerged from the focus group activities and discussion which have contributed to further refinements being applied to the system implementation. The comments from the participating students were categorised into five topics: data input process of LPRS, matching criteria, display of recommendations, information of recommended peers to be displayed, and additional features

In terms of the data input process of the system, the participating students provided a number of suggestions. Firstly, users' answers to characteristic forms should be saved for future revision. At the point of the focus group, the system only recorded users' characteristic results, which according to the participants was inconvenient. Secondly, the navigation feature could be improved if users can go back and forth between the user characteristic forms during the data input process. This could be realised with navigating buttons placed in each of the forms. Thirdly, the students expected a consistency in the way the questionnaires were presented. For instance, the original WTC questionnaire used the range from zero to 100 for its items. According to the focus group participants, Likert-scaled items might be more suitable in comparison to the range used in the original version because it would help improve the consistency amongst the forms. Moreover, the students commented that it was difficult for users to choose an exact number to represent their willingness to communicate.

Regarding the matching criteria used by LPRS, the participants suggested that additional factors could be taken into account, such as availability (days of the week, AM, PM), location (campus), degree, major, interests, and active status (last login, frequency of activity). Moreover, a filtering feature which combines different criteria was perceived to be desirable by the students.

Concerning the three recommendation presentations, all participants reported that the first version (Figure 5.16a) was not very informative, while the second version (Figure 5.16b) was simple and useful. Regarding the third version (Figure 5.16c), the students commented that this way of presenting the results was more appealing compared to the other versions. They also suggested that legends for different colours and a demonstration of how to interpret the bar chart would be helpful.

In regard to the information of recommended peers displayed to users, the focus group participants expressed that they would want to have more information in order to facilitate their decision making in whether to contact the peers. The additional pieces of information suggested by the students included the peers' demographics (age, gender, nationality) and interests (for example, programming, database, visualisation, and the like).

With regard to additional features integrated into LPRS, as presented in subsection 5.4.5, three utility functionalities were implemented including message box, peer connection, and peer voting. Feedback from the students suggested that the messaging was crucial since it facilitated initial contact amongst students, whereas the other two features might not be used as much by users. Furthermore, the participants expressed a need for common features which had not been implemented including deleting account and resetting password.

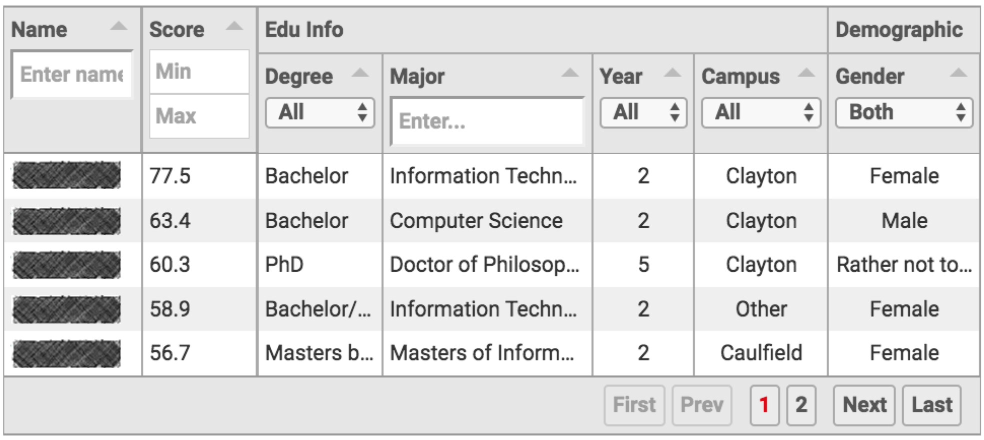
The aforementioned suggestions from the participating students were expected to influence the process of refining LPRS, which is presented in the following section. It is important for modifications to be made in alignment with students' requirements so that the system is ready for evaluation in the next phase of the project.

5.5.3.2 System Refinements

The suggestions from the focus group participants presented in the previous section were revised and taken into account in LPRS refinements. In terms of the data input process, several modifications were made. Characteristic questionnaires were transformed towards a consistent scale i.e., the most positive opinion is represented by the last point (on the right of the scale); while the most negative response is denoted by the first point (on the left of the scale). Moreover, in order to ensure the consistency across the questionnaires, a 7-point Likert scale is used to measure the degree of students' WTC instead of the 0 to 100 scale as in the original questionnaire. Hints and minor instructions were added in case users needed to clarify understanding. For newly created accounts, users were guided through questionnaires sequentially and the progress of questionnaire completion is displayed. For users who have completed the data inputs, they could choose from the available questionnaires and update their responses

Regarding the utility features, notifications on the user's home page were implemented to notify students about new updates (regarding messages, changes in the list of recommended peers, connection requests). Moreover, LPRS was programmed to automatically send an email to a user's address regarding new updates. Additional features including deleting account and resetting password were also implemented.

With regard to the recommendation presentation, "help" buttons with user guidelines and samples were added for more comprehensive demonstration. Another version of presenting recommendation results was developed, providing students with recommended peers' extra information based on which they can filter the results. Figure 5.17 shows a screenshot of this feature.



Name	Score	Edu Info				Demographic
Enter name	Min / Max	Degree: All	Major: Enter...	Year: All	Campus: All	Gender: Both
[redacted]	77.5	Bachelor	Information Techn...	2	Clayton	Female
[redacted]	63.4	Bachelor	Computer Science	2	Clayton	Male
[redacted]	60.3	PhD	Doctor of Philosop...	5	Clayton	Rather not to...
[redacted]	58.9	Bachelor/...	Information Techn...	2	Other	Female
[redacted]	56.7	Masters b...	Masters of Inform...	2	Caulfield	Female

First Prev 1 2 Next Last

FIGURE 5.17: Recommendation results display: Tabular presentation with filtering feature

As shown in Figure 5.17, students can filter the recommendation results based on peers' name, how much they are matched, educational information (degree, major, location, year), demographic information (gender, age group, country), as well as skills and academic interests that the peers have.

5.6 Summary

This chapter described the process of the Learning Partner Recommender System (LPRS) design and implementation, aiming to address research sub-questions 4 to 6 regarding data sources which are available and can be used in the system (sub-question 4), matching approach and implementation (sub-question 5) and presentation approach and implementation (sub-question 6). The system goal and requirements were established. After that, the types of data required by the system for recommendation generation were identified. The characteristic questionnaires used to collect data about students' characteristics were retrieved from literature and integrated into the developed system. Algorithms to generate students' compatibility scores and recommendation list were implemented. Given a generated list of recommended peers, in order to present the result to students, inline bar chart was used to provide them with information about the compatibility score decomposition. An initial user acceptance test was conducted with a focus group of eight students from the Faculty of Information Technology, Monash University. Feedback was revised and system refinements were made.

In summary, phase 2 realised the proof of concept of the research with the working system. The recommender system – LPRS – was tested, evaluated by its target users so that modifications could be made to improve the system before performing evaluation on a larger scale. Figure 5.18 shows a screenshot of the LPRS homepage as a web-based recommender system.

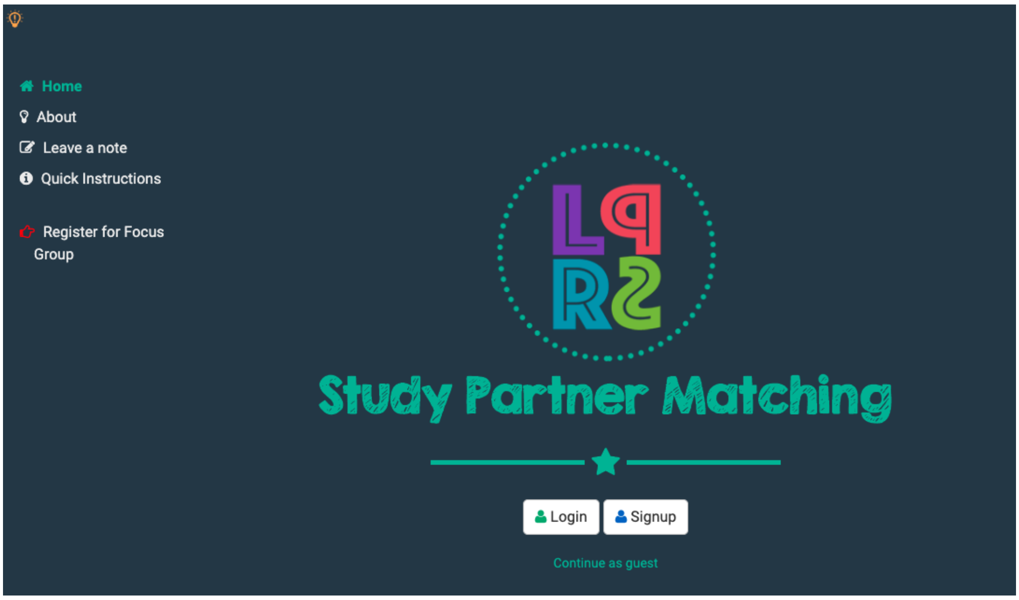


FIGURE 5.18: Screenshot of LPRS homepage

Chapter 6

Phase 3: Evaluation

6.1 Introduction

Chapter 6 focuses on the process of evaluating the proof of concept of this project, the online Learning Partner Recommender System (LPRS), aiming to address the second last research question regarding investigation of the potential impact of the recommender system in creating and increasing positive interactions amongst students. Figure 6.1 shows how the process presented in this chapter methodologically fits into the research design of the present project.

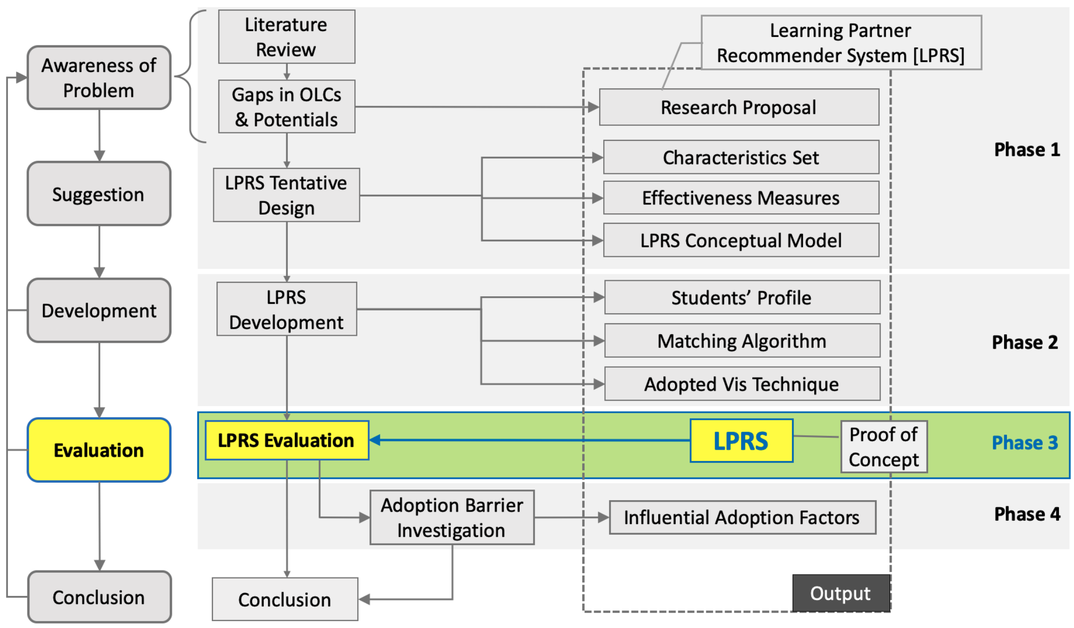


FIGURE 6.1: Project evaluation in research design

Previous chapters have articulated the processes of identifying gaps in the literature (*Awareness of Problem* step), establishing the research proposal which involves building a learning partner recommender system with a goal to promote students' informal learning communities (*Suggestion* step), and then designing and implementing the proof of concept (*Development* step). This chapter details the next step of the research design of the project, *Evaluation* step – which is manifested in the process of evaluating the developed LPRS.

In terms of project phases, the content presented in Chapter 6 constitutes phase 3 of the research (see Figure 6.2). The primary objective of phase 3 is to address the second last research question – **"What is the impact of the learning partner matching system in creating and increasing positive interactions amongst**

students?". This phase, thus, focuses on assessing how LPRS is perceived in terms of its intended purposes.

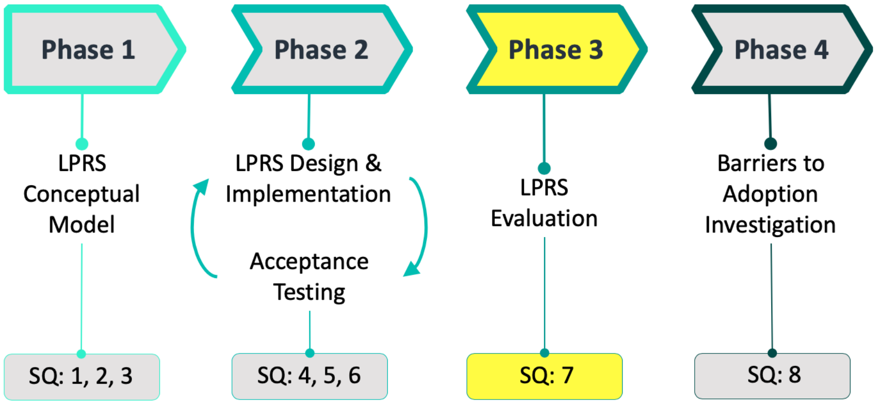


FIGURE 6.2: Project evaluation in project phases

The process of evaluation presented in this chapter was conducted and therefore discussed in correspondence with the two sources of data collected – students as system users and educators (including teaching staff and educational designers) as experts in the educational area. Evaluation with the first participant group was performed with a goal of investigating LPRS in terms of technical validation and the practical impact on the formation of informal learning communities amongst students. Meanwhile, data collection was conducted from the second group in order to gain insights into experts' perspectives regarding benefits of the research and their recommendations for improving system uptake.

The following sections in this chapter present the evaluation process in detail with respect to the aforementioned participant groups. Section 6.2 focuses on a study conducted with students and is composed of two sub-stages: a pilot test on a small set of users and a system rollout on a larger scale. The two stages were conducted with students from the Faculty of Information Technology at Monash University during semester 2 2018 and semester 1 2019, respectively. In Section 6.2, the pilot test and the system deployment are articulated with key points consisting of (a) the primary objectives of each phase; (b) selection of data collection participants, instruments and approaches to collecting data; and (c) results of each phase as well as lessons learnt from the implementation of the evaluation plan.

Section 6.3 describes the data collection organised with a number of experts who have been working in relevant fields including teaching, student engagement, educational design, and course management. In this section, the main goal of the data gathering is defined and the data collection instrument, which was designed in order for the desired data to be collected, is discussed. Results retrieved from the data collection with the educators are reviewed afterwards.

Finally, Section 6.4 concludes the chapter with a summary of the research evaluation with the two groups of participants, students and educators, presented in this chapter. It provides a concise overview of the evaluation process and findings extracted from the data collection.

6.2 Students as System Users

As presented in the previous chapter, LPRS was developed and initially trialled with a group of target users using a focus group approach. Results from this second data collection confirmed the need for such a system to help connect learners with compatible characteristics. This also reaffirmed students' genuine interests in what the system aimed to provide. Furthermore, refinements were made based on feedback from the focus group participants to improve functionality of the system. Therefore, with the goal of assessing the implemented and refined system in a real-life setting, an evaluation plan with students in tertiary education as participants was designed.

The system evaluation with students as system users was conducted in two consecutive stages including a pilot test and a system roll-out. The pilot test was conducted in a unit (also called a subject) taught in semester 2 2018 in the Faculty of Information Technology at Monash University, which is presented in subsection 6.2.1. The small-scale pilot run was followed by the system roll-out implemented on a larger scale during the teaching period of semester 1 2019. Subsection 6.2.2 details the second run in full.

6.2.1 Evaluation Stage 1: LPRS Pilot Test (Data Collection 3)

In this subsection, objectives of the pilot test are firstly presented, followed by a description of participants, data collection instruments, and the method to conduct the pilot test. Results and lessons learnt are thereafter discussed.

6.2.1.1 Objectives

LPRS was designed and implemented with the intention of facilitating learners in finding study partners who potentially hold compatible characteristics. With the target users being students, the system was expected not only to serve its primary purpose, which is to provide students with suggestions for learning partners, but also to operate in an effective manner in the event of users' interactions. For that reason, the main objectives of the first pilot run were to assess the major functionality of the recommender system in a real-world use and to identify any issues regarding usability, functionality, and the purpose of the system. In order to realise these objectives, it was necessary to recruit students as participants to stimulate real users' regular and continuous use.

6.2.1.2 Participants

In order to present the research project along with the developed recommender system to students in a timely and attentive manner, participant recruitment was conducted on a single unit. An undergraduate unit in the Faculty of Information Technology at Monash University, IT Professional Practice, was identified as suitable to run the pilot test because the unit had a large cohort of first year students (413 students enrolled). In addition, one of the aims of the unit is to equip students with communication skills and various techniques for successfully working in a team. Importantly, students' characteristics as matching criteria employed by LPRS are relevant to some topics of the unit such as personality, learning styles, and group collaboration. This data collection was approved by Monash University Human Research Ethics (see Appendix D.1).

6.2.1.3 Data Collection Instruments

With the purpose of integrating the learning communities topic and LPRS into students' discussion activities, a tutorial discussion script was proposed by the researcher. That way, students might become aware of an available tool which they could take advantage of to find study partners and extend their peer source pool. The proposed tutorial discussion included topics such as the definition of a learning community and its significance to students, and how learners' individual characteristics can affect collaboration/teamwork. Also, in the proposed tutorial discussion, LPRS was mentioned to students as an available tool for providing suggestions for study partners. Details of the tutorial discussion topic can be found in Appendix D.2.

Furthermore, in order to gather students' opinions on their experiences with the recommender system, a usability survey was designed. Most questions were designed as five-point response items based on two well-known usability measures – USE (Lund, 2001) and SUS (Brooke, 1996). Details of the online survey can be found in Appendix D.3. The survey attempted to investigate students' perception of LPRS in terms of four key aspects – usefulness, ease of use, satisfaction, and usability. Usefulness denoted students' judgements on how well the system performed in serving its intended purpose. The ease of use section contained questions about the level of difficulty perceived by students when interacting with the system. The third section concerned students' overall satisfaction towards LPRS and potential for the future use of the system. The last section attempted to explore users' opinions on the provided recommendations for study partners as well as to reveal existing issues in order to improve the system.

6.2.1.4 Data Collection Process

A number of steps were taken to conduct the pilot test. Firstly, the unit academics were contacted by the researcher to request their support in the project presentation and participant recruitment. After that, a lecture visit was organised to give the students of the unit a brief introduction about the research as well as to invite them to participate in the project by using the LPRS system. Contact with the academics was initiated at the beginning of semester 2 2018; however, the lecture visit could not be realised until week six of the teaching period.

Moreover, as an effort to insert LPRS into some activities of the unit, minor features were added to the system, and the tutorial discussion topic was proposed to the unit academics. In terms of system adjustment, some small modifications to LPRS were made to align with the unit academics' requirements. For example, previously users only gained access to the services or tools of the system when they had signed up and inputted required information. As suggested by the academics, a trial version were implemented before the study began. The trial version allowed students to interact with LPRS as guests with limited features. This was to enable a student to experiment with LPRS before deciding whether to fully engage with the system.

With regards to the tutorial discussion, as informed by the unit academics, two important foci of the tutorial in week seven were about teamwork and impacts of individual personality on collaboration. Therefore, the set of topic points was designed and handed to the unit academics, which could be used by the tutors of the unit as a reference (see Appendix D.2).

After five weeks, by week 12 of semester 2 2018, 28 students (6.7% of the enrolled students), as recorded by the system, created an account, completed data inputs and could receive recommendations on learning partners. It should be noted that the system did not keep track of the number of students who used LPRS as guests; so the actual usage might have been higher. The online usability survey was sent out to the 28 aforementioned students at the end of the teaching period (end of week 12, semester 2 2018). However, the survey response rate was low – only four students responded to the questionnaire.

6.2.1.5 Results & Lessons Learnt

As reported above, over a period of six weeks during semester 2 2018 when LPRS was made available for students from one unit, 28 students had interactions with the system. The system usability survey received low response from the 28 users – only 4 out of the 28 took the survey.

With regard to verification of the major functionality of the system, feedback from the four respondents was positive regarding the four key aspects which the survey attempted to investigate. In terms of the usefulness of the system, three responses were positive about the potential of LPRS in facilitating expansion of students' choice of study partners; the other response was neutral. The four students also agreed that the recommender system could help in triggering students' self-reflection on their individual characteristics and better understanding of one's own characteristics could facilitate collaboration with other peers. Three out of the four students responding to the survey contended that the quality of recommendations generated was good and the way results were presented to users was easy to understand, while the other student chose the neutral option.

Regarding ease of use aspect, all four students shared the same opinion that it was easy to learn to use LPRS, the instruction provided was adequate, and LPRS successfully performed expected interactions. However, only two students agreed upon the ease of navigation of the system while the other two respondents held an impartial view.

In respect of perceived satisfaction, three students remarked that LPRS was pleasant to use and the experience they had with the system was satisfactory. Two out of the four survey participants asserted they would want to use the recommender system in the future, while the other two only provided a neutral indication of intention for future use.

Concerning perceived usability, all four responses agreed that LPRS had good potential to facilitate connecting students with compatible characteristics and improving learning experience. All four respondents expressed that they had an understanding of the meaning of the recommendations and the matching process of the system behaved as expected. Moreover, three students commented that the features of LPRS were well integrated; and the other remarked that the developed functionalities were acceptable. The system was monitored closely during the five-week period and any issues were addressed promptly. As a consequence, no student reported that they had encountered any technical issues. At a minimum, through the pilot test, it was verified that the system functioned well technically and was ready to be deployed on a larger scale.

In terms of encouragement of real users' regular and continuous use, the number of students who interacted with the system was not high: only 28 students created an account and completed all data inputs. The low figure could be explained by some factors. The first factor was the late launch of this data collection. If the participant recruitment had commenced earlier when the semester started, the amount of data collected from the pilot test might have been increased. Since the research project (along with LPRS) was presented to students during mid-semester period, it was predicted that students might not have enough time to explore the system and/or to become aware of benefits from using it. Moreover, it could be assumed that after the first six weeks of the semester students in the unit had already found peers to work/learn with; or they had formed their own way of doing their study (either individually or with an existing group) without having a need for finding new study partners. The second factor could be the trial feature of the system where students could take the personality test during a tutorial without having to sign up. The system at that point did not keep track of the number of guest users; therefore, the system's actual usage could be higher, but there was no official record of this figure.

Stage two of the evaluation process (subsection 6.2.2) was specified to focus on the impact of the implemented system in terms of facilitating students in finding learning peers and encouraging the formation of informal learning groups (communities). Strategies for recruiting participants and conducting the research evaluation needed to be carefully planned.

6.2.2 Evaluation Stage 2: LPRS Deployment (Data Collection 4)

This subsection focuses on the system deployment on a scale larger than the previously presented pilot test. The contents of this section are organised as follows. Firstly, objectives of this round of data collection are specified, followed by participants, data collection instruments, and the approach to conducting the study. Finally, results of this stage of the evaluation process are discussed.

6.2.2.1 Objectives

As presented in subsection 6.2.1, the LPRS test run was performed with a small number of system users who were students in one unit in the Faculty of Information Technology at Monash University in semester 2 2018. The results provided indications that LPRS functioned well according to the participating students' feedback. With a goal of investigating the potential impact that the system might have on facilitating the creation of students' informal learning communities, another data collection was planned which aimed to recruit a larger number of students from more diverse cohorts. The objectives of this round of data collection included:

- to explore students' general engagement in using the proposed learning partner recommender system,
- to investigate students' opinions of recommendations of study partners as well as the approach to presenting the recommendations, and
- to study potential effects of the system on encouraging the formation of informal learning communities/groups amongst students.

6.2.2.2 Participants

In order for LPRS to generate recommendations which are close to students' preferences, the number of users should be relatively high. In addition, a more diverse user pool from different years, courses and majors, was desirable. Therefore, the participant recruitment of this data collection was expanded, aiming to reach both undergraduate and postgraduate students from different courses.

As for the postgraduate group, the recruitment was performed in semester 1 2019 Orientation week (O-week) in the Faculty of Information Technology. The research project and the developed recommender system were briefly introduced to new Master's students during three lecture sessions during that week. The students were invited to participate in the research by experimenting with the system and using it as a facilitative tool to look for study partners.

In terms of the undergraduate cohort, invitation to participate in the research was conveyed to students in two units in the Faculty of Information Technology. The first unit was the same one with which the pilot test had been conducted (approximately 100 students). The second unit was a first-year programming subject with a large number of students (approximately 400). Approved and supported by the unit academics, a visit to workshop sessions was organised to inform students about the project and to seek their participation. This data collection was approved by Monash University Human Research Ethics (see Appendix E.1).

6.2.2.3 Data Collection Instruments

This round of data collection was conducted for the whole semester (12 weeks) throughout which the system was available for both groups of students to use. The data collection instruments included (1) the recommender system collecting data that students entered; (2) three online surveys: two surveys about system usability in week six and week ten, and a 1-minute survey about barriers to system usage which was sent to students who created accounts but did not complete data input forms; (3) individual interviews with students in order to get better insights in the system usage and its potential impact.

As for the first data collection instrument, LPRS was made available to students as a tool to find study partners with compatible characteristics. At the same time, it was employed as an instrument to collect data about users' engagement with the system (in terms of number of logins and completion of data inputs) and interaction with other users (in terms of messages sent and connections created).

With regard to questionnaires, three online surveys were designed to gather students' opinions of LPRS. The first survey was released in week six, aiming to explore the sense of community amongst students, the situation in which students were using LPRS in facilitating searching for compatible learning partners, and to investigate any issues emerging which might cause difficulties (or obstacles) in making use of the system. This online survey can be found in Appendix E.2.

In addition, a one-minute survey was created and sent out during week six to students who had signed up but never proceeded to complete any input form. This short survey aimed to explore students' perceived difficulties in or barriers to using the system. There were three questions – two check-box questions and an optional question. The first two questions asked for reasons for not using the system and factors which might help improve users' engagement. The third question asked for students' suggestions or feedback. This short questionnaire can be found in Appendix E.3.

Lastly, a final survey was designed and planned to be sent out in week 10 of semester 1 2019 to students who had completed all data inputs on LPRS. The last survey consisted of five main sections – perceived usefulness, perceived ease of use, perceived satisfaction, perceived usability and feedback on learning groups or communities (if any created). The first four sections of the questionnaire were based on USE (Lund, 2001) and SUS (Brooke, 1996) questionnaires and the last section was based on Sense of Community (McMillan and Chavis, 1986) and CSS questionnaire (Rovai, 2002c). The final questionnaire can be found in Appendix E.4.

Apart from the online surveys, students who had used the system were encouraged to take part in an individual interview which aimed to gain better insights in the system usage, strengths and weaknesses, as well as the potential impact of the system. The full version of the interview procedure is provided in Appendix E.5.

6.2.2.4 Data Collection Process

In comparison to the pilot test, the scale of stage two of the project evaluation was larger, targeting a higher number of students from different levels and educational backgrounds during a longer period of time. A series of steps were taken to recruit participants and perform a data collection.

With regard to postgraduate students, first of all, contact was made with professional and academic staff who were in charge of O-week activities so that the research project presentation could be embedded into the agenda. During O-week, new students were encouraged to attend a number of lecture and lab sessions designed to help make the transition to university life of the newcomers' easier. With an aim of reaching as many new students as possible, a five-minute slide set introducing the project and the system was prepared and provided to the academic staff who were giving talks in the welcome lecture sessions. The project introduction was meant to be reasonably brief so that students would not be overloaded, considering the fact that a great amount of new information was planned to be presented during O-week.

In conjunction with the brief research project presentation, which aimed to make students aware of the tool, in order that students would indeed start experimenting with the system, an activity was embedded into lab sessions that were supported/run by the peer mentors of the faculty. The activity was 10 minutes and designed for the peer mentors to present the main features of the recommender system and for new students to take the first step in trying out the tool. Before the lab session, the peer mentors were briefed on the research project and the developed system as well as important points expected to be covered about the system within the 10-minute session. The mentors were also provided with detailed instructions and a set of presentation slides that could be used when they went through the LPRS introduction with students. The materials for peer mentors can be found in Appendix E.6.

As for the undergraduate students mentioned above, lecture/workshop visits were organised with the two selected units to invite students to participate in the project. LPRS was introduced to the students as an available tool that they can use when looking for study partners. They were also encouraged to respond to other data collection instruments during the semester.

During the 12-week teaching period, the data collection instruments were implemented on both cohorts. Firstly, throughout the semester, LPRS kept track of the number of accounts created, students' data completion progress, and users' interactions within the system. Secondly, the three online surveys were released in corresponding order as planned. The week-six questionnaire was sent to 46 students who had created an account with LPRS and completed all required data inputs (consisting of a basic information form, four characteristic questionnaires, and a form about preferences on study partners). Also, the students who signed up but did not proceed to complete any forms in LPRS were invited to take the one-minute questionnaire; however, there was no response from the invitees. After that, an invitation to the final survey was sent out in week 10 of semester 1 2019 to 49 students who completed the system data input. Lastly, there were five students who registered for the interview session; however, only one Master of Data Science student responded to the request for organising an interview.

6.2.2.5 Results & Lessons Learnt

LPRS was made available for students in FIT, Monash University throughout the 12-week teaching period of semester 1 2019. Invitations to three online surveys were sent to students who had different degrees of engagement with LPRS. Nevertheless, the response rate of the surveys was low. Moreover, students were invited to and reminded of the individual interview; however, only one was successfully organised. This subsection discusses the results from stage 2 of the evaluation process with regard to the three objectives established in subsection 6.2.2.1.

Objective 1

With regard to exploration of students' general engagement in using LPRS, the overall system usage and response to surveys as well as the interview invitation were low. Figure 6.3 shows the summative student participant figures over the 12-week period in which the system was deployed.

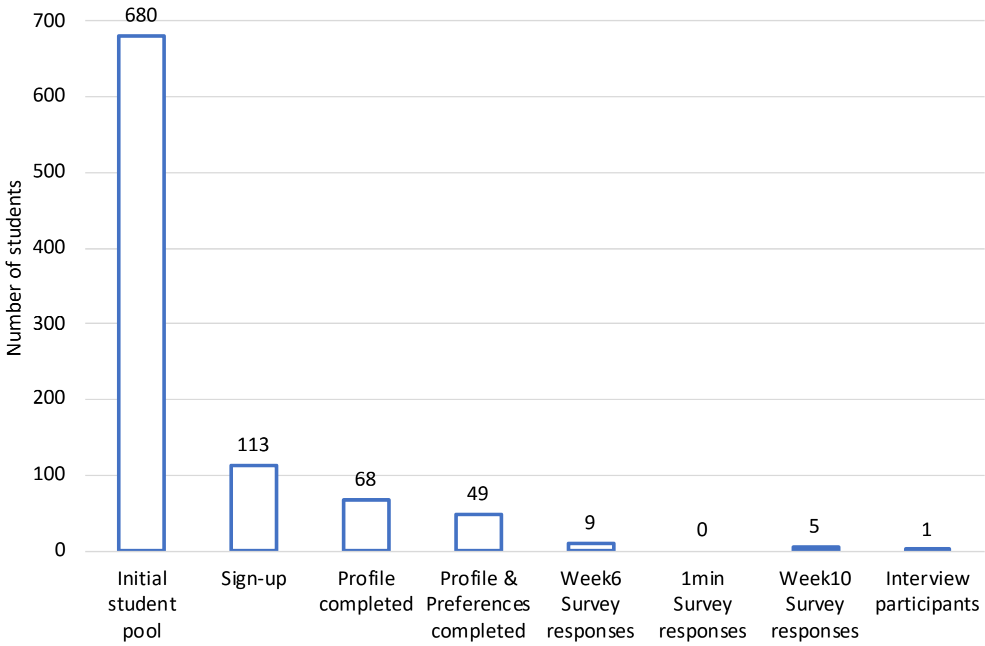


FIGURE 6.3: Student participant summative figures

In Figure 6.3, the first four columns are about students' LPRS usage. The potential user pool was identified by summing up the number of students to whom the research project and LPRS were presented. According to provided attendance statistics, 449 students attended sessions during Orientation week, about 30 students were present in the lecture of the first undergraduate unit and around 200 students took part in the workshop of the second undergraduate unit on the day of the project research presentation. The aforementioned numbers made up a total of 680 potential target users, out of which 113 (around 16.6%) created an account (signed up) with the system. However, only 68 of the students who signed up, filled out all characteristic forms and received results for their characteristics. Results for the characteristics, which included Willingness to Communicate (WTC), personality, self-efficacy, learning styles and motivation, altogether constitute a user's characteristic profile. Out of the 68 students with profile data, less than 75% (49 students) proceeded to fill out the last form – preferences on study partners – in order to receive recommendations on peers with compatible characteristics.

The last four columns in Figure 6.3 show the number of students who responded to the three online surveys (Week6 Survey and Week10 Survey about system usability; 1min Survey about reasons for disengagement) and the interview invitation. As presented in subsection 6.2.2.4, invitations to the two surveys about system usability were only sent to students who had completed all required data inputs. The reason was that users' feedback on LPRS was considered valid only when they had indeed experimented with the system. Thus, 46 students were invited to do the first usability survey and 49 students were asked to fill out the second questionnaire (46 and 49 was the number of accounts with completed data inputs by the end of week five and week nine semester 1 2019, respectively). As shown in Figure 6.3, only nine students returned their feedback in response to the first usability survey and five for the second one. There was no response to the one-minute questionnaire. As for the interview, 54 students were invited to participate in the session including those who had explicitly registered for the interview and the 49 students with completed data input in LPRS. Yet, only one student responded to the invitation and took part in the interview.

Low buy-in from students during system deployment posed a substantial question which required more thorough investigation – "What were the main barriers to system adoption?". In order for the chapter to be consistent about the process of system evaluation, content presented in this chapter emphasises aspects of the data collections relevant to the system evaluation. The emerging question mentioned here is for the purpose of foreshadowing the focus of the next chapter, Chapter 7 of this thesis.

Objective 2 & 3

In terms of investigation of recommendation quality and presentation as perceived by students (objective 2) and potential effects of the system on encouraging the formation of informal learning communities/groups (objective 3), there was not sufficient data to draw a proper conclusion on these matters. While students' responses to the surveys and interview participation were poor, feedback from the respondents did provide some important insights. Responses to the surveys were collated and thematic analysis was performed on the transcript of the student's interview so that corresponding concepts were assembled into one primary point. Three key points worth mentioning which emerged from the responses to the surveys and the interview are presented below.

The first point was about a generally positive perception of the system. Survey responses ranged from neutral to positive when asked to give feedback on the potential of the system for facilitation of finding study partners and creating initial contact. The quality of recommendations generated were perceived as easy to interpret and have good potential to help students find peers who they could learn and work well with. Also, all respondents agreed that LPRS was easy to use. The student participating in the interview held the same line of thought, *"I find the user interface quite user-friendly, it's easy to use"* (interview, June 2019).

The second point was regarding possible reasons for low usage. Respondents to the first survey provided some reasons that might have been important factors in low system interaction. The reasons mentioned involved students' busy schedules, lack of interest in finding learning partners, unawareness of the tool, unclear benefit of the system, and plagiarism and/or collusion avoidance. Again, the interviewee agreed that one plausible explanation for low LPRS use was students being unaware of the tool. As the student participating in the interview remarked,

> *"Maybe it's about the awareness. Not many of us are aware of this. I knew about this because I was in the peer mentor training session, but many other don't even know about this. So you should put some banner or something like that so that people know there's a platform like this."* (interview, June 2019)

In addition, the student also raised that users' slow response time (when using message box feature) due to the insufficient notifications from LPRS might cause loss of interest in being engaged with the system,

> *"But in the system, when I messaged someone, I did not have a notification if someone messaged me. So I had to log in and check the message. I*

> *didn't log in with the system everyday so sometimes when I checked, I had a message one week ago. And then they would respond me after one week."* (interview, June 2019)

Even though emails were automatically sent by the recommender system to notify students of changes in the top five recommended peers and/or new messages received, this way of notification might have not been effective. However, when asked whether the student received notification emails from LPRS, the student admitted, *"Yes, but because I've got many spam mails from some forums for example, I just marked them as read and didn't really read them"* (interview, June 2019).

The third point concerned suggestions for improving user engagement. There was an optional question in the two online surveys asking students for their opinion on what can be done to make them more engaged with the recommender system. Some suggestions were: a mobile app version of LPRS, a more appealing user interface, and more useful features offered by the system. The student who was interviewed also suggested some functionalities which could be favourable to the students. The student commented that if the system had allowed filtering recommendations based on units which recommended peers were taking (or had taken), it would have been more relevant and useful for users. As the student explained,

> *"Maybe you can have a feature which allows students to contact people from the same class also. For example, in my class there are more than a hundred people, I just know like five or six of them – these five or six, I've known from before. Otherwise, we don't really talk in class in a hundred people lecture. So if you have a feature like 'if you want someone from your own class', that would be more relevant."* (interview, June 2019)

Additionally, an experience shared by the student during the interview is also worth mentioning. The student talked about getting contacted by another student through the system, and how the participant advised the peer regarding questions about the course and some units:

> *"There was this student, she's from semester one. She had some doubts regarding the same subject that I already had. She texted me, and I texted her. So we had our contact and later on I helped her on that [...] We have met quite a few times. Because she's a first year, I can't really ask her anything because my subjects are not related to her right now, but yes I could solve her doubts and help her with that."* (interview, June 2019)

Although a thorough exploration on this case was not conducted, the told experience was an interesting demonstration of the potential for encouraging and facilitating connection making amongst students.

6.2.3 Summary

To summarise, the process of evaluating the project with students as participants was conducted in two main stages – a pilot test in semester 2 2018 and a system roll-out during semester 1 2019. LPRS was made available to students to use during teaching weeks in the two semesters as a tool to find study partners who potentially have compatible characteristics with them. It was contended that the concept of the project was realised successfully with the main intended function – suggesting compatible study partners. However, the low survey response rates from students made it difficult to provide concrete remarks on the quality of recommendations generated as well as the tangible impact of the system regarding facilitation of the formation of informal learning communities.

One significant aspect emerging from the evaluation stage was about system adoption. Results from the previous rounds of data collection (presented in Chapter 4 and 5) had demonstrated positive feedback and genuine interest from students. Nonetheless, the system usage and engagement when it was in deployment was much less than anticipated, which raised a significant matter of interest – what are the barriers to system uptake. In order to keep this chapter focused on the evaluation of the research project, the next section continues to present the data collection conducted with educators regarding the system – its strengths, weaknesses and potential. Chapter 7 is dedicated to a discussion on system (as well as education application) adoption – enlightened by literature and from both educator's and students' perspectives.

6.3 Educators as Experts in the Area (Data Collection 5)

This section focuses on the research evaluation with educators as experts in the educational field. The objectives of this investigation are specified in subsection 6.3.1, followed by the description of participants and employed data collection instruments in subsection 6.3.2). The process of data analysis and results are presented in the last subsection.

6.3.1 Objectives

With the ambition of promoting the creation of informal learning communities amongst students, students' feedback on the implemented recommender system was undoubtedly vital. However, given the area to which the project aimed to make contributions and the context in which LPRS was deployed, educators' perspectives on the research project as well as the developed tool were considered greatly valuable. Therefore, a study was conducted with educators who have had considerable experience in the educational area. The objectives of this round of data collection with the educators were:

- to gather the participants' opinions on strengths and weaknesses of the developed learning partner recommender system, and
- to explore the potential impact of the research on encouraging the formation of informal learning communities in alignment with participants' professional perspectives

6.3.2 Participants and Data Collection Instruments

6.3.2.1 Participants

To recruit educators as participants for this round of data collection, convenience sampling was used. The potential participants' contact information was retrieved from Monash University's public domain with thoughtful consideration for maximising the diversity of participants. Fifteen faculty members from the Faculty of Information Technology at Monash University were contacted and invited to participate in the research. Eleven out of the 15 (eight males, three females) agreed to participate in this round of data collection which was conducted in May and June 2019. The participating educators have been involved in different capacities within the faculty, including teaching, student engagement, educational design and course management with years in the position ranging from two to more than 20 years. Amongst the participants, there were four educational designers, six lecturers, two course directors, one learning advisor, and one deputy dean of education (note that a participant could be in more than one position at one point in time). Although all participants were from the same faculty, they had different expertise, experiences, roles and responsibilities. This diversity, to a certain extent, did form a representative sample which could provide insightful inputs on the research project and the developed system. Table 6.1 summaries the information about the role and years of experience of the educators participating in this data collection.

Participant	Role(s)	Years of Experience
1	Educational designer	4
2	Educational designer	8
3	Educational designer	5
4	Educational designer	4
5	Senior lecturer Course director for the Master of IT	7
6	Senior lecturer	7
7	Senior lecturer Deputy dean of education	21
8	Senior lecturer Course director of Master of Data Science	4
9	Lecturer	2
10	Lecturer Learning advisor	15
11	Senior lecturer	20

Table 6.1: Summary of educator participants

6.3.2.2 Data Collection Instruments

The educator participants took part in the data collection by doing an individual semi-structured interview, except for a focus group organised with the educational designers. The focus group with the educational designer team was conducted for over an hour, while the duration of the interviews ranged from 35 minutes to 55 minutes. The list of the questions used in this round of data collection can be found in Appendix F.

As for the educational designers, the focus group approach was used since the participants usually work together as a team on a daily basis. Moreover, discussion organised amongst team members could create a more interactive situation where insightful feedback was more likely to emerge. The questions asked during the focus group regarding participants' experience with students were also slightly different from the interviews because the educational designers in general focus more on facilitating educators in designing and developing learning experience in terms of suitable use of technology, learning and teaching techniques and strategies.

With regard to the more academic-focused participants, individual interviews were employed to better fit the participants' schedule. Interview questions consisted of three main sections: (1) participant's information, (2) participant's awareness of the formation of students' informal learning communities, and (3) feedback on the research project along with the developed recommender system. In the first part of an interview, a participant would talk about the role they were in and the experience they had with students. In the second part, the participant would share their view on students' informal learning activities – the importance of informal learning communities, factors which they considered significant to the formation of students' informal learning groups based on their experience, and also factors which they believed to be important when students were assigned into groups in formal learning contexts. The last part of the interview focused on the participants' inputs regarding the present research and the learning partner recommender system – its strengths and shortcomings, as well as the potential impact of the system.

6.3.3 Data Analysis and Results

The focus group and interviews were audio recorded with the participants' consent and transcribed. Spoken fillers and repetitions were removed so that the statements were presented in a concise manner. By adopting a saturation sampling approach (Saunders et al., 2018), the process of conducting the interviews, transcribing and analysing the transcripts was performed simultaneously until no new data emerged within each focused topic.

The data analysis process involved two stages. In the first stage, the participants' answers were grouped into different categories which were based on the frame of the interview questions (as in Appendix F). Six initial categories were identified. The first category was about educators' awareness of students forming informal learning communities. The second category gathered the participants' remarks on the strengths of LPRS, while the third category concerned the drawbacks. The fourth category explored the educators' opinions of the potential benefits of LPRS. The fifth category consisted of the participants' suggestions on improving the recommender system. Lastly, other feedback regarding the research, along with LPRS, that did not fit into the previous categories were grouped into the last heading, called additional comments.

In the second stage, from points commented on by the educators in the categories listed, a number of themes emerged. The themes were identified in alignment with different aspects of the research and the developed recommender system. For instance, remarks on the process of collecting students' data appeared in different categories such as the strengths and drawbacks of the system, educators' suggestions, as well as additional comments. By iterating through the points and assigning them into suitable topics, a set consisting of eight themes was formed. The first seven themes are summarised in Table 6.2. The last theme about the educators' views on possible reasons for low buy-in from students is presented in the next chapter since its focus is to explore the barriers to the adoption of LPRS, and voluntary technology for learning purposes in general.

<table>
<tr><th>#</th><th>Theme</th><th>Aspects</th></tr>
<tr><td>1</td><td>Students' forming informal LCs</td><td>• Awareness of existence
• Uncertainty of the LC formation process</td></tr>
<tr><td>2</td><td>Creation of students' characteristic profile</td><td>• Length of process
• Potential of users' misinterpretation
• Necessity of employed forms

<u>Suggestions:</u>
• Exclude some forms
• Pull data from external sources
• Modify the questions
• Provide multiple levels of matching</td></tr>
<tr><td>3</td><td>Recommendations for study partners</td><td>• Visual presentation
• Reliability of LPRS & results generated
• Characteristics used as matching criteria
• Report & filtering feature

<u>Suggestions:</u>
• Simplify result display
• Provide different levels of details of matching score</td></tr>
<tr><td>4</td><td>Suitability</td><td>• Types of students
• Time points to advertise LPRS</td></tr>
<tr><td>5</td><td>Benefits to students' learning experience</td><td>• Direct benefit
• Side benefits</td></tr>
<tr><td>6</td><td>Data privacy</td><td>• Potential of data abuse

<u>Suggestions:</u>
• Apply security procedure
• Employ a sound privacy policy & terms of use agreement</td></tr>
<tr><td>7</td><td>User interface</td><td>• Navigation
• Main features display
• Visual appeal</td></tr>
</table>

TABLE 6.2: Themes from data collection with educators

The following subsections 6.3.3.1 to 6.3.3.7 elaborate the themes summarised in Table 6.2. In the discussion below, educational designers are referred to as Ed-designers; individual academic participants are referred to as A-1, A-2, and so on.

6.3.3.1 Awareness of Students' Informal Learning Communities

Regarding experience with students and awareness of formation of students' informal learning communities, all participants confirmed that they were aware that there existed activities where students informally got together to discuss, share ideas, help and learn with each other outside formal classes. There was no firm explanation for the process of forming such informal learning groups; however, the participants' anecdotal and/or observational experience converged on a number of common factors. The first and foremost factor mentioned was students' common backgrounds, either demographic or academic backgrounds. As remarked by A-8,

> *"What I've found is that [...] interactive media students hang together [...]. Or students who are in Games Design who sit together. [...] There's a number of international students who also sit together, assuming that those who don't speak English in class. So I think that's language commonality."* (A-8)

Also, A-2, who had been teaching both undergraduate and postgraduate units, commented,

> *"With the postgrad students, one thing I notice to start with is that almost all of the groups are basically by language. So Chinese students sitting together, Indian students sitting together and so on. So they are the two largest groups. That's one of the major ways that they separate into groups. Apart from that, I'm not really sure."* (A-2)

The second factor commented by the educators was familiarity, the situation where students had previously taken the same units together. As noticed by different participants, some students might have completed a number of subjects together and consequently, they tended to form a group when they attended another unit. A-3 noted,

> *"I see them working together, not necessarily because of the group assignments because of their previous friendship... they know each other even from the past (or) from overseas maybe they studied undergrad with each other."* (A-3)

The third factor which was believed to play an important part in the formation of informal learning groups was tutorial activities designed to encourage interaction and collaboration amongst students (A-3, A-4, A-7). As A-3 explained, not every student joining a class knew other peers. In this case, in order to encourage students' interactions and collaboration, activities of a unit needed to be designed taking this goal into consideration. The participant shared,

> *"But if they are all totally strangers to each other, then I think it's really important for the lecturer and the tutors – of course more for the tutor during the tutorial environment – to create some activities to provide them opportunities to introduce themselves and work with each other. Because in the programming units, they all work on their own machine with no group assignment or group discussion or group activity. I have seen students start alone and end up alone at the end of the semester. Within the tutorials, no friendship started, or any informal group created."* (A-3)

Another factor mentioned was close proximity in a same physical space that happened randomly (either a formal or an informal physical meeting space) (A-6, A-7). The participants believed an important factor which helped creating effective informal learning groups was students' shared physical space where they could be in the same setting to discuss, share ideas, and learn with and from each other. As A-6 asserted,

> *"I would think that what important is working in person, physical space – maybe sitting next to somebody, especially peer programming sitting next to someone, you can google to solve the problem together, reading an error message together... something like that, it really helps if you have another human being sitting right next to you. If you're trying to describe them over email, slack, WhatsApp or WeChat, it's a lot harder. You lose a lot of context. So we always encourage informal setting."* (A-6)

Also affirmed by A-7,

> *"They clearly need to be in the same space, same environment which actually create the physical setting. Because many students complain that they don't have time to meet outside their contact hours. It sounds like a minor inconvenience but when you start talking about informal study groups and so on, that is really crucial."* (A-7)

The last but not least important factor was students' shared viewpoints regarding their study. As A-7 contended, one of the elements which students would find important when they looked to form a learning group was *"right attitude"*, a situation where students shared similar expectations for what they wanted to achieve and for what they were supposed to do to achieve the goal. The educator explained,

> *"I can see the difference in expectation and different ways of engaging with whatever happening in the room. It kind of creates the bond. In the lecture theatre, which is quite an isolated environment, you sort of start seeing little pockets of communities here and there. Of course sometimes there are loners. But I see that sort of communities, they're usually behaving in a very similar way."* (A-7)

Thus, although there was no official observation regarding how students informally formed learning groups or learning communities, the participating educators did provide insight into the situation based on their practical experience with students. The factors remarked included students' common backgrounds – either demographic or academic backgrounds; familiarity – the situation where some students had previously taken the same units together; tutorials designed to encourage interaction and collaboration amongst students; (randomly) close proximity in a same physical space (either a formal or an informal physical meeting space); and shared expectation and attitude towards their learning.

From the educators' perspectives, although informal learning groups have obvious benefits, the formation of these activities are homogeneous, mainly driven by cultural background or mere randomness. The current work, on the contrary, aims to stimulate informal learning communities which are not randomly created. Rather, the formation is based on students' relevant characteristics and differences in their preferences for study partners in order to maximise the compatibility degree of recommended students.

Apart from exploring the educators' perspectives on students' informal learning communities, this round of data collection with educators, as mentioned previously, aimed to obtain feedback from educational perspectives primarily on the strengths and drawbacks of LPRS as well as its potential impact. The following subsections 6.3.3.2 to 6.3.3.7 present the themes regarding the recommender system which emerged from the focus group and interviews with the participants.

6.3.3.2 Students' Characteristic Profile Creation Process

The second theme emerging from the data collection with the educators was about the process of creating students' characteristic profile in the recommender system. This is the very first steps students need to take in order to receive recommendations on study partners when using LPRS. The following presents the participants' concerns regarding (1) long process of data input and (2) provision of false information. Suggestions for addressing these concerns were also discussed by the educators.

First of all, one point which was raised by 9 out of the 11 participants was the time required to complete all data inputs. The participants seemed to share a similar view that the time a student needs to spend on completing the data input before receiving recommendations on study partners might be unnecessarily long. Some comments regarding this aspect included: *"it's a lot of forms here"* (A-6); *"there's quite a bit of work for them to do – there's quite a lot of details, questionnaires."* (A-4); *"It looks like there's quite a lot of information for an individual to fill in. If it takes like half an hour [to complete all the forms], some might feel like too much"* (Ed-designers); *"I'd be interested to see how much patience the students actually have to go through all the forms"* (A-2). However, one participant affirmed the importance of all the characteristic questionnaires used and considered the number of forms as acceptable. As the participant argued,

> *"Your work is very research-based, it's based on literature and everything. All the things you've considered are important. So you can't go and say 'ok I'm removing this because it's long'. Because you're focusing on actually covering all the attributes and variables and factors."* (A-3)

Thus, the participant acknowledged the necessity of employing the questionnaires in order to collect students' data which were required to generate more accurate recommendation results.

Another point which was suggested to be taken into account by some educators was the possibility of false information provided by users. As previously presented, user data collected by the system consisted of three main categories: basic information (demographics, education, skills and academic interests), characteristic profile (WTC, personality, self-efficacy, learning styles, and motivation), and preferences on study partners (regarding the five characteristics and skills). In this round of data collection, participants had different concerns about either unintentionally or deliberately incorrect information which users might input into the system. For example, A-2 was worried that, since characteristic data were retrieved using questionnaires (self-rating in some sense), students might be tempted to make themselves look good – "there might be a tendency to just put in as high as possible; otherwise you won't find a match". Another participant was also concerned about inaccuracy in profile data inputted by students, but unconsciously, due to a mismatch between the students' self-judgements on the characteristics and their actual characteristics. The participant referred to motivation and language skills as an example: a student who was highly motivated or had good English skills might rate themselves as low at motivation or poor at language skills due to their lack of confidence. Also, regarding false information, A-4 was worried that some users might use the system with wrong intentions and therefore would input misleading (or false) information:

> *"Unfortunately, some people out there maybe target female students because they're lonely or whatever and want to make connections, they're not interested in study, they're just interested in meeting more females."* (A-4)

In terms of the long forms of data inputs, the educators suggested some approaches to shortening the process. Firstly, as some participants proposed, some characteristic questionnaires, such as willingness to communicate (WTC) and motivation quizzes, could be excluded. The participants believed that a student's decision to sign up with the recommender system was sufficient to indicate that the student was someone moderately willing to communicate with others and promisingly motivated in doing well in their learning (A-2, A-6, A-7). As A-7 suggested, *"I think the fact that they already register, you can limit the amount of information that students can actually input"*. This way, the information input process could be shortened. However, the data collected about students' characteristics would then merely be based on an assumption.

Also, there would not be concrete values for those characteristics, while these values are critical for generating the recommendations.

Another approach to improving the process of creating the students' characteristic profile was to retrieve data from external sources such as a Learning Management System (LMS) (Ed-designers, A-6). With data extracted from an LMS, students' learning styles and/or motivation as well as basic information could be identified; and consequently, would make it easier for students. As A-6 commented,

> *"I wonder if there's a way that you can go and get some information from Moodle. So I think about the way you work with Moodle, you go and look at each individual week one at the time or you look at the assessment section, like tell me what the big picture is. We can get the information about learning styles at a low level, and then they do a survey at a higher level if they want to."* (A-6)

This aspect, data retrieval from external sources, was acknowledged in the present research as a potentially greatly approach to collecting students' characteristic data. This could help speeding up the profile creation process as well as improving the objectivity of data inputted. Nonetheless, this was identified as further research due to limitations on time and resources.

A third approach to alleviate the situation was multiple level of matching (Ed-designers, A-4, A-6). It was suggested that the system should have been able to provide students with recommendations on study partners without having to provide all information at once. Reminders and prompts could be used to encourage students to complete the data input at later stage in order to receive better recommendations. The participants affirmed that this technique could help with the process of building students' characteristic profile. As A-6 commented,

> *"If there's a way to do that without necessarily filling all the forms, I think it can get a lot more attraction because it seems like a lot of stuff."* (A-6)

With respect to dealing with inaccurate data inputted by users, some suggestions were also provided by the educators. One way to address this concern was data extraction from external sources to improve the equitability of input data (as mentioned above). Another solution suggested by a participant was to rephrase the questions in a neutral manner. As A-2 suggested, *"So if there's some way that you can phrase the questions so that they don't appear kind of positive or negative, then maybe that would get more honest answers"*. The participant remarked that students might think scoring highly in the characteristic quizzes was equivalent to having a good image, which might lead to a tendency to provide misleading information. In this case, framing the questions in the characteristic questionnaires in a neutral way could improve the situation.

To summarise, there were some concerns from the educator participants in terms of the process of collecting students' characteristic data. Suggestions were provided in order to address the issues raised, which showed a space for improvements in the future. Moreover, feedback from the academic group suggests good potential for integration of Learning Analytics into LPRS for utilisation of available learners' data in online learning environments. Interview data also implied the importance of immediacy in order to improve system usability.

6.3.3.3 Recommendations for Study Partners

The third theme identified from the data collection with educators was around recommendations on study partners generated by the system. Positive comments were mainly focused on the set of characteristics used as matching criteria and the ability of LPRS to allow further filtering of recommendations. Some drawbacks regarding the recommendations included perceived reliability and presentation. Moreover, the participants also provided input on approaches to address the remarked shortcomings.

Firstly, the set of individual characteristics used as matching criteria by the system to generate recommendations on learning partners was highly commended by the educators participating in the focus group and the interviews. According to the participants, the characteristics which were taken into account were important and highly relevant in the context of students' collaboration. As A-2 commented,

> *"[...] things like personality, learning styles, I think that really makes sense if you could find someone who has similar interests and similar way of going about that. I think that's a really good idea if that could really work."* (A-2)

Another positive feature was noted, *"I love the way you have considered pretty much all the factors which I'm sure part of your literature review and everything"* (A-3). Particularly, one participant was teaching two undergraduate and postgraduate units which require students working in a team either to develop an application for a real world client (undergraduate) or to conduct research in a particular area (postgraduate). The participant commented on the thorough consideration for the choice of the characteristic set,

> *"You care a lot about the things that we care about, right. We also consider culture, gender diversity. We also do a personality test [...] You care about skills; we care about skills too. I think we should care a little bit more about motivation and so on."* (A-6)

The positive feedback demonstrated that from the education perspective, the set of characteristics employed to generate recommendations on learning partners was significant and had potential for generating meaningful and relevant recommendations.

The second positive response from educator participants regarding the peer recommendations was about its ability to allow users to further filter the initial recommendations generated for them. As presented in the previous chapter (Chapter 5 – LPRS Design and Implementation), with the tabular presentation of recommendations students could filter the learning partner recommendation results based on criteria such as the peers' demographics, education and/or academic interests. The participants remarked that this feature could provide students with more flexibility and control over the suggestions given to them. As a participant observed,

> *"I like the way at the end you even give them even further flexibility – so it's not just recommendations, you also allow them to choose from so many different variables to make further filtering."* (A-3)

Beside the positive feedback on the recommendations generated by LPRS, as mentioned at the beginning of the subsection, some issues were also raised in terms of students' perceived reliability and the complicated visual presentation of recommendation results. The following presents the educators' concerns regarding these drawbacks, along with suggested approaches to address them.

As for reliability, one participant mentioned, *"whether this works might depend on whether students see the system as trustworthy, if the matchings they get actually turn out to be accurate"* (A-2). This concern could be considered in two different ways – whether students perceived the system itself as legitimate and consequently accepted and acted on the recommendations on learning partners which were presented to them; or whether the recommendations generated based on inputs from students indeed had good quality and successfully met students' needs. However, either way, results from the round of data collection with students (presented in Section 6.2) could not provide enough information for conclusive evidence of the factual impact of the system. In order to enhance the perceived reliability of the system as well as the recommendations generated, some participants suggested employing the influence of social norms and/or endorsement from different stakeholders. As A-6 explained,

> *"If you have some champions who are also students who could vouch for it, then it's no longer like teacher saying or education staff saying 'you should do this because it would be good for you'. Because it's the same as saying 'here's the pdf on Moodle that you should read because it's good for you'. They are not going to read it, right? But if you have a student saying 'Hey, I did this in the past and it was successful'. So in Open Day, you have a little tent, you have 'here's a free drink and by the way, do you know this is a system here for you to go and meet up with other people'. I feel like student champion would be one way to do it, but I don't know what form that would take."* (A-6)

Also, A-6, A-7 and A-8 affirmed that endorsement from creditable stakeholders would increase students' perception of the learning partner recommender system. As A-7 believed, *"I think some level of endorsement [...] and contextualisation can also play a role of creating a safe environment"*.

In terms of the way recommendations were presented, most of the educator participants agreed that both ways of presentation (inline bar chart and tabular presentation) were carrying a large amount of information which could potentially overwhelm users. With regard to the visualisation, the Ed-designers commented,

> *"The bar chart of recommendations here, there's a lot going on and it's not quite easy how to understand it... The visualisation is really good, but it needs training and we don't know whether students read the instruction or not."* (Ed-designers)

Nonetheless, they acknowledged that in order for users to have a comprehensive view of a number of top recommended peers, such amount of information was required to be displayed in a single view – *"you're going to have everything in the same page, it can get very big – which is not necessarily a bad thing, you just need to manage it"* (Ed-designers). The similar feedback was given regarding the tabular presentation. A-4 remarked,

> *"Trying to put up a lot of information at once, they may be overloaded. The score there is like matching score, maybe initially that's what they want to know, when they click on that, it shows them a bit more information rather trying to show everything at once."* (A-4)

In summary, the educators asserted that the recommendation presentations were informative and useful to students; however, simpler approaches could be more desirable in order to facilitate users' quick comprehension of recommendation results.

6.3.3.4 The Suitability of LPRS

The fourth theme emerging from the discussions with the participating educators was about the suitability of LPRS in terms of its users and usage. There were mixed views on the types of users that the system would be most beneficial for and the time points when it would be most needed.

One point of view was that LPRS would be most helpful for a new cohort of students who freshly enrolled in their courses and the system should be introduced at the beginning of a semester. Explanation for the remark was that in the context of today's universities with increasing numbers of international students, as well as large-sized classes, such a system might help improve students' feelings of isolation and facilitate the transition process into a new learning environment (A-2, A-3, A-4, A-8). As A-4 remarked,

> *"Then you've got other students who arrive and it's very clear that they feel very isolated, they haven't made those connections. And it's not just international students, it's a bigger barrier for international students, I feel domestic students also. They come to a university and they're put into big classes, they feel it difficult to make connections with other students."* (A-4)

Another view proposed that the recommender system would be best used at certain points during a teaching period for specific purpose such as assignment preparation and exam revision (Ed-designers, A-6). The participants believed that at those points of time, students tended to have a need for finding learning partners with whom to carry out their study. A-6 provided an example of such a suitable time for the system to be used – when students look for the schedule of consultation sessions:

> *"There is a block called consultations on Moodle units. Students can go there and be like, 'When is the consultation time? Oh, there is a peer study thing we can do as well'. Because they are in a mind-set where they're actively looking to find help for a particular problem they're trying to solve. That point in time might be worth to try the system and use it."* (A-6)

Also, the participant was convinced that students would be more attracted to using LPRS at certain points during a teaching period:

> *"It feels like a tool like this might be seasonal around exam time. It would be great if I have someone to study with. If you're doing it at the start of the semester, you try to invite people to use it at the beginning of the semester, it's not as obvious as it could be used."* (A-6)

Even though the educators held different views on the usage and reasonable points of use of the system, they converged towards one point: the system usage would be tightly related to students' needs, their perceptions with regard to learning with others, and whether they need help and/or want to connect or not. A-7 provided an insight,

> *"Some students who are in a certain mind set, they make use of it, whatever you throw at them. They are that kind of students. While others, maybe they have other priorities, they are quite keeping to themselves, whatever you're going to give to them, they will pass it. My point is it's good to give some suggestions or directions of how to make use of it. We also need to be aware that we can lead a horse to water and we can't actually make it drink."* (A-7)

Feedback from the participating educators regarding the suitability of LPRS can well serve as a suggestion for who the system is advertised to and when. Most participants believed students who were new to the university would benefit most from the recommender system. Others were inclined to think that it was more important to get the system in front of students at the right times, when they actively seek help in their study.

6.3.3.5 Benefits to Students' Learning Experiences

One important goal of the data collection round with educators was to gather feedback on the potential impact of the project from educational viewpoint. Results from the focus group and interviews showed that from educational perspectives, the research had both direct and indirect potential benefits to students' learning experiences.

Direct benefits

The direct benefit which all educator participants asserted was aligned with the primary goal of the research project – to facilitate the formation of informal learning communities amongst students. The Ed-designers remarked,

> *"You're matching up students against each other, which is presumably better than just talking to someone randomly that you meet in a class – that's also powerful. My personal feeling is if you can get the stickiness there, this can be a powerful product."* (Ed-designers)

The "stickiness" discussed by educator participants during the focus group referred to the features of a system which could help improving user retention. The educational designers asserted that the research could make a compelling impact on encouraging the creation of learning groups (or communities) amongst students provided that the system could provide extra support to better retain its users.

In a similar vein, other participants' feedback maintained that the research would potentially help with students' learning experiences in terms of connecting with peers with compatible characteristics and supporting each other in their study. A participant, who was a course director, remarked:

> *"I think I like the idea because I think people find it difficult to form groups or to meet other people especially international students I think they feel quite isolated when they come here so some online tools for basically match-making is probably a really good idea. Rather than online dating apps, this is more targeted towards study, I think that's a really good idea."* (A-2)

Similarly, A-6, who showed strong support for peer learning during the interview, believed that the present research fits well with what might help with promoting peer learning – *"I think the direct benefit of having people connected and actually appreciate the benefit of peer learning is the most important thing you can have from something like this"*. Another participant, who was a course director of a Master's course, commented *"Of course it [LPRS] is beneficial to the students. Especially when they lack background knowledge."* (A-5)

Thus, from an educational experts' viewpoint, the system held a potential impact which was along the lines of the primary goal of the research project – facilitating the formation of informal learning communities amongst students.

Indirect benefits

Apart from the direct benefits presented above, some indirect benefits were identified by the faculty members participating in the data collection, including trigger for self-reflection and a group forming facilitation tool integrated within a particular unit.

Students' self-reflection

One interesting side benefit recognised by the participants was the potential capability of LPRS to trigger students' self-reflection. During the process of data input, students were asked to create their characteristic profile which was the composition of results from different characteristic questionnaires. According to the participating educators, students, through doing the characteristic forms with earnest intent and revising the profile results presented to them, might naturally and effectively think about themselves, the way they work and study. An Ed-designer contended,

> *"Just thinking about the way that you learn and how you can learn effectively with another person is incredibly powerful. So even if that's the only thing that you get out of it [the system], I think it's already a good thing."* (Ed-designers)

Along the same lines, A-2, A-6 and A-7 also acknowledged this by-product of the learning partner recommender system. As A-2 remarked,

> *"I don't think that many students are kind of self-reflective when they come in. So when doing those questionnaires honestly then a side-effect would be you actually think about what your learning style is or your communication style is or something like that. I don't think that a lot of students are aware of that – like learning style or personality traits. Maybe they can just benefit from that kind of exercise."* (A-2)

Especially, the educator, who was a lecturer of the unit with which both the pilot test and system deployment were conducted, asserted:

> *"I think by identifying something and thinking about it makes them aware of what they are (self-reflection). I can see the pragmatism of framing it as a match finder, I can see the practical incentives around it. At the same time, I also see the benefit of this if it were framed as a way for them to identify where they are at as a learner."* (A-7)

One important point to notice was that the participants independently recognised this potential benefit of the learning partner recommender system throughout the focus group and individual interviews. This showed that from the educators' perspectives, students during their learning process might not consciously reflect on the way they performed their learning. They maintained that the characteristic questionnaires employed by the system, with thoughtful design and implementation, could potentially trigger students to take a step back and self-review their learning for adjustments and improvements.

Mediation tool in particular subjects

Another side benefit of the system suggested by some educators was about an opportunity where LPRS could be integrated into particular units in order to facilitate forming groups which align with the learning objectives of the units. A-8, the chief examiner of a unit providing students with an opportunity to experiment with different kinds of technology, commented,

> *"I think the informal network is interesting. But I also think it [the system] can be useful for forming teams to work in my units [. . .] It gives you the side benefits of finding someone that I potentially want to work with within the classes."* (A-8)

Similarly, A-7 affirmed LPRS could be employed within a unit if it could support *"the nature of the unit and assessment design"*. The participant explained,

> *"I can see that the system can work as a mediation device; especially you can't expect all tutors have that level of skills to mediate or manage the group, the system gives a quite interesting and objective isolated interface to make the process much more transparent."* (A-7)

In addition, A-5, course director of a Master course, believed the system had the potential to be a facilitation tool for a unit with a large number of students where it could help them find peers to learn with or to seek advice as long as it would not lead to plagiarism or collusion. A-5 commented,

> *"Other things [beside assignments] would be good, like tutorial questions because we only have two hours so students might not understand the material, then after the class they can seek for help from peers."* (A-5)

Thus, from educational perspectives, beside the main intended benefit – facilitation of informal learning group formation – the learning partner recommender system could also provide some indirect benefits. LPRS was considered to have potential for encouraging students' self-reflection. In addition, the system could be used in particular units where it aligned with the design of the units.

6.3.3.6 Data Privacy

One theme which emerged during the focus group and interviews was centred around data privacy issues. This concern was mentioned by more than half of the participants (8 out of 11 educators). The educators were concerned that students might prefer not to share information about their individual characteristics – such as learning styles or personality – with others. As A-4 asserted, *"some students may find it as an invasion of their privacy, or they don't want to do these tests or they don't want people know what their personality is"*. This was also a matter of concern to some other participants, which they thought might play as a factor preventing students wanting to use the system. As A-6 pondered,

> *"I wonder if there's any privacy consideration that having my information on the system might prevent me wanting to use it. But that's something that I might be different from a student; others might have quite strong opinion about it. It might or might not be something important."* (A-6)

The educational designers also had a similar view on the data privacy matter. One educational designer mentioned,

> *"For many systems, when you sign up with your information – that information is yours. But at some point, with this system, the system shares the information with others. This might be not about right or wrong, but if we can find out if this is something that make them uncomfortable then you know what to do."* (Ed-designer)

With the concern being raised, the participants suggested the issues could be addressed through a proper security procedure, data privacy policy and terms of use agreement. A-4 contended that addressing the drawbacks regarding data privacy might improve students' feelings of safety when they came to use LPRS.

> *"I think privacy and security is a big issue and you need to get some assistance on what is appropriate – what sort of inputs are available, what sort of security about people's personal information, what are possible options in terms of responses (can people block contact from people that they don't want to), how do you manage that, how do you deal with people pretending to be other people.... I think you can address a lot of those, and it might give more peace of mind to student when using it."* (A-4)

6.3.3.7 User Interface

The last theme arising from the data collection with educators was related to the user interface (UI). As was in the case of the suitability of LPRS, the participants had different views on how the system looked and felt.

The educational designers suggested that the main functionality of LPRS should be displayed more profoundly to the users and thoughtful consideration should be given to colour use. The participants explained that since most significant feature of the system was to provide recommendations on study partners, this part of the system should be the centre of the whole application:

> *"Things like My Basic Info, My Profile, My Preferences – they are sort of things that you might want to change every now and then, but that's not the main business, I would say. While things like Message Box, Connections, Recommendations – they are the main. [...] The main business of the tool should be displayed in an obvious way."* (Ed-designers)

Moreover, regarding the colours used in the interface of LPRS, the educational designers suggested that the colour use needed to be consistent and purposeful in order to convey their intended meanings.

> *"Another thing is we spend a bit of time is Information Design, I would think that there's a lot of colour going on. You should definitely consider about people who are colour-blind, those who can't pick up the colour as well. [...] I want to say that you should keep it consistent. At the moment, I think that my eyes are actually go to the orange but actually this (a different) part is more important on this page."* (Ed-designers)

Other participants were quite positive about the user interface. According to them, the UI of the system was a plus point. Simple, clean, and easy to navigate are the main feedback from the educators. Some positive comments included *"I like the interface. It's nice and colourful"* (A-8); and *"I really like the interface. [...] It's so nice and clean. I really like it. First of all, I like the UI of it. It's so fantastic"* (A-3). Although this aspect of the system had not been intended to be particularly important, an appealing and easy-to-use user interface was observed by educators who were experts in Computer Human Interaction area. This, to some degree, confirmed the user friendliness aspect of the developed system.

6.4 Key Findings

The process of evaluating the research and the developed system involved data collection conducted with two main groups of participants – students and educators. The findings emerging from the evaluation process were as follows:

- The learning partner recommender system functioned well in a real life context in terms of realising the concept of this research – collecting data about students' characteristics along with preferences on learning peers, and generating recommendations on study partners based on the provided data.
- Response from students about LPRS showed generally positive feedback with regard to its usability, potential impact on facilitating students in finding study partners with compatible characteristics, user interface and features provided.
- From educators' perspectives, apart from the main goal of the research, which is to encourage the formation of informal learning communities amongst students, the research and the system holds potential for bringing other by-products – encouraging students' self-reflection and being integrated into units in formal learning contexts.
- System engagement from students was low, which necessitated further investigation of barriers to the uptake of LPRS in particular and educational applications in general.

6.5 Summary

This chapter described the process of evaluating the learning partner recommender system (LPRS), aiming to address sub-question seven about the impact of implementing the learning partner recommender system in terms of encouraging positive interactions amongst students. The evaluation process presented made up the first part of phase 3 of the project, as demonstrated in Figure 6.2.

Data collections were conducted with participants who were students and educators in the Faculty of Information Technology at Monash University. Results from the data collection with students confirmed that the proof of concept of the research functioned well in a real life setting with real users. However, the buy-in from students was low which called for a more in-depth investigation and thorough reflection on the research, which is the focus of the next chapter. Importantly, feedback from the educator participants showed that the system has both primary and secondary potential benefits for students' learning experiences. Strengths and drawbacks of the system were also commented on. In summary, LPRS was fairly remarked by the participating educators with suggestions for improvements and solvable issues.

Chapter 7

Phase 4: Barriers to Voluntary Educational Technology Adoption

7.1 Introduction

As briefly mentioned in the previous chapter, the necessity to understand the general efficacy of the developed Learning Partner Recommender System (LPRS) as well as to investigate the reasons for the unexpected low uptake of LPRS was of great importance. This study might shed some light on relevant stakeholders' perceptions of information technology (IT) adoption in informal non-mandatory situations and factors influencing students' decision-making process. This is particularly significant given that a growing number of educational technologies continue to be introduced, and yet the adoption rates are not as high as expected (Abrahams, 2010; Al-Ammary, Al-Sherooqi, and Al-Sherooqi, 2014). Therefore, this chapter focuses on a study of the barriers to students' adoption of technology for learning purposes in voluntary contexts, with LPRS as a case study. Figure 7.1 illustrates the position of the study in the research design of the present project.

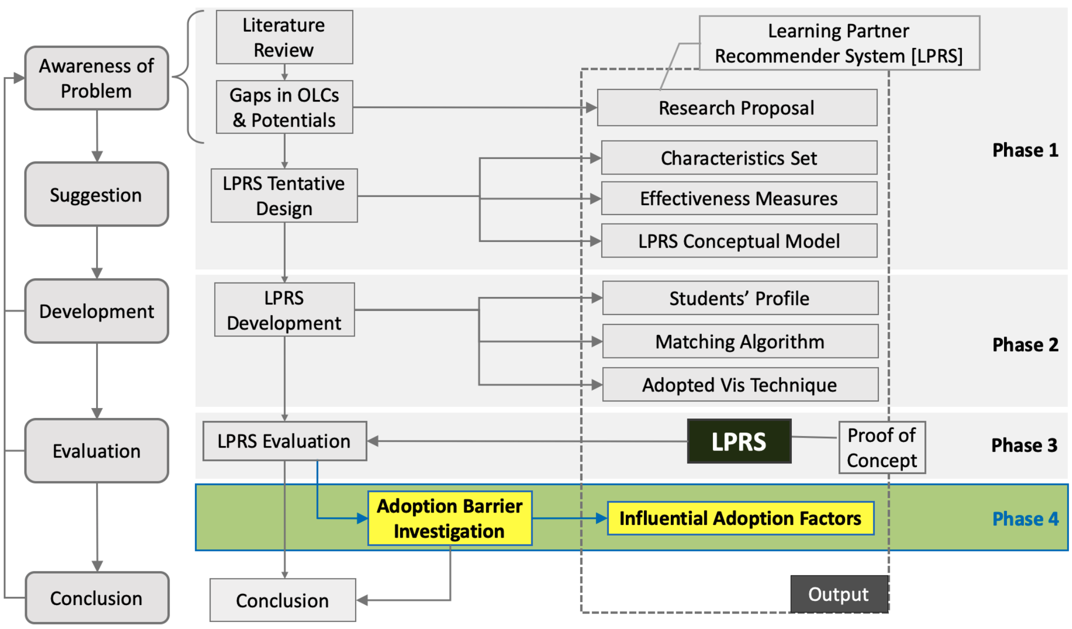


FIGURE 7.1: Study of barriers to students' adoption of voluntary technology in context of the research design

This chapter presents an inquiry to explore the obstacles to voluntary technology adoption with students as the target users, aiming to address the last research question: **"What factors influence students' adoption of voluntary applications for learning purposes?"**. The primary goal of the investigation is, therefore, to conduct a thorough reflection on the process of the implementation and evaluation of LPRS; and, more importantly, to obtain better insights into factors important to students' adoption/rejection of unmandated educational applications.

The chapter is organised as follows. Section 7.2 provides a review on the most widely known technology acceptance theories. After that, Section 7.3 describes the method of the study: research model, participants, data collection instruments, and the approach to analysis. Section 7.4 to 7.6 present the findings from the analysis of interview data with educators (Section 7.4), students (Section 7.5), and synthesis of the views from the two participant groups (Section 7.6). Subsequently, implications for technology adoption research induced from the findings from the study are highlighted in Section 7.7. Finally, Section 7.8 concludes the chapter with an overview of the study of barriers to adoption of voluntary information technologies conducted in phase 4 of the research project.

7.2 Literature on Technology Acceptance

In order to obtain insight into what might prevent students from using a new technology, an understanding of the key factors influencing users' adoption of technology is essential. In the literature, a number of theoretical models have been developed in attempt to better explain the adoption and diffusion of a new technology, or an innovation as referred by Rogers (2010).

The current research is aligned with the view of adoption and diffusion as presented in Straub (2009), which describes adoption as a subprocess of diffusion. Straub (2009) proposes that diffusion theories concern the "macro-perspectives" of the whole adoption-diffusion process, while adoption theories emphasise "micro-perspectives" aspects. She argues that an adoption theory focuses on investigating the choices that an individual makes to adopt or reject an innovation (new technology). A diffusion theory, on the other hand, attempts to explain how an innovation is spread amongst a population. Therefore, diffusion theories strive to provide a comprehensive overview of the stages and elements constituting the complete process in which an innovation/technology is accepted, and its usage is spread amongst members in a certain social context. An important point is that diffusion is composed of individual adoption. Technology diffusion is unable to occur without an individual adopting the technology.

A good number of technology adoption theories and associated models have been introduced which attempt to identify the determinant factors impacting an individual's behaviour of accepting a newly introduced technology, including, but not restricted to, Theory of Reasoned Action (TRA) (Ajzen and Fishbein, 1980), Theory of Planned Behaviour (TPB) (Ajzen, 1985), Innovation Diffusion Theory (IDT) (Rogers, 2010), Technology Acceptance Model (TAM) (Davis, Bagozzi, and Warshaw, 1989; Venkatesh and Davis, 1996; Venkatesh and Davis, 2000; Venkatesh and Bala, 2008), and Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003). Amongst them, IDT, TAM, and UTAUT are the most widely used technology adoption theories/models (Taherdoost, 2018).

The following in this section discuss Rogers's Innovation Diffusion Theory (IDT) (subsection 7.2.1), Technology Acceptance Model (TAM), along with its extended versions (subsection 7.2.2), and Unified Theory of Acceptance and Use of Technology (UTAUT) (subsection 7.2.3). Rogers's Innovation Diffusion Theory has been widely employed in a large range of disciplines as the most influential theoretical framework to explain the process of an innovative idea being spread amongst a community (Sahin, 2006). Meanwhile, TAM has been considered "to be a valid and robust model that has been widely used" (King and He, 2006, p.740) as well as "the most common ground theory in e-learning acceptance literature" (Šumak, Heričko, and Pušnik, 2011, p.2068). As for UTAUT, the model was introduced by Venkatesh et al. (2003) from the integration of similar constructs in existing influential user acceptance models. Since its formation, the model has been cited by a large number of publications (nearly 25,000 citations based on Google Scholar searched in October 2019), and therefore the model appears to be a popular choice for researchers in the technology adoption area. These three adoption theories/models have been widely employed in attempts to understand technology adoption in educational contexts.

7.2.1 Innovation Diffusion Theory (IDT)

Rogers's Innovation Diffusion Theory (IDT) has been considered as a seminal work which establishes the foundation for later research on technology adoption and diffusion. In his work, Rogers stated that diffusion is "the process in which an innovation is communicated through certain channels over time amongst members of a social system" (Rogers, 2010, p.5); and "diffusion is a special type of communication in which the messages are about a new idea" (Rogers, 2010, p.6). Rogers's theory provides a comprehensive framework for understanding the factors that influence the collective adoption of a new idea/concept/technology. The work covers several aspects of the diffusion process such as elements of diffusion, the innovation-decision process, characteristics of innovation and their adoption rates, adopter categories, change agents, and so on. Because of the breadth of Rogers's IDT, in order to provide a basic understanding of the theory, only relevant aspects are reviewed and presented in this section including elements of diffusion and perceived characteristics of an innovation.

7.2.1.1 Elements of Diffusion

As suggested by the definition, there are four main elements of diffusion. These include *innovation*, *communication channels*, *time*, and *social system*. An *innovation* is "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (Rogers, 2010, p.12). Thus, the "newness" characteristic of an innovation is subjective, mainly depending on the individual's perception. An idea could have been invented or used for some time, but if an individual considers it as novel, it is still an innovation. Also, the "newness" of an innovation implies a certain degree of uncertainty (about different aspects of the innovation such as functions, advantages, disadvantages, outcomes, obstacles) in the diffusion process. Individuals, in the innovation-decision process, keep on seeking for and processing information in order to reduce this uncertainty and make a decision to adopt or reject the innovation.

The second element of diffusion, according to Rogers, are *communication channels*. Rogers defined communication as "the process by which participants create and share information with one another in order to reach a mutual understanding" (Rogers, 2010, p.18). There are four primary components composing the diffusion/communication process: the idea (innovation); the source (an individual or an adoption unit) with experience/knowledge on the innovation; the receiver (another individual or another adoption unit) with no experience/knowledge on the innovation; and a communication channel. The communication channel is the means by which the idea is conveyed from one end to the other. It can be either mass media which is beneficial in the early stage of the diffusion process to facilitate individuals' awareness of the innovation, or interpersonal communication which "has become more important for the diffusion of certain innovations in recent decades" (Rogers, 2010, p.18).

The third element of innovation diffusion involves *time*. Rogers remarks that time is an aspect which has received little attention by most behavioural science research. According to Rogers, the time element is involved in the diffusion in three aspects: (1) the innovation-decision process, (2) the innovativeness of an individual (or an adoption unit), and (3) the adoption rate in a specific period of time.

Social system is the last element of diffusion, defined as "a set of interrelated units that are engaged in joint problem solving to accomplish a common goal" (Rogers, 2010, p.23). Because the diffusion process occurs within the social system, different aspects of the social structure have a great impact on either facilitating or impeding the adoption and diffusion of a new technology. Rogers also explains how several factors such as social norms, opinion leaders, and change agents can influence the diffusion process.

7.2.1.2 Perceived Characteristics of an Innovation

The theory posits that characteristics of an innovation perceived by individuals can help explain and predict the rate of adoption of the innovation. Rogers defines rate of adoption as "the relative speed with which an innovation is adopted by members of a social system" (Rogers, 2010, p.22). The diffusion of an innovation over time resembles an S-shaped curve, demonstrating cumulative frequency of individuals' adoption from the early stage till the end of the diffusion process. Though different factors such as nature of communication channels, nature of social system, and the change agents' effort also have an effect on the adoption rate, most research focused on the perceived attributes of an innovation to predict its rate of adoption.

Five attributes of innovation discussed by Rogers include *relative advantage*, *compatibility*, *complexity*, *trialability*, and *observability*. *Relative advantage* is defined as "the degree to which an innovation is perceived as better than the idea it supersedes" (Rogers, 2010, p.15). This characteristic is posited to positively relate to the adoption rate of an innovation. Factors which may make an innovation be perceived as "better" can be economic advantage or social status. Importantly, Rogers emphasises that the "better" notion of the innovation is mainly subjective – objective advantages of the new technology are not as significant as how individuals personally view it. The perceived relative advantage can be in different forms such as low cost, profitability, time-saving, or immediate reward. He further points out that a preventive innovation, a new technology that an individual decides to adopt in order to reduce the probability of unwanted incidents in the future, has a slow adoption rate. This is because it is not easy for the relative advantage of a preventive innovation to be demonstrated.

Compatibility refers to "the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters" (Rogers, 2010, p.15). Thus, a technology can be perceived by individuals as compatible (or incompatible) with their own socio-cultural values and beliefs, with their experiences with previously used technologies/systems, and with their own needs. This perceived attribute is believed to be positively related to its rate of adoption. Factors, such as how the innovation is named and positioned within the potential adopters' social system, play an important part in increasing the perceived compatibility of the innovation.

Complexity is the feature which is negatively related with the adoption rate of an innovation. It is "the degree to which an innovation is perceived as difficult to understand and use" (Rogers, 2010, p.16). Although using a new technology can be beneficial for its adopters, an excessively complicated process might reduce the likelihood of the innovation being used. For example, Ng, Shroff, and Lim (2013) found that the Mahara platform was perceived as difficult to use and inflexible by student teachers even though they did go through official training. The simpler and easier to use a system is perceived, the more likely it becomes favoured by its target users.

Trialability refers to "the degree to which an innovation may be experimented with on a limited basis" (Rogers, 2010, p.16). A new technology which allows its potential users to experiment with a certain number of features can help reduce the uncertainty about the innovation. Hence, this attribute of an innovation, perceived by individuals, is positively correlated with the adoption rate. Previous studies on adoption of the internet and e-learning in educational institutions have shown that trialability is one significant factor predicting how users accept or reject the new technology (Hsbollah and Idris, 2009; Martins, Steil, and Todesco, 2004).

Observability is the last perceived attribute of an innovation which was discussed in Rogers's IDT. It is defined as "the degree to which the results of an innovation are visible to others". This attribute is stated to have a positive correlation with the adoption rate – the more discernible the results of an innovation are, the more likely it is for individuals to adopt it. The results can be perceived by the potential adopters personally or vicariously (Straub, 2009).

Thus, Rogers's IDT has informed the significance of different elements of diffusion (innovation itself, communication channels, social system and time) as well as the essential role of the perceived attributes of the innovation to the likelihood of the innovation to be adopted by individuals. It provides a comprehensive framework for understanding individual as well as collective adoption; and it has been widely used to study innovations acceptance in a large range of areas. However, the theory is "primarily descriptive rather than prescriptive" (Straub, 2009, p.632) – it mainly describes the adoption-diffusion process and why adoption-diffusion happens; it does not provide advice on what best course of action to take to facilitate adoption. In addition, as Straub (2009) remarked, the magnitude of IDT "makes it difficult to frame a single study within the structure" (p.632). Most studies which employed IDT made use of a part (or parts) of the theory to conduct investigations in their particular contexts.

7.2.2 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) was first introduced by Davis (1985), being adapted from Theory of Reasoned Action (TRA) (Ajzen and Fishbein, 1980), to specifically explain the determinants of users' adoption of information systems. According to TRA, an individual's Behavioural Intention (BI) is the precondition for one's actual performance of a behaviour. BI, in turn, is directly determined by one's attitude toward the behaviour and Subjective Norm (SN).

As in TRA, TAM is based on findings of previous information system research and posits that a user's actual behaviour of using an information system primarily depends on his or her BI. However, TAM postulates that behavioural intention is jointly influenced by attitude and Perceived Usefulness (PU). The attitude toward using the system, in turn, is majorly determined by Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). Figure 7.2 shows the original TAM by Davis, Bagozzi, and Warshaw (1989). PU is defined as "the prospective user's subjective probability that using a specific application system will increase his or her job performance within an organisational context" (Davis, Bagozzi, and Warshaw, 1989, p.985); while PEOU refers to "the degree to which the prospective user expects the target system to be free of effort" (Davis, Bagozzi, and Warshaw, 1989, p.985).

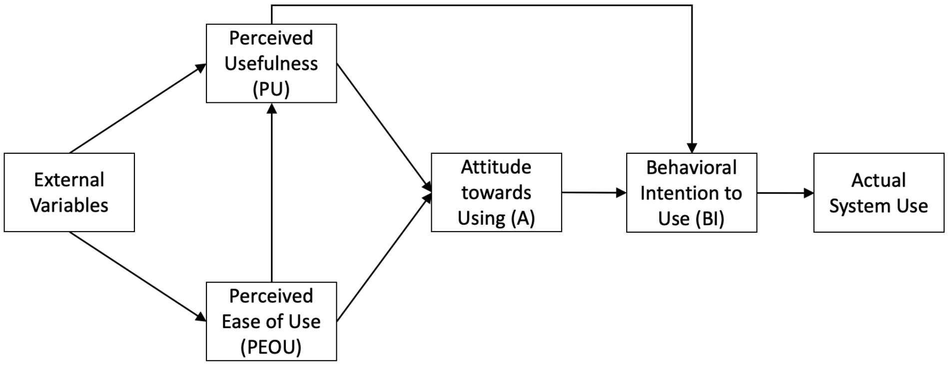


FIGURE 7.2: Original Technology Acceptance Model (TAM), adapted from (Davis, Bagozzi, and Warshaw, 1989)

In 1996, Venkatesh and Davis, presented another version of TAM, with an exclusion of the attitude construct, demonstrating that potential users' behavioural intention was directly determined by perceived usefulness (PU) and perceived ease of use (PEOU). The authors also suggested that PU and PEOU are influenced by various external factors such as system features, nature of implementation process, technical design, organisational context and so on (Venkatesh and Davis, 1996).

TAM2 (Venkatesh and Davis, 2000) was proposed as an extension of TAM by adding external factors which played as the antecedents of PU, the construct which has been considered the most primary determinant of behavioural intention (BI). The external variables proposed cover two categories, social influence processes (SIP) and cognitive instrumental processes (CIP). Figure 7.3 shows the TAM2 model with the external factors added which, according to Venkatesh and Davis (2000), have influence on an individual's PU.

According to TAM2, subjective norm (SN) and image belong to the social influence processes; while job relevance, output quality, and result demonstrability are in the cognitive instrumental processes group. Social influence processes involve two determinants (*subjective norm* and *image*) and two moderators (*experience* and *voluntariness*). Subjective norm (SN) refers to "a person's perception that most people who are important to him think he should or should not perform the behaviour in question" (Venkatesh and Davis, 2000, p.187). SN, according to TAM2, has direct effect on PU and intention to use (ITU). Experience, on using the target technology, and voluntariness, "the extent to which potential adopters perceive the adoption decision to be non-mandatory" (Venkatesh and Davis, 2000, p.188), were reported to have a moderating effect over the influence of SN on PU and ITU. Image is defined as "the degree to which use of innovation is perceived to enhance one's status in one's social system" (Venkatesh and Davis, 2000, p.189). As can be seen in Figure 7.3, image is posited to be directly influenced by SN and it has a positive effect on PU.

In terms of cognitive instrumental processes, TAM2 theorises that an individual's rational judgement about the usefulness of a system is formed partly based on comparison between his or her set goals in their job and the capabilities of the system. Four key components included in TAM2 which cover the cognitive instrumental

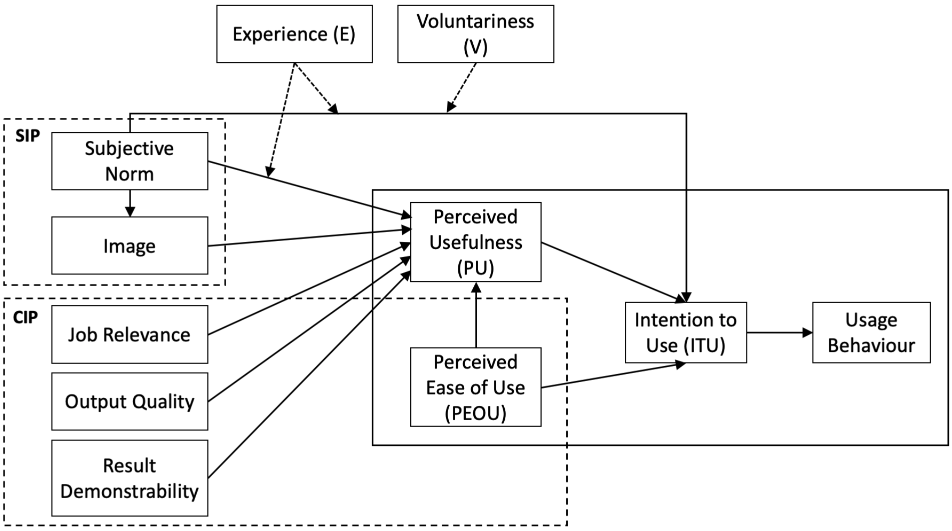


FIGURE 7.3: Technology Acceptance Model TAM2, adapted from (Venkatesh and Davis, 2000), with dashed arrows illustrating moderating effects

processes are *job relevance* (an individual's perception on the extent to which a system can facilitate him or her in getting their job done), *output quality* (the quality of the tasks performed by the system), *result demonstration* (individual's acknowledgement of the system use contributing to achievements or productivity at work), and *perceived ease of use* (PEOU).

The TAM2 model was tested by conducting four longitudinal field studies with four different organisations at three points in time, pre-implementation, one month after implementation, and three months after implementation (Venkatesh and Davis, 2000). The results showed that the external factors could explain up to 60% of the variance in individuals' perceived usefulness; and TAM2 performed well in both mandatory and voluntary settings.

The latest extended version is TAM3 (Venkatesh and Bala, 2008), as demonstrated in Figure 7.4. Additional factors influencing an individual's perceived ease of use (PEOU) were included.

Since its formation, TAM and its extended versions have enjoyed a long history in the research literature. A substantial amount of empirical research has supported TAM and it is praised for fulfilling three characteristics of a good theory – parsimony, verifiability, and generalisability (Chintalapati and Daruri, 2017; Lee, Kozar, and Larsen, 2003). In a statistical meta-analysis study of TAM using 88 published studies, King and He (2006) concluded that TAM is "a powerful and robust predictive model" (p.751).

Having said that, there exist some potential gaps in previous technology acceptance studies. Firstly, previous work relied on self-reported system usage instead of actual usage data (Bagozzi, 2007; Lee, Kozar, and Larsen, 2003). Data was collected using online questionnaires, consisting of Likert-scale items which had been adapted to a specific system to measure the TAM constructs. Lee, Kozar, and Larsen (2003) remarked that self-reported usage could be affected due to method bias, which may lead to inaccurate results of the causal relationships between exogenous and endogenous variables in the TAM. Moreover, existing literature tends to treat intention to use and actual usage as equivalent behaviours. Several studies have measured individuals' behavioural intention and drew conclusions on their acceptance and use, e.g., Šumak

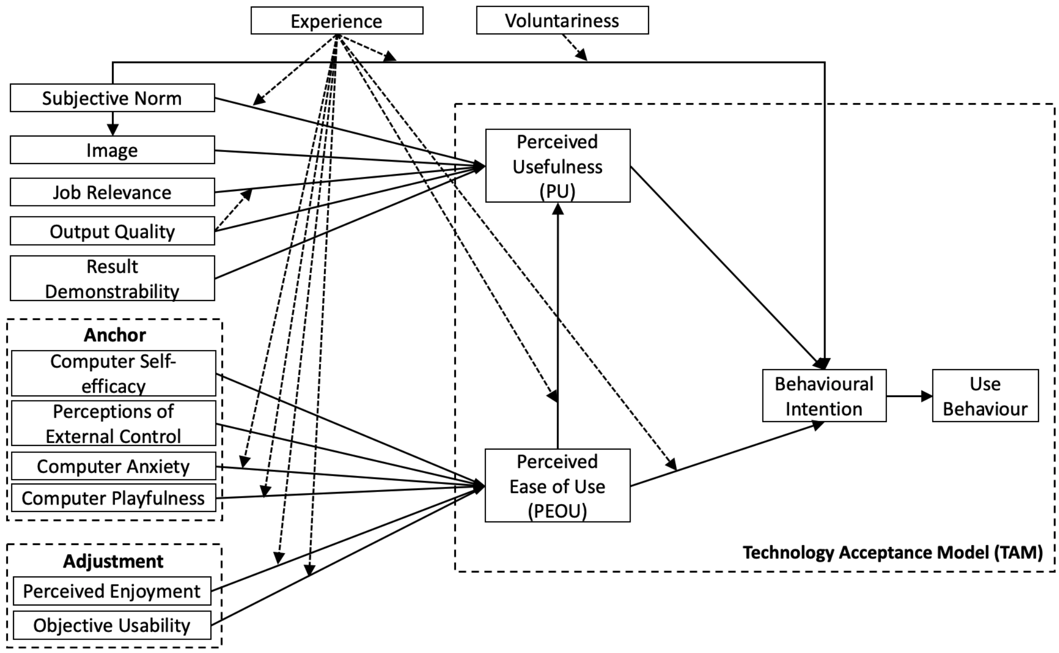


FIGURE 7.4: Technology Acceptance Model TAM3, adapted from (Venkatesh and Bala, 2008), with dashed arrows illustrating moderating effects

et al. (2011) and Yen et al. (2010).

A second gap identified in TAM research is about the context (environment) a new technology is deployed in. Previous research did not clearly classify compulsory and voluntary contexts, or it was assumed that the technology was implemented in a voluntary situation (pseudo-voluntary settings) (Lee, Kozar, and Larsen, 2003). In a context where users have total freedom of whether to use a technology, factors which influence their choice between adopting or rejecting it might be different from those in a mandatory or a seemingly voluntary setting.

A third gap in TAM research is the rarity of qualitative research. Studies in the IS acceptance area is dominated by quantitative methods. An overview of TAM meta-analysis papers showed that out of seven TAM literature reviews, only one took qualitative studies into account; others only focused on the work using a quantitative approach (Vogelsang, Steinhüser, and Hoppe, 2013). In general, quantitative analysis aims to test relationships amongst constructs using statistical methods, such as structural equation modelling. Results from those studies are usually presented in a collection of causal relationships with a set of statistical measures most often including independent variables, dependent variables, path coefficient, and significance level (Šumak, Heričko, and Pušnik, 2011). Vogelsang, Steinhüser, and Hoppe (2013) found that the majority of quantitative technology acceptance research since 2004 has adopted suitable constructs from existing theories and frameworks, combined them in one model, established hypotheses, and then empirically tested the hypotheses. A qualitative approach is not used to explore the details of the questions examined and potentially relevant factors. Thus, quantitative research resorting to questionnaire-based data collection may result in overlooking relevant influential factors as well as failure in revealing complex interaction between potential adopters and the technology (Huang, Teo, and Zhou, 2019; Ng, Shroff, and Lim, 2013; Vogelsang, Steinhüser, and Hoppe, 2013).

7.2.3 Unified Theory of Acceptance and Use of Technology (UTAUT)

UTAUT was introduced by Venkatesh et al. (2003), from identifying the similarities and differences amongst eight of the most common models which were employed in the area of information system adoption, which included Theory of Reasoned Action (TRA), Technology Acceptance Model (TAM and TAM2), Motivation Model, Theory of Planned Behaviour (TPB), Combined TAM and TPB, Model of PC Utilisation, Innovation Diffusion Theory (IDT), and Social Cognitive Theory. It posits that four core constructs, including Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions, directly influence behavioural intention to use an information technology system and eventually the Use Behaviour. Also, it is theorised that the effect of the four key constructs on BI and Use Behaviour are moderated by gender, age, experience, and voluntariness (see Figure 7.5).

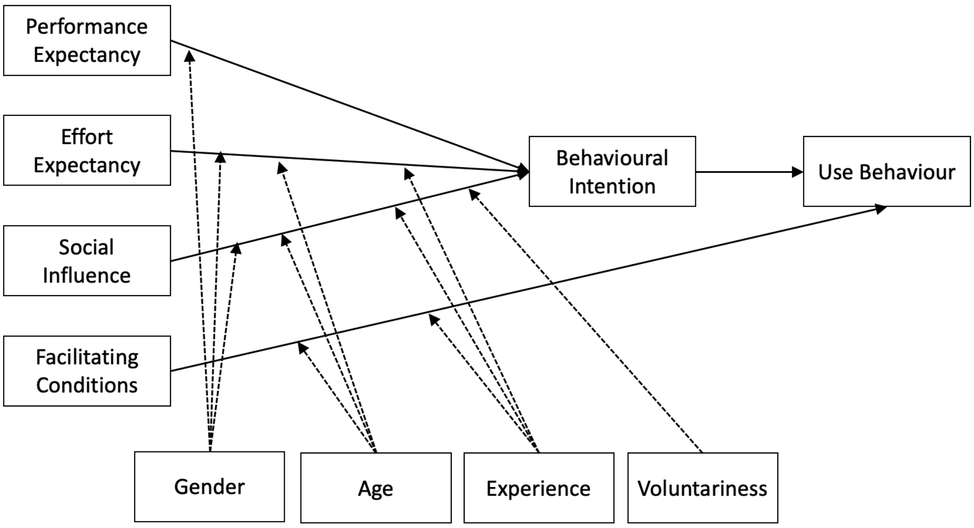


FIGURE 7.5: Unified Theory of Acceptance and Use of Technology (UTAUT), adapted from (Venkatesh et al., 2003), with dashed arrows illustrating moderating effects

Venkatesh et al. (2003) conducted an empirical comparison of the eight models through a within-subject longitudinal validation with individuals in four work-based organisations. Results from the empirical study showed that the eight models examined could explain 17 to 42% of the variance of individual acceptance. Using data from an empirical validation with two industry-based organisations, UTAUT was claimed to outperform previous acceptance models, being able to explain 70 percent of the variance in users' intentions to use a new IT and 50 percent of the variance in use (Venkatesh et al., 2003).

In 2012, an extended version of UTAUT, UTAUT2, was introduced to study individuals' acceptance and use of IT in consumer contexts (Venkatesh, Thong, and Xu, 2012). Three constructs were included in the model, including hedonic motivation, price value, and habit. An empirical study conducted with users of mobile internet technology in Hong Kong showed the extended version could explain 56 to 74% of variance in behavioural intention, and 40 to 52% of variance in technology use.

Thus, as a combination of prevalent constructs from most widely used theories, UTAUT was introduced with a goal of increasing the predictive power of technology acceptance models. However, UTAUT was criticised for its lack of parsimony: "in the end we are left with a model with 41 independent variables for predicting intentions and at least eight independent variables for predicting behaviour" (Bagozzi, 2007, p.245).

Moreover, the constructs in UTAUT share similarities with other models, particularly TAM3 (Attuquayefio and Addo, 2014). Table 7.1 summarises the description of the determinants and moderators in UTAUT, along with similar constructs in TAM.

UTAUT Determinant	Description	Similar construct in TAM
Performance expectancy	"the degree to which an individual believes that using the system will help him or her to attain gains in job performance" (Venkatesh et al., 2003, p.447)	Perceived Usefulness (TAM, TAM2, TAM3)
Effort expectancy	"the degree of ease associated with the use of the system" (Venkatesh et al., 2003, p.450)	Perceived Ease of Use (TAM, TAM2, TAM3)
Social influence	"the degree to which an individual perceives that important others believe he or she should use the new system" (Venkatesh et al., 2003, p.451)	Subjective Norms, Image (TAM, TAM2, TAM3)
Facilitating conditions	"the degree to which an individual believes that an organisational and technical infrastructure exists to support use of the system" (Venkatesh et al., 2003, p.453)	Perceptions of External Controls (TAM3)

TABLE 7.1: UTAUT & TAM determinants similarity

Another point is that while TAM has enjoyed a long and intensive use in research literature, UTAUT is still a relatively new model (Straub, 2009). Despite of the high number of citations, there has been a caution that "the level of actual UTAUT use in practice is somewhat lower than the citation level may suggest" (Williams et al., 2011, p.8).

7.2.4 Technology Adoption-Diffusion in Informal and Voluntary Situations in Education for Students

Rogers's IDT, TAM, and UTAUT are unarguably the most influential theories in the research area of IS adoption-diffusion. They provide a valuable foundation on significant factors which have effect on individuals' decision on adopting (or rejecting) a new introduced technology. General concerns and limitations regarding each theory were discussed in the earlier sections. In the context of the current research, the question of interest is if these theories and their constructs (or significant elements) help explain why LPRS, or any new introduced genuinely voluntary system in an informal learning context, has not been adopted as anticipated.

Regarding Innovation Diffusion Theory, it covers a massive range of aspects of the whole diffusion process, while this phase of the research aims to investigate what factors cause the stumbling block at the starting point to students' taking on a completely voluntary new application for informal learning purpose. The perceived attributes of an innovation (Rogers, 2010) are considered to be relevant to the matter in hand; and therefore they are included in the research model which is presented in Section 7.3.

In terms of the TAM model, it has been widely employed to lay the groundwork for research on the acceptance of e-learning technology. Šumak, Heričko, and Pušnik (2011), in their meta-analysis study of 42 independent papers in the field of e-learning technology acceptance, have shown that TAM has been the most common grounded theory, being adopted (or adapted) by 86% of the analysed studies. In the context of the current research, an exploration of technology for learning purposes targeting at students, some limitations in TAM exist, including the nature of voluntariness and approaches to conducting research.

Firstly, in the educational context, the situation of technology adoption most often is encouraged and eventually mandated systems. 107 recent studies in the e-learning acceptance area, reviewed by Abdullah and Ward (2016), listed e-learning technology types (systems or tools) and different user types (teachers, employees, or students); yet the context was not specified. In an educational institution, when a technology is encouraged to be used in the school curriculum, the situation is typically not completely voluntary. Teaching staff (or employees) fundamentally do not have a choice as to whether or not use the technology (Straub, 2009). Inevitably, students are expected to engage (to a certain degree) with the systems or tools used for course content delivery. LPRS, developed in this present research, was implemented in a fully informal voluntary situation where system use by students was completely voluntary. The informal and voluntary characteristic of the context requires a deeper examination into which factors might prevent a new tool to be accepted in such environment.

Secondly, as previously discussed, studies in the IS acceptance area are dominated by quantitative methods. The work on technology adoption in the educational context is no exception. In a review of technology acceptance studies in education (Imtiaz and Maarop, 2014), only results retrieved from quantitative research were presented, which showed causal relationships amongst constructs in the TAM model (along with other technology acceptance models). In the context of the current study, factors influencing a student's decision to adopt or reject a new technology might be different from those in explicitly/implicitly mandatory settings. Therefore, a qualitative approach is employed to conduct an exploration of barriers to students' adoption of new introduced tools in informal voluntary situations using LPRS as a specific use case.

With respect to UTAUT, despite the high number of citations, the actual use of the model in previous studies is lower than the suggested figure. In addition, the constructs of UTAUT, as formerly discussed, share great similarities with TAM3. Furthermore, research in technology acceptance within educational contexts has demonstrated a greater favour towards using TAM as the base theory in comparison with UTAUT (Imtiaz and Maarop, 2014).

7.2.5 Implications for the Current Study

From the review of the three adoption models above (Rogers's IDT, TAM, and UTAUT), there exists some potential gaps regarding applying adoption-diffusion theories in informal voluntary situations. Amongst the three most influential models, TAM is determined to be the most appropriate model to be employed in order to gain better understandings of obstacles to LPRS uptake and voluntary educational technology in general. Although the original TAM has been criticised for having too few factors, resulting in limitations in explaining IT acceptance and use (De Grove, Bourgonjon, and Van Looy, 2012; Imtiaz and Maarop, 2014), Abdullah and Ward (2016) argue that "TAM with specified external factors not only predicts technology usage but also provides explanation of why a particular system may not be adopted" (p.5). The model has proven to be efficient, valid, and widely adopted in education settings (Šumak, Heričko, and Pušnik, 2011). Its robustness also comes from the fact that the model can be extended with factors relevant to the specific contexts (De Grove, Bourgonjon, and Van Looy, 2012). Therefore, in the present study, TAM3 with the collection of external factors has been selected as the base theory to guide the analysis of the data collected. In addition, some additional factors, retrieved from Rogers's IDT which are not covered in TAM3, are integrated in the model such as trialability and compatibility.

Moreover, the predominance of quantitative studies in TAM research might hold limitations on explaining the complex interaction between a target system and its potential adopters as well as revealing relevant factors influencing individuals' system acceptance and use. It is not the intention of present work to test the relationships amongst the constructs and variables in the TAM or any other technology adoption models, but to strive to gain a deeper insight into what factors encourage/discourage students' use of a new available system in an informal voluntary context. Therefore, the present work has employed a qualitative approach in order to contextualise factors significant to students' decisions.

7.3 Investigation of Factors Influencing Students' Adoption of Voluntary Educational Technology

This section covers the investigation conducted to obtain an insight into factors that have an impact on students' decision to adopt or reject a newly introduced technology for learning purposes in non-mandatory contexts. The overview of the study is presented in subsection 7.3.1. Subsection 7.3.2 provides the description of two participant groups of the investigation, along with the data collection instruments used with each group. The next subsection 7.3.3 introduces the research model employed to guide the data analysis of this study. The last subsection 7.3.4 explains the process of analysing the collected data.

7.3.1 Overview

The research question this chapter aims to address is: **"What factors influence students' adoption of voluntary applications for learning purposes?"**. Thus, the study conducted in this phase of the research attempts to gain a better understanding of what factors would encourage (or discourage) students' decisions to trial and use of a new system in an informal voluntary situation. LPRS is used as a case study in order to explore the important factors relevant to this situation.

As stated in the previous section, the present work employs a qualitative approach through conducting in-depth semi-structured interviews with both educators and students in order to obtain ideas from different perspectives. The collected data is analysed through the lens of established technology acceptance models to better explain the situation in the current project (the low uptake of LPRS during the evaluation phase). The qualitative approach is used to help discover factors that are influential to a student's decision to trial and use a completely voluntary educational application. Therefore, constructs in the latest version of TAM (TAM3) and the perceived attributes of an innovation in Rogers's IDT are combined into the research model (see Figure 7.6). The model is used to guide the process of data analysis in this study. Details of the analysis approach are presented in subsection 7.3.4.

7.3.2 Participant Groups & Data Collection Instruments

This study of barriers to students' adoption of technology for learning purposes employed a qualitative approach through conducting in-depth semi-structured interviews with both educators and students in order to obtain ideas from different perspectives.

This study was approved by Monash University Human Research Ethics (see Appendix G.1). Consent forms were signed by the participants at the commencement of each interview.

7.3.2.1 Educators

Objective
Interviews with educators were conducted in order to obtain views of experts in the field on possible barriers to LPRS adoption.

Participants, Data Collection Instruments, and Method
As presented in Chapter 6, data collection 5 was conducted in May and June 2019 to gather educators' opinions on the strengths and weaknesses of LPRS as well as the potential impact of the research in encouraging the formation of informal learning communities amongst students. Feedback regarding possible reasons for the low uptake of LPRS from the educators' perspectives was also collected at that time. Therefore, the participants and the data collection instrument are the same as in the previous chapter. The eleven educators are experienced faculty members with different roles and expertise from the Faculty of Information Technology at Monash University. The instrument used to collect data was the semi-structured interview protocol. Details of the participating educators, the interview questions, and the method were presented in subsection 6.3.2.

7.3.2.2 Students

Objective
The objectives of this study were (1) to explore factors influencing students' adoption of technology for learning purposes, and (2) to investigate the potential reasons for the low uptake of LPRS from the students' perspectives. Therefore, a new round of data collection (data collection 6) was organised with students to get a better understanding of factors influencing their adoption or rejection of a newly introduced application for learning purposes in a voluntary situation.

Participants
Convenience sampling was employed to recruit students as the second participant group for this study. An invitation to participate in the study was posted on the Facebook page of students from the Faculty of Information Technology at Monash University. Fifteen students (six females and nine males) agreed to take part in the interview sessions which were conducted from July to September 2019. Amongst the 15 participating students, three participants were doing their undergraduate studies; the others were postgraduate students.

Data Collection Instruments
This study used semi-structured, in-depth interviews to obtain deeper understanding of factors which influence a student's decision to accept or reject a new application (information technology) for learning purposes, particularly in a voluntary context. LPRS was used during the interviews as a sample application about which the participants provided comments while interacting with the system. LPRS interactions included completion of data input forms, exploration of study partner recommendations generated, and experimentation with LPRS utility tools. Additional questions were

asked in order to clarify and explore the points discussed by the participants. Details of the interview questions can be found in Appendix G.2.

Method
All interviews were conducted face-to-face, following the interview question protocol. Each interview was comprised of three main parts: (1) general questions where the participant shared experience about applications/systems for learning purposes which they adopted and/or rejected; (2) LPRS as a case study where the participant interacted with LPRS and gave feedback on the system while interacting; and (3) perceived barriers to system adoption where the participant provided their view on reasons for the low uptake of LPRS with reflection on the discussion in part one of the interview. The interviews were audio-recorded, then transcribed for data analysis. The interviews lasted for approximately 40 minutes to 65 minutes.

7.3.3 Research Model

Figure 7.6 illustrates the research model used in this investigation of barriers to students' adoption of technology for learning purposes in voluntary contexts.

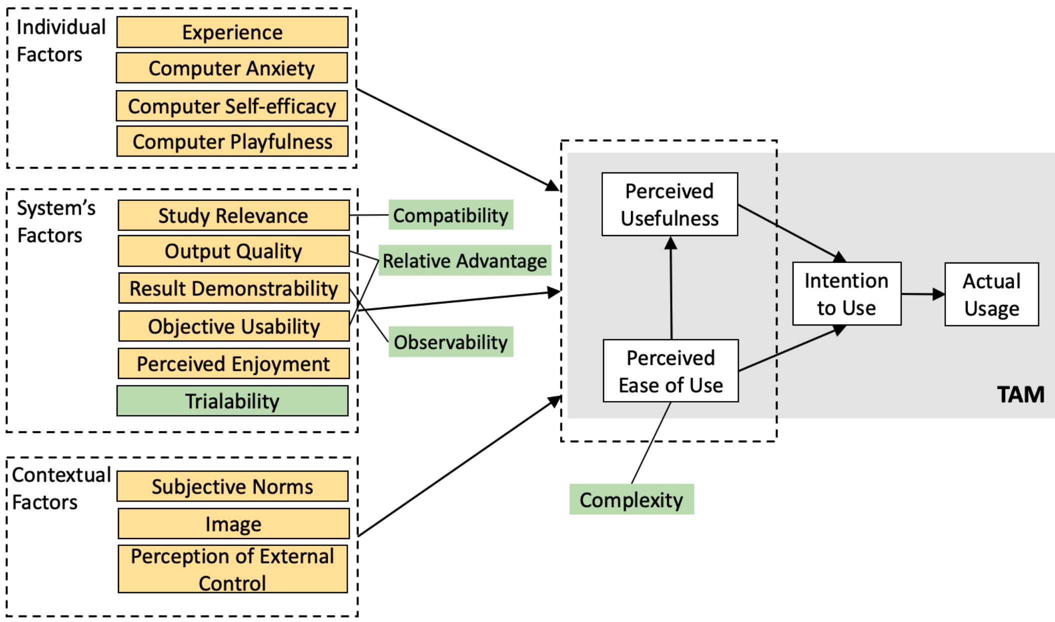


FIGURE 7.6: The research model for the study of barriers to students' adoption of technology for learning purposes in voluntary contexts, with factors from TAM3 (yellow) and IDT (green)

The two key constructs of TAM (PU and PEOU) play as the determinants of an individual's intention to use a technology. The three groups of factors which have been identified to have influence on PU and PEUO are individual factors, system's factors, and contextual factors. These groups are based on Straub's discussion on the common categories of characteristics shared by adoption and diffusion theories (Straub, 2009). All factors of TAM3 are included in the research model, illustrated in yellow shade. The five factors in green shade are from Rogers's IDT. There are similarities amongst the five attributes of innovation in IDT and some of the constructs of the TAM3 model: observability and result demonstrability, relative advantage and objective usability, compatibility and job relevance. One characteristic of innovation suggested in IDT was not covered in TAM3, which was trialability; therefore, it was included in the research model.

Furthermore, in TAM, "experience" and "voluntariness" act as mediating factors. The former factor presented in TAM is about the experience of using the target system or technology; while the concept of experience included in the present research model also included user's expectation regarding the target technology based on previous experience of interacting or using other applications and technology. As for the latter factor, it is not included in the research model since the focus of the study is on students' adoption of voluntary technology aiming at students' learning.

7.3.4 Analysis Approach

The approach employed to analyse the interview data with both academics and student participants was thematic analysis (open coding and theme identification). The analysis process began with the collection of data in the set of transcripts based on the interview questions. Repeated concepts mentioned by the participants were grouped into a theme. The emerging themes were then checked against the research model (see Figure 7.6) in order to identify the factors that the themes coincided with. Themes which were unable to be mapped to existing factors in the research model were classified as emerging factors.

An example of the process of analysing the interview data can be viewed in Figure 7.7. For instance, quotes such as *"Because if it takes like half an hour, some might feel like too much"* and *"It's long. It's very personal. There's a lot of detail there"* were grouped into a common theme about the long input process. This theme was identified to match the Object Usability factor in the research model. Whereas, themes such as *Quick results versus effort* and *Data privacy* did not align with the existing factors and were marked as emerging factors. Rectangles with asterisk (*) notation in the "Factor Mapping / Emerging Factor" step represent emerging factors.

In the following sections, educational designers are referred to as Ed-designers; individual academic participants are referred to as A-1, A-2, and so on; students who participated in this study of barriers to adoption are referred to as S-1, S-2, and so on.

7.4 Educators' Views: Data Analysis and Results

During the interview sessions, the 11 educator participants were asked to provide their opinions on reasons for the low usage of the Learning Partner Recommender System. Their responses were analysed applying the analysis approach presented above. Figure 7.7 illustrates the process of analysing the educators' interviews regarding their postulated reasons for LPRS low uptake.

Table 7.2 summarises the postulated reasons for LPRS low uptake from the educators' perspectives and whether the points are aligned with the research model. Factors with the asterisk (*) are ones which cannot be mapped to the existing factors in the model.

The first main reason for LPRS low engagement suggested by the educators was the long input process. Nine out of the 11 educators remarked that the long input process was one key factor that discouraged students when they saw the system for the first time. As previously discussed in Chapter 5 regarding LPRS implementation, in order for students to receive recommendations on study partners with compatible characteristics, they are required to complete a number of forms (which include: a basic information form, four characteristic forms, and a preference form). This approach to collecting data for LPRS seemed to cause a great obstacle for drawing

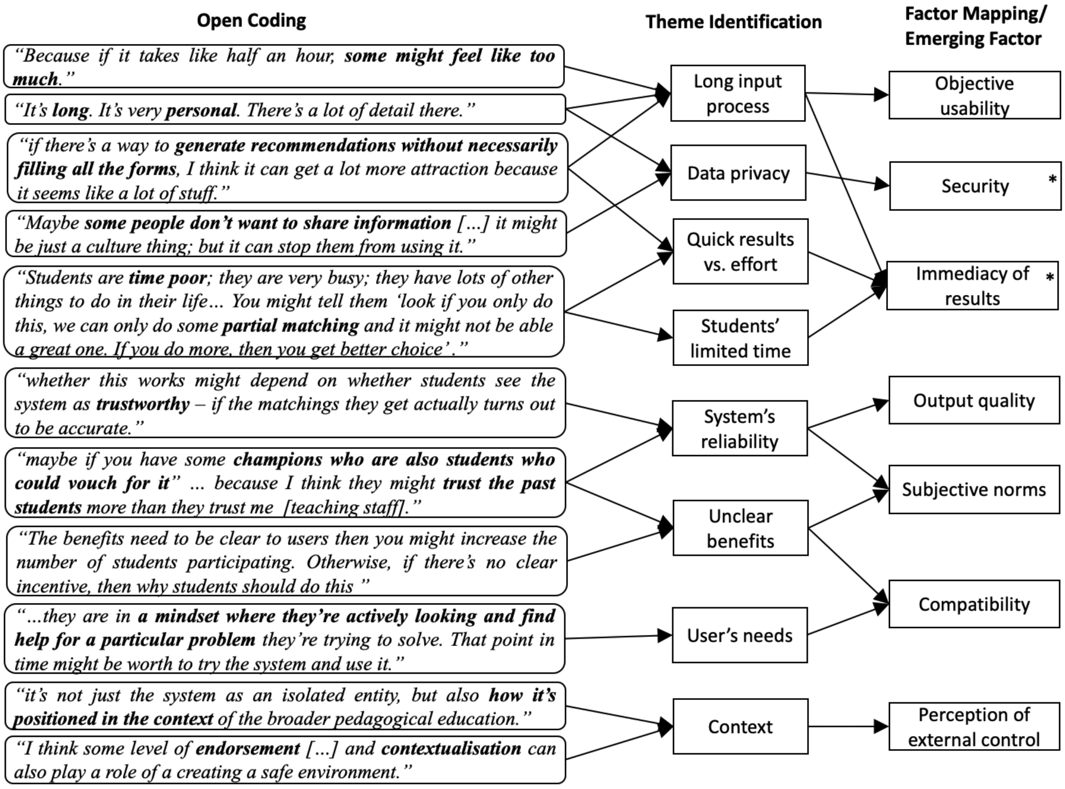


FIGURE 7.7: Data Analysis process example (interviews with educators), asterisk (*) denotes an emerging factor

#	Postulated Reason	Fit in Research Model
1	Long input process	- Objective usability - Immediacy of results *
2	Security (Data privacy)	Data privacy *
3	Unclear benefit due to: - lack of social influences - incompatibility with users' needs	- Subjective norms - Job (Study) relevance
4	Trust issue	Output quality Subjective norms
5	Students' needs & attitude towards CL & LCs	Job (Study) relevance
6	Students' limited time	Immediacy of results *
7	System deployment context	Perception of external control

TABLE 7.2: Data Collection 5: Reasons for low system uptake from educators' perspectives, asterisk (*) denotes an emerging factor

students' interests in experimenting with the recommender system. This obstacle to system adoption was explained to have close relation to students' limited time budgets (obstacle 6 as in Table 7.2). One educator commented:

> *"I think the main reason is you need to make it as easy and quick as possible for people to buy in. Students are time poor; they are very busy, they have lots of other things to do in their life."* (A-4)

The solutions to this obstacle recommended by the educators were presented in detail in the previous chapter (subsection 6.3.3.2), including (1) shortening the system input process by eliminating some input forms and/or retrieving students' data from external sources, and (2) implementing multiple levels of matching.

The second big concern raised by the educators, as discussed in subsection 6.3.3.6, was security or data privacy issues. Particularly, one participant mentioned that the system collected very personal information and that might be one of the main barriers to the uptake of LPRS. The previous chapter also presented the educators' recommendations for improving the issues. The participants suggested the issues could be addressed through a proper security procedure, data privacy policy and terms of use agreement.

The third reason for the low buy-in from students which the educators remarked upon was about unobvious benefits from using LPRS. This related to the degree to which students believe that using the recommender system could be beneficial for their learning experience. The educators remarked that the perceived benefits of the system were highly related to requirements of units which the students were taking; if there was no group work or group assignment within the units, they might find it irrelevant to look for a study partner. Moreover, despite the advantages that collaborative learning could bring, students might not be aware of its importance. A participant explained:

> *"There's a lot of evidence that says that peer learning is good. A lot of the courses in the universities are being re-written to take more of an active approach where students do more peer learning and we're just here to facilitate that learning, provide correction and extra context around. So absolutely, peer learning is important. Convincing students that it is important is a different matter."* (A-6)

Possible solutions to this matter given by the participants included utilisation of effect of subjective norms (influences from peers and/or teaching staff), and integration of additional features in the system to increase the system usefulness (such as facilitating meet-up sessions, reminders for assignments and the like).

The fourth obstacle to system uptake postulated by the participating educators was trust matter, which referred to the degree of reliability students thought of the recommendations the system provided. A more detailed discussion regarding this was presented in subsection 6.3.3.3. Suggestions for improving the reliability of the system as well as the generated recommendations on study partners included employment of the influence of social norms: endorsement from different stakeholders such as student champions, teaching stuff, and the university.

The fifth possible reason for low system uptake remarked by the educators was regarding students' needs for finding study partners and their attitudes towards learning communities. This factor is closely related to the third obstacle discussed above, unclear perceived benefits of using LPRS. When an individual is not in a situation where he or she has a need for finding someone to conduct their learning with (due to either irrelevance to unit requirements or personality/preference for studying individually), that individual would not find such a system beneficial. Similarly, collaborative learning and learning communities might not be perceived as an advantageous concept by certain students, which would lead to the inapplicability of the application. According to some educators, the situation might be improved through some approaches. One way would be to target students at a number of certain points during a semester such as: at the beginning of a teaching period when new students are unfamiliar with the university life and might need some help in finding learning partners; or some time before students' assignments are due when they are most likely in the mindset where they find it necessary to look for help from or collaboration with other peers.

Another cause of the low uptake of LPRS suggested by the participating educators was about the contextual factors. This referred to where the recommender system was located in the university environment and kind of endorsement and/or support it received. How a new introduced application places itself within a higher education setting plays an important part in forming students' perception of the tool; and the endorsement from the institution helps increasing perceived trust and reliability. An educator emphasised the importance of the context:

> *"It's not just the system as an isolated entity, but also how it's positioned in the context of the broader pedagogical education. [...] It's not just about what's in the system but also how it's placed. [...] I think it's not just about the system, it's also something to do with the context. It's one thing. Another thing is about the intrinsic information balance or asymmetry – how much information do students have to feed in before they start getting what they consider as reasonable return. But I tend to think it's the context thing more so than the actual system."* (A-7)

The idea of lack of endorsement was mentioned throughout the interviews with A-6, A-7, and A-8. In particular, A-7, who was a lecturer of the unit with which both the pilot test and system deployment were conducted, provided an insight:

> *"For example, last year when we offered this as a part of the unit, we kind of integrated it more closely in the tutorial exercise. They had a chance to touch and feel by doing the personality test, and somebody actually pursued, I don't have an exact number. It gives the idea of there's some level of endorsement, if you like. It tells that it's not a random system, they actually see somebody behind the system which creates some relationship with the system. When the system does not have that context, for students to engage and invest in a particular system as a user – it's a commitment, isn't it? So how much commitment do you expect. You usually commit to certain things when you know about it. It doesn't need to be a system; it can be a course or any product you buy at a grocery shop. How you motivate students, justify the student to invest in the commitment."* (A-7)

In summary, the 11 educators participating in the study, with their diverse expertise and experience, provided a number of insights into key factors leading to the low uptake of LPRS. The obstacles suggested by the participants generally fitted into the three categories of factors influencing individuals' PU and PEUO; individual factors, system's factors, and contextual factors (as demonstrated in Table 7.2). Interestingly, there were two new factors which emerged from the data collected with this group of participants including data privacy and immediacy of results. The factor data privacy was directly mentioned by the participants, while immediacy, although not obvious, became apparent throughout the data collection.

The following section presents the study conducted with students in order to gain insights into students' perspectives on factors influencing their adoption and rejection of a new technology for learning purpose in non-mandatory situations.

7.5 Students' Views: Data Analysis and Results

Following the protocol of interview questions (see Appendix G.2), students participating in the study shared their experiences on using a new information technology (IT) for their learning: how they started, what factors made them keep using the IT, what factors contributed to later rejection (after adoption), and what stopped them from trying out a new introduced IT in the first place.

7.5.1 Factors Influencing Students' Adoption

This subsection presents results from the data collection with the 15 students regarding the factors that are influential in their decisions about initial trial and ongoing usage of a newly introduced technology for learning purposes.

7.5.1.1 Initial Trial

A number of factors were mentioned by the participating students as how they started using a voluntary application for learning purposes, such as personal drive (in a sense that they wanted to improve some certain skills), study/job relevance (to get a better understanding of learning material in some units), and references from other people. Throughout all the interviews, references (subjective norms) emerged as a factor significantly influencing their choice of technology/resources for their studies.

Figure 7.8 demonstrates the process of data analysis of students' responses to the questions asking about how they started using a technology for learning purpose.

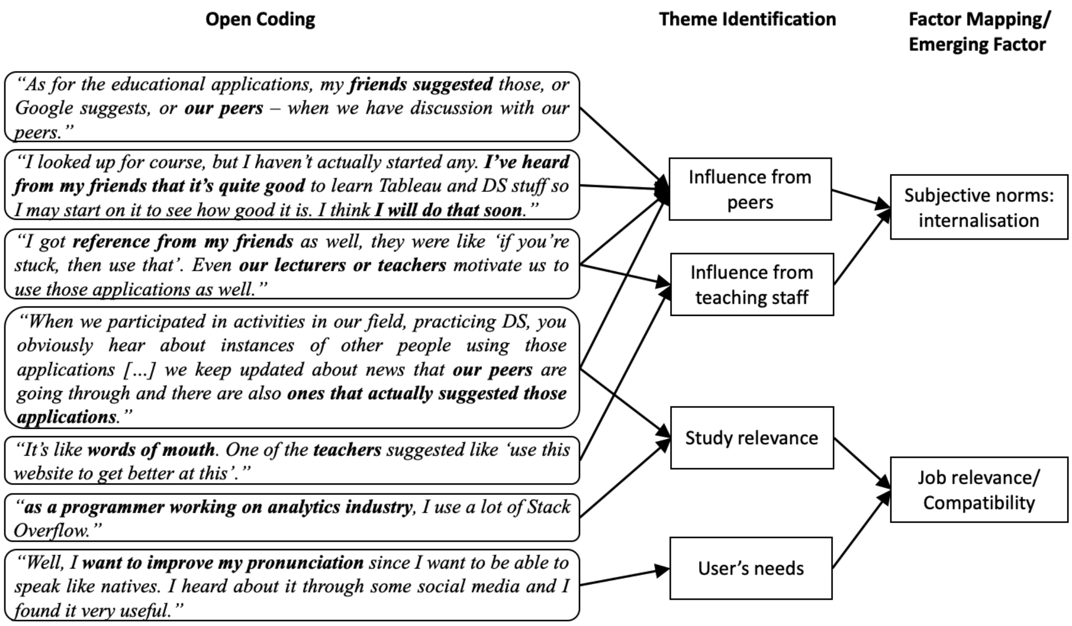


Figure 7.8: Students' perspectives: Influential factors to students' adoption of technology for learning purposes at initial stage

Subjective norms: Social influences as an internalisation process

According to the student participants, social norms, mainly influences from peers, seemed particularly significant to their intentions to use a new technology for study or acquiring information for their learning. It appeared to be the most common way that they knew about and started using an application. Some representative quotes from the students are as follows:

> *"As for the educational applications, my friends suggested those, or Google suggests, or our peers – when we have discussion with our peers."* (S-3)

> *"...because my friends told me that 'you should have a LinkedIn profile'. It's really important because even though I'm not an active member on LinkedIn, they told me it's necessary."* (S-7)
>
> *"I got to know it through one of my friends... I looked up for course (on LinkedIn), but I haven't actually started any. I've heard from my friends that it's quite good to learn Tableau and DS stuff so I may start on it to see how good it is. I think I will do that soon."* (S-8)
>
> *"So when we are talking, we share the experience like 'You can try this app, this will work out, this has been really helpful to me, it will be helpful to you as well'. That way, word of mouth has a great role it comes to sharing information about the applications."* (S-13)

Social influences (peers, friends, or teachers) on students' intentions to use a new technology and their actual usage were expressed clearly through the participants' responses. An interesting finding was that in a voluntary situation, the process of social influence was internalisation and it turned out to have a positive direct effect on both perceived usefulness and intention to use (contrasting with hypothesis 1b in TAM2 suggested by Venkatesh and Davis (2000)). Three different processes of attitude change (also the behaviour of adopting a new IT in the context of technology adoption) under social influences, as proposed by Kelman (1958), include compliance, identification, and internalisation. Although the external resulted behaviour of adopting a technology might be the same, the internal process of the adopters may be different. *Compliance* refers to an individual's act of accepting a social actor's suggestion to perform a specific behaviour (to use a new technology in the context of technology adoption) in order to gain a reward or avoid punishment from the social actor. *Identification* refers to the act of performing a behaviour (using an application) in order to create, maintain, and/or improve one's status in the community. *Internalisation* refers to a situation where an individual accepts influence from others because he or she has incorporated the others' belief into his or her belief structure. The content of the behaviour (which can be considered as an intrinsic value of a technology) is irrelevant in the case of compliance and less important in the case of identification. On the contrary, in the case of internalisation, features of an information technology (its usefulness, functionality, compatibility with the individual's needs/values) play the most essential role in their decision to adopt the technology.

In a voluntary context where students have complete freedom of choice as to whether to use a technology for their learning, compliance-based social influence reasonably does not have any significant effect on their intentions to use a technology: none of the participating students referred to the idea of compliance. Similarly, the concept of identification did not emerge as a reason for students to form their initial intentions to use a technology. However, the students' responses revealed that in non-mandatory situations, the process where they formed their attitude towards using a technology, their intentions to use the technology, and eventually the actual use of the technology due to influences from social actors (particularly from peers and friends) was indeed internalisation. They expressed that they perceived websites or applications suggested by their peers as potentially useful for their learning and the intention to use the recommended technology was strong. Furthermore, most participating students shared that they in fact started using some technologies (applications/systems) because of suggestions from friends and/or tutors.

Importantly, data from the study with students suggested that social norms play an important part in forming students' perception of a newly introduced information technology and in influencing their behavioural intention even before actually experimenting with the technology. The formed perception could be positive or negative depending on feedback from the influential others, which would potentially result in either initial trial or premature rejection.

7.5.1.2 Ongoing Usage

In terms of factors that make students keep using a voluntary technology, three determinants of Perceived Usefulness in the TAM3 model, including job/study relevance, output quality, and result demonstrability, seemed to play the most essential role. Moreover, other factors including ease of use, accessibility, little rewards for motivation, and immediate results were also remarked as important for the students to engage with an application. Table 7.3 provides some quotes from students regarding the factors.

Students' responses	**Factor Mapping / Emerging Factor**
"So I do coding as a job so it's very helpful to get other resources and people's insight as to how to have best coding practices." (S-1)	Job relevance
"I would also say Kaggle and Coursera. They are the two other websites that I regularly visit. Kaggle aims at DS, and I need to work on DS to improve my skills. Kaggle also has short courses, machine learning courses, AI courses, they are practice-based courses." (S-3)	Job relevance
"I tend to gravitate towards Stack Overflow because there are a lot of helpful people. Also, the answers are very precise, and you can verify your answers to see if it's right." (S-11)	Output quality
"So we need to change the code and improve it. I need to compare two versions of the source code; I would use the software called Beyond Compare. It shows the versions of the source code on the left side and the right side and tells you what's the difference between them. Software like this is very useful." (S-10)	Job relevance Output quality
"It's very handy. Without that, I probably wouldn't been far in my degree as I am." (S-4)	Result demonstrability
"I think I can see my improvement after using the app." (S-5)	Result demonstrability
"You feel like you have learnt something from it so you will go back and refer to that if it turns out to be reliable." (S-15)	Result demonstrability
"It would help me understand the concept better." (S-8)	Result demonstrability

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Table 7.3 – continued from previous page

Students' responses	Factor Mapping / Emerging Factor
"The main aspect that would attract the users toward is the user experience from the website, like the ease of navigation through different things are there on the portal, the ease of finding the information that you're trying to search – that's one of the most important aspects that you need to take into consideration." (S-6)	Complexity Accessibility
"It's free. Well, you have paid version, but the free aspect makes it a lot more approachable." (S-4)	Accessibility
"Ease of access. Accessibility in terms of different platforms. Is it easy to see on your phone or desktop, do I have to log in, do I have to create an account, do I have limited previews? Things like that." (S-12)	Accessibility
"Then it's a little something, it's not a big important thing, but it's like an achievement. If you did several lessons for days in a row, you got little badges, it's like a tiny reward, a motivation. It also means like 'Oh wow, I've been doing this for a week straight. I didn't even notice'." (S-4)	Reward for motivation
"So the rewards are different for each application. That's one of the things that make me use an application." (S-2)	Reward for motivation
"Maybe at the start, it (ability of a system to meet users' need) was the focus of why I started using it. But in general, as you gradually use that platform, you understand there's a purpose why you are using it. It's rather than just a job, it's an e-portfolio for you. That stands as a virtual image of you in a platform." (S-6)	Image
"I would say social connection. If you can share your certification socially, that would be really helpful. Let say I learn a course on Coursera, and I want to share it with my social connections, I use LinkedIn for that." (S-13)	Image
"The application would have to be able to answer a lot of my questions. I want immediately an answer from that website." (S-1)	Immediacy

TABLE 7.3: Influential factors to user retainment from students' perspectives

As previously discussed, students' perception and their intentions to use a newly introduced technology are significantly influenced by social norms, particularly influences from their peers. However, interviews with the 15 students revealed that factors which play the key role in maintaining their engagement with an application are the ones of the cognitive instrumental processes (Venkatesh and Davis, 2000). Initial experiments with a system occur mainly due to social influences; but after the initial trials, students are likely to make their own rational judgement about the usefulness of the system. The usefulness degree is in turn judged by students primarily based on three influential factors: study relevance, output quality, and result demonstrability. Some other factors were also perceived as important by the participants in user retention, including: accessibility, reward for motivation, and immediacy.

Equivalent to job relevance in the TAM model, study relevance refers to a comparison which a student makes to evaluate the degree a system/application can support important tasks in his or her study. For instance, students who are taking programming units find resources which help improve coding practice and/or facilitate the code debugging process very useful. On the contrary, if an application is incapable of performing a student's required tasks, the application is considered as irrelevant and excluded from the student's list of options for further consideration.

While the study relevance factor helps a student make a decision of whether to use a technology after initial trials, output quality plays a vital role in long-term usage. In a situation where a student is introduced with a number of available technologies with similar features, the more efficiently and effectively an application can support key tasks in his or her study, the better quality the technology is perceived, which leads to a higher degree of usefulness. As S-11 shared, amongst different informal learning resources the student prefers to employ Stack Overflow, a site where people can ask questions about programming and receive answers/suggestions for their problem:

> *"I tend to gravitate towards Stack Overflow because there are a lot of helpful people. Also, the answers are very precise, and you can verify your answers to see if it's right."* (S-11)

Result demonstrability is another crucial component which contributes to the usefulness of a system perceived by students. As asserted by Venkatesh and Davis (2000), even an effective technology can fail in maintaining user engagement if its users have difficulty in relating their improved performance to the technology. The interview participants confirmed the significance of this factor with an acknowledgement that improvements in their study were attributable to a number of applications or learning resources they were using (S-4, S-5, S-8, S-15).

In addition, a number of other factors also have influence on students' continuance intentions to use a technology for their learning, particularly when the technology usage is not mandatory. Firstly, an application should be both economically and technically accessible. Students have certain expectations for a voluntary technology: it should be free of charge, or at a low price. Moreover, the technology should be easy-to-use, compatible with different devices and function well in different modes, online or offline. Thus, in order for a non-mandated application to gain students' favour, it needs to have a comparably high degree of accessibility. Secondly, affective aspects of a technology can influence students' decision to continue the technology use. If a technology has features which can encourage students' intrinsic motivation, they will be more likely to keep using it (S-2, S-4, S-11). As Straub (2009) argued, technology adoption studies largely focus on addressing cognitive and contextual concerns, while neglecting affective aspects. When an application is genuinely voluntary, triggering positive emotions in students might improve users' engagement with the technology. Thirdly, using some technologies (particularly social networking sites focusing on professionals) is also perceived by students to maintain and improve their status amongst social connections they have. Take LinkedIn for an instance, students might sign up for the site due to various factors such as: influences from others, job seeking, career advancement, and professional networking (Brewer, 2018). Interestingly, one main reason for their decision to continue the site use is to gain visibility in that virtual environment and to promote themselves as professionals in their related fields

(Florenthal, 2015). Lastly, immediacy of results is one factor which students expect from an application when using it for their informal learning. In formal learning contexts, when a technology is included in a course curriculum, the technology use is mandated whether employing the technology is facile or tedious. Whereas, for a voluntary application to be frequently used, it is expected to provide fast results with least effort invested by students.

Thus, the three factors influencing Perceived Usefulness in the TAM3 model (which are study relevance, output quality, and result demonstrability) have appeared to be critical for students' continuance intentions to use a technology for learning purposes. Other factors were also valued by students, according to the interview data, including accessibility, motivation stimulator, image, and immediate results. It cannot be concluded if these factors have greater importance to technology adoption in voluntary situations compared to mandatory contexts. However, this work contributes to an attempt to obtain better understanding of factors influencing students' choices to continue their use of non-mandatory technologies for learning purposes.

7.5.2 Factors Influencing Students' Rejection

During the interviews, after discussing the adoption of voluntary information technology (IT) for learning, the participating students were asked to share their experience on rejection cases (see Appendix G.2). The students provided a number of insights into factors influencing their decision to abandon a previously used application (later rejection), and to reject a new IT in the first place (premature rejection).

7.5.2.1 Later Rejection

Table 7.4 summarises the most representative quotes from students when discussing matters around their decision to later reject an IT which they used in the past.

Students' responses	Factor Mapping / Emerging Factor
"Khan Academy is a good one actually. I used it during my year 12, high school time and then I stopped using it because I found that there were better sources of information that would actually answer my questions in particular." (S-1)	Relative advantage
"It was just like listening to the class (Udemy, Coursera), I didn't have anything to do. Probably I didn't have enough resources. Whereas, there's things like Google learning platform, they have good interactive sessions, so I do make use of them. They come up with lots of things for students quite often if you have registered there as a student. So they have quite good learning opportunities." (S-8)	Relative advantage
"Like Mars, it doesn't have the flexibility to have written questions. It just allows one kind of question (MCQ) you can ask. That might be the reason, that's why Flux is better than Mars." (S-9)	Relative advantage

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Table 7.4 – continued from previous page

Students' responses	Factor Mapping / Emerging Factor
"I used to use some websites where I could download English video files and listen to them. I stop using them because they lacked interaction, lacked feedback." (S-5)	Output quality
"I stopped using an application because there were only videos in it. I didn't want to go through just the videos because I find learning from videos which are one and a half hour long is like putting me to sleep." (S-13)	Output quality
"I think a lot of notes just stopped being updated. A lot of them are like three or four years ago. I think with Monash, it's very hard to use notes like that because they change it relatively." (S-12)	Output quality
"Normally when I stop using, I might have finished all the content on it. Or I got bored with that sort of content or I wasn't interested in educating it anymore. There've been a few times I read the information and stuff, I did it a few days but I didn't care anymore, so I didn't go back to it." (S-4)	Study relevance
"Maybe it's a one-time thing. It's relevant to me at one point, then I didn't need to go back to it." (S-14)	Study relevance
"They are only seven-day trial. In seven days, I never have a fair enough idea of where I'm heading to, I need, maybe in my point of view, a month is needed for me to know if the application is suiting my needs." (S-2)	Trialability
"It should have a good interface. Many times, the application is really interesting, but the interface is bad, or old. Also, it should have good visual, colours and graphics." (S-3)	First impression
"I stopped using it because you had to purchase the note, you ended up using actual cash that they converted to points or something. Or you could upload your own notes. And, I think it got higher after some time. They just decided to charge you more and when they're taking notes from you they give you less. It's a very bad counterbalance." (S-12)	Accessibility
"Because it wasn't user friendly, it's not easy to navigate through." (S-15)	Ease of use
"I think time essence as well. Rather going into each and every website to check, I would rather just google it, pick the first few and get it over with. Rather than logging in, waiting, uploading notes, getting the credits, waiting for few more weeks or so." (S-12)	Immediacy

Table 7.4: Influential factors to later rejection from students' perspectives

Throughout the interviews with students, three factors emerged as main reasons for their rejection of a voluntary IT in a later stage. The factors included relative advantage, compatibility, and output quality. The first factor induced from the students' responses was relative advantage (S-1, S-8, S-9, S-10). Relative advantage refers to "the degree to which an innovation is perceived as better than the idea it supersedes" (Rogers, 2010, p.15). After using an application for a period of time, students might find better alternatives with more convenient features which could perform the tasks they wanted with greater quality (better output quality) and/or in a more effective and efficient manner (greater objective usability). Consequently, an application with lower quality than a newly introduced technology, as perceived by students, is most likely to be replaced.

The second factor which influences students' decisions to abandon a technology was output quality (S-2, S-3, S-4, S-5, S-8, S-9, S-12, S-13). This factor is considered as different from the one discussed above. In the case of relative advantage, students experiment with a number of applications and have a comparison of those applications in terms of both quality and degree of effort required. Although output quality is an important factor in weighting different applications with similar features (as discussed in subsection 7.5.1.2), in this context it suggests students' independent judgements on a technology. As discussed in Chapter 2, today's learners employ a wide range of technologies for their study. They now have higher and more diverse demands for both quality learning experience and greater convenience in the learning process (Garrison and Kanuka, 2004). A system which does not deliver the quality as expected by students is likely to be abandoned.

The third rejection influencing factor that emerged from the interview data was study relevance (S-4, S-5, S-9, S-14). This factor is specifically related to students' needs or interests. There is a high likelihood that today's learners perform their learning in a wide variety of courses in possibly different areas due to requirements introduced by the knowledge-based economy which demands that its labour force is equipped with multi-disciplinary skills (Cobo, 2013; Siemens, 2005; Stukalina, 2008). Thus, important tasks in students' learning journeys are inclined to change continuously. As a consequence, the study relevance of a technology perceived by students also changes correspondingly.

Other factors which were mentioned by fewer participants (1 to 3 participants) included trialability (S-2, S-3), accessibility (S-2, S-3, S-12), user interface (S-3), ease of use (S-15), and immediate results (S-12). According to the participants, in order to improve user retention of an application, particularly a voluntary application, a reasonable trial period is necessary for students to make an informed decision of the usefulness of the technology. Otherwise, they are more inclined to discontinue the technology use after the short trial. Accessibility, as discussed in subsection 7.5.1.2, has influence on students' continuance intentions to use a technology for their learning. At its worst this factor can lead to students' later rejection. In addition, a system for learning purposes is expected by students to be relatively easy to use, have an appealing interface, and perform required tasks in a swift manner.

7.5.2.2 Premature Rejection: Initial Barriers

The majority of data from the study with students can be mapped to the factors in TAM3 and the perceived attributes of innovation suggested in IDT (see Figure 7.6 – Research Model). Social norms (social influences) were remarked as an essential factor in the formation of students' positive/negative attitudes towards using a new IT as well as their intentions to use the IT. The data collected also supported the importance of several factors influencing perceived usefulness (in TAM3) as well as the perceived attributes of innovation (in IDT), including: job relevance, output quality, result demonstrability, objective usability (or relative advantage as in IDT), trialability, compatibility, and image.

However, there is a potential gap in the technology adoption process, specifically in a voluntary context. The innovation-decision process proposed by Rogers (2010) is illustrated at the bottom of Figure 7.9. The first stage is *knowledge* where an individual learns about the existence of a technology and its basic functionalities. The second stage is *persuasion* where the individual forms their attitude toward using the new technology. While knowledge stage is mainly cognition-specific, persuasion is more affection-based. The third stage is *decision* where the individual decides to adopt or reject the technology. First trials of the innovation are part of an individual's decision to adopt or reject. *Implementation* is when the individual actually employs the adopted technology in performing intended tasks. Finally, *confirmation* is the last stage where either further adoption or later rejection may occur depending on the support the individual receives and his or her perception of the technology after the implementation stage. Rogers also states that each stage in the 5-stage model is potentially a rejection point.

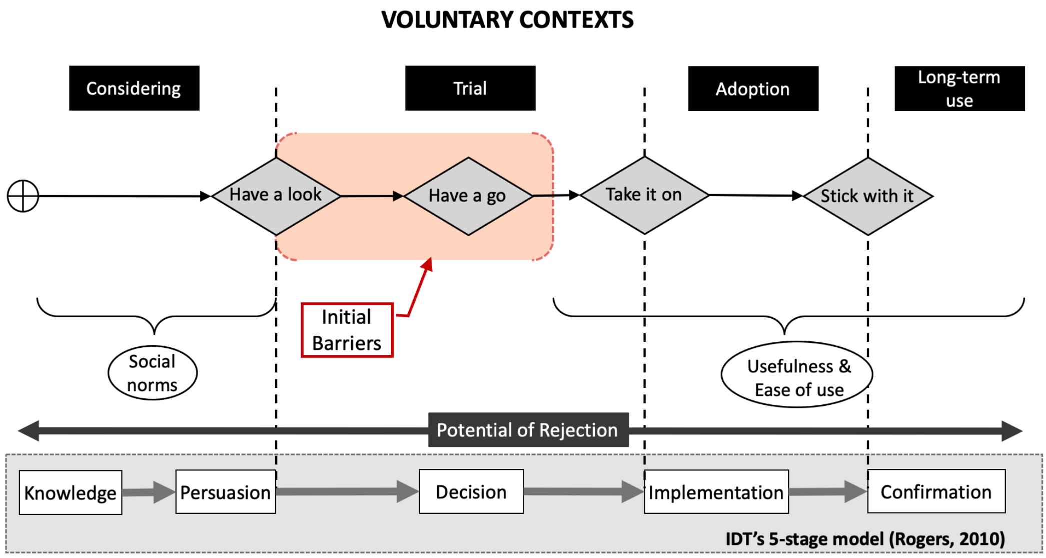

FIGURE 7.9: Potential gap regarding initial barriers (highlighted) to students' adoption of technology for learning purposes in voluntary contexts

Based on Rogers's model of five stages in the innovation-decision process (Rogers, 2010), the general flow of technology adoption in a voluntary context can be composed of: considering, first trial, adoption, and long-term use (see Figure 7.9). Firstly, an individual gets to know about a new technology through some communication channels (particularly social actors) and forms an attitude towards using the technology. At the end of the *considering* step, the individual decides to either take the first look at the technology or reject it. The next step is *first trial* where the individual firstly experiments with the newly introduced technology. The result of this step is either an early rejection or an adoption. In the *adoption* step, the individual employs the technology for its intended purpose for a period of time. After the usage period, the individual might continue to use the technology (*long-term use*) or decide to abandon it. The research model, which was retrieved from TAM3 and IDT, helped explain important factors influencing the *considering*, *adoption*, *long-term use*, and part of the *trial* steps. Nonetheless, what has not been covered are factors which might stop an individual (a student, in the context of this study) from experimenting with the newly introduced voluntary technology in order to get the intended results in the first place.

As a general discussion on their previous experience on information technologies for learning purposes, the interview participating students expressed what would quickly discourage them to experiment with a new system. According to the students, the lack of some factors in an application would likely lead to their loss of interest and potentially early rejection. Table 7.5 shows the most mentioned factors.

Students' responses	**Factor Mapping / Emerging Factor**
"A very messy UI . . . stuff that makes it very tedious to use. Sometimes it's just like bright colours when it doesn't need the bright colours, it just hurts the eyes. Then confusing layout." (S-4)	First impression
"To be honest, my Monash would be the one. Something about it is just not great. I know they kept revamping the design and the layout but still." (S-12)	First impression
"Again, even the website, if there's only a lot of information, no picture, no video, nothing, I wouldn't want to use it much." (S-15)	First impression
"I would say if it's not interactive, I don't want to do it. I don't want someone coming up in a video and telling this is this, this is that but wouldn't give us an opportunity to try it out on our own. I wouldn't find it interactive." (S-8)	First impression
"User interface, because most of the time, we download an application on our phone, hoping to use it once we have free time. If it's hard to manoeuvre to get through the app, it can be a pain." (S-11)	First impression Ease of use
"If it's too hard to use, it'll take me too long to get to know the tool, it won't save me enough time in the future to get started." (S-1)	Ease of use
"Not being relevant to the field of my study." (S-15)	Study relevance
"I take note taking for example, the note taking apps which I'd stay clear off are note taking apps which do not have images, you can't paste any images or anything; they don't have rich text, you can't bold text or make them into a list; note taking apps which put everything into one page, which is really hard to categorise." (S-1)	Study relevance
"When I go look at any apps, I usually look at users' reviews and feedback [...] But reviews, recent reviews, they suggest if the application is good or not, if the application has regular updates. Those kinds of recent reviews influence my thought, whether I should go for an application or not." (S-2)	Subjective norms

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Table 7.5 – continued from previous page

Students' responses	Factor Mapping / Emerging Factor
"When we download it, the first page coming up asks you to sign up for this, subscribe to it. It doesn't even allow you to at least have a look at what it is." (S-3)	Trialability
"Or free trial for 30 days but then they still ask for your payment details and you don't want to do that because you might forget to cancel the subscription and you'll get charged." (S-14)	Accessibility

Table 7.5: Student's perspectives: Initial barriers to technology adoption

As can be seen from Table 7.5, first impressions of a technology appeared to be a factor which most influences students' early intentions to reject. First visual impressions of an online application (or website) are defined as "the tangible aspect of the online environment that reflects the 'look and feel' or perceived attractiveness of a website" (Montoya-Weiss, Voss, and Grewal, 2003, p.450). Visual appeal of an application, including colours, graphics and visual complexity, is one key factor which can either attract or repel students, and users in general. A poor graphic design and presentation (as the participating students stated as *"messy UI"*, *"boring colours"*, or *"confusing layout"*) can cause users confusion and negatively affect their willingness to further explore the technology (Montoya-Weiss, Voss, and Grewal, 2003; Reinecke et al., 2013). Moreover, the visual appeal of an application is also related to ease of use and enjoyment perceived by users (Merhi, 2016; Yan et al., 2019).

Another factor discussed by the students was perceived ease of use. It should be noted that this factor is greatly related to students' first impressions of an application since the perception regarding the ease of use aspect is formed in an early stage when they initially interact with the system. When students first open an application, if they are presented with a confusing layout which makes navigation difficult, they are likely to perceive that the application falls short of their expectations of user-friendliness. Consequently, they might form a negative attitude towards the application and feel discouraged to experiment further with the technology.

Study relevance was also one factor raised by the participants. When students regard a technology as unrelated to their study, they are likely to reject the technology. In another circumstance, after initial trials, if an application does not have features to perform students' desired tasks, the application is viewed as irrelevant by the students and removed from further consideration.

In addition, other factors including subjective norms, trialability, and accessibility also appeared to have influence on students' early rejection of a new technology for learning purposes. Firstly, user reviews, a form of social influence, have an impact on how students perceive an application and consequently affect their decision to try out the new technology (McLean et al., 2020). An educational application with negative reviews is unlikely to stand a chance to attract students. Secondly, as discussed previously, trialability of a new technology is positively associated with its adoption rate. Therefore, if an application does not have a trial version or the trial period is not long enough for students to get a feel for the application, it is expected that the students will lose their interest for the technology. Thirdly, accessibility, particularly affordability, was mentioned by the participating students as a factor which might prevent them from forming an intention to try out a new technology.

Thus, factors including first impressions, perceived ease of use, study relevance, subjective norms, and trialability were considered important by the students. With a mandated system, for example a learning management system employed by a university, students do not really have a choice as to whether to use the technology. But with a voluntary application, if the system is tedious to use, it does not provide fast results, it gives a negative impression, it is not interactive, or if the students do not have a chance to experiment with the system without subscription, there is a good chance that they would completely reject it. The explanation for this was given by students including their time constraints and their clear awareness of the fact that there are a lot of other applications/technologies available out there that can help them do similar tasks.

7.5.3 LPRS as a Case Study

As previously presented, results from the studies prior to the evaluation phase (presented in Chapter 6) had shown good prospects for LPRS and genuine interest in the system from students. Nonetheless, when it was made available to them, the system usage and engagement was much lower than excepted: 113 students signed up to participate in the research, 68 completed parts of the required forms, 49 completed all data inputs and were able to receive recommendations for compatible study partners. Although students' responses to the surveys on LPRS usability were low, the results showed the potential usefulness and ease of use of LPRS perceived by the students (as in subsection 6.2.2.5). Thus, the system usage figures suggested that there were two points which posed very early barriers to students' buy-in: (1) before their first sight of the recommender system; and (2) their first interactions with the system.

In relation to the second objective of this data collection with students (as specified in subsection 7.3.2.2), the 15 participating students were asked to interact with LPRS where they completed data input forms, explored study partner recommendations generated, and experimented with LPRS utility tools (see Part 2, Appendix G.2). Moreover, the students were encouraged to provide comments on LPRS during system interaction (see Part 3, Appendix G.2). Responding to the question "What do you think would be the barriers to the system uptake?", responses from the participants converged toward three main reasons: the role of social influences; the look and feel of LPRS; and the long input process. Table 7.6 illustrates the three barriers to LPRS uptake postulated by the majority of the students, along with the most representative quotes.

Students' responses	**Factor Mapping / Emerging Factor**
"I think advertising for this is important, I didn't know this system existed. Advertisement on social channel at Monash at least would help, there would be people tempted to look into it. Some flashy banners would be good too." (S-13)	Subjective norms

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Table 7.6 – continued from previous page

Students' responses	Factor Mapping / Emerging Factor
"I mean in the sense of how they launch it, like coordinating with student association like Monsu, other associations... these people are our peers, and I feel like you more tend to download something if you hear about it from someone at our age or someone you're familiar with, over people that you see once during Orientation [week] but never see again." (S-12)	Subjective norms
"That's what goes with students, I guess, it's word of mouth. You say like 20 students really like it, it's going to be a hit. Otherwise, it's just like if some students say 'no, it's not good' it's just not going to work." (S-8)	Subjective norms
"When I first look at a new website, I wouldn't think of the benefits, just see if this website is interesting or fun for me to use. I think the most important thing is to attract users when they open this website for the first time." (S-10)	First impression
"I think the design overall, the feel of it... I think the platform, I feel it reminds me of something old and less fun. It looks very basic, simple. I think the overall functionality and appeal of it is a bit off." (S-12)	First impression
"The outlook of the website in general can be made more interactive because this conveys that it is an academic product, it follows academic look thick borders, square, white border." (S-6)	First impression
"I found the UI quite simple, it's not attractive." (S-5)	First impression
"My suggestion would be to match people in the initial phase based on their interests or projects that they are interested in, that would give users motivation to continue with other forms. It's like 'ok I have a partner who is going to study with me for Data Wrangling' and then other forms after that to get better recommendations." (S-2)	Immediacy of results
"I think the main barrier is the input forms are too long to finish." (S-5)	Immediacy of results
"I feel that the forms were long because right now my end goal is to see the report, but I have to fill in all the information like this." (S-3)	Immediacy of results
"Maybe just give like five or six questions at the first time and based on those answers, you can give them the recommendations. And then when they use the website for some time, then you can ask them more questions, not at once." (S-10)	Immediacy of results
"Maybe limiting the questions to like three per page. I think at the initial stage you can recommend a big group of people. From there, I think additional questions will come up." (S-12)	Immediacy of results

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Table 7.6 – continued from previous page

Students' responses	Factor Mapping / Emerging Factor
"Every time I fill in a form, I get some recommendations." (S-13)	Immediacy of results
"I think the main thing is you need to reduce the number of questions, make it as short as possible." (S-14)	Immediacy of results

Table 7.6: Students' perspectives: Reasons for the low uptake of LPRS

Firstly, social influences, according to the students, played a key role in making them aware of the existence of LPRS and forming their (either positive or negative) perception of the application even prior to experimenting with it. The formed attitude towards the application can be positive or negative depending on feedback from social agents, which highly likely lead to students' decisions to experiment with or disregard the recommender system. This aligned with the discussion presented in subsection 7.5.1.1 regarding the significance of subjective norms. There were efforts in raising students' awareness of availability of the system in the evaluation phase of the project; however, according to the participants, they would be more convinced to try out the system if there was a stronger branding campaign and there were peers vouching for it.

Secondly, the very first impressions of the application that students had could remarkably influence their perception of the system. As S-10 explained,

> *"Probably when I first look at a new website, I wouldn't think of the benefits, just see if this website is interesting or fun for me to use it. I think the most important thing is to attract users when they open this website for the first time."* (S-10)

Thus, at the very first sight, if students perceived the voluntary technology as uninteresting, it would be discouraging for them to experiment from the very start. The general comment on the look and feel of LPRS by the participating students was, it is unappealing: *"I found the UI quite simple, it's not attractive."* (S-5); *"the outlook of the website in general can be made more interactive because this conveys that it is an academic product"* (S-6); *"the design overall, the feel of it. It reminds me of something old and less fun. It looks very basic, simple [...] appeal of it is a bit off"* (S-12). It was remarked by the participants that by failing to capture students' interests from the beginning, LPRS might have fall short of students' perceived enjoyment and intentions to use the system.

Thirdly, the long input process was proposed by the majority of participants (except for S-9) as one of the biggest obstacles to system engagement. As the students commented:

> *"It's tough when you try to get people onto the platform if the process is really long."* (S-1),
>
> *"Filling the forms, especially when they are this many, could decrease the amount of interest for any person."* (S-2)

The fact that the long input forms of LPRS could drain its users of interest was also mentioned by the educators (as in Section 7.4). However, one key point emerging during the further discussion with students was about the immediacy of results. Most of the participating students showed an understanding that it was required for the application to collect data through the forms in order to provide recommendations that best fitted their characteristics and preferences. Nevertheless, after a while of filling out the input forms without being able to receive some results, the students would easily become demotivated and likely decide to leave the system. As S-12 expressed, *"I think I know it's trying to narrow down to a group of people to recommend, but maybe limiting the questions to like three per page"*.

Along the same line, other participants indicated that they would want to be presented with recommendations after some basic inputs with an awareness that the results might be of higher quality with more information being provided (more effort being invested). Some quotes from the participating students that demonstrate the importance of immediacy are as follows:

> *"My suggestion would be to match people in the initial phase based on their interests or projects that they are interested in, that would give users motivation to continue with other forms. It's like 'ok I have a partner who is going to study with me for Data Wrangling' and then other forms after that to get better recommendations."* (S-2),
>
> *"Maybe just give like five or six questions at the first time and based on those answers, you can give them the recommendations. And then when they use the website for some time, then you can ask them more questions, not at once."* (S-10),
>
> *"I think at the initial stage you can recommend a big group of people. From there, I think additional questions will come up."* (S-12)

Thus, with LPRS as a case study of an application for learning purposes in an entirely voluntary context, three factors were revealed to be important initial blocks to overcome before the other influential factors start taking effect. The three factors included social norms, first impressions of the application, and immediacy of results (as demonstrated in Figure 7.10).

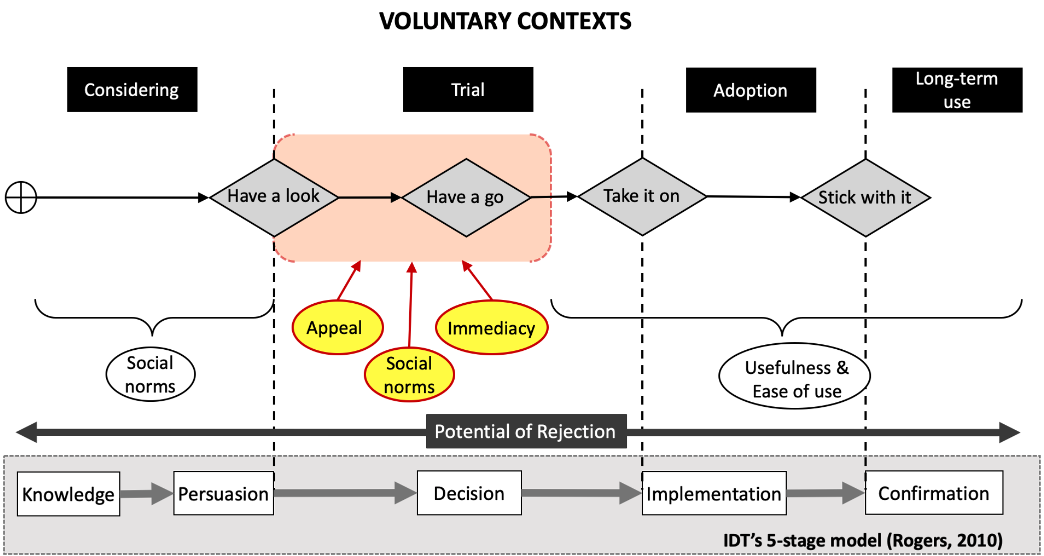


FIGURE 7.10: Influential factors (highlighted) as initial barriers to students' adoption of technology for learning purposes in voluntary contexts

As discussed at the beginning of this section, there were two points of early barriers to the system uptake: (1) prior to students' first sight of LPRS; and (2) their initial experiments with the system. Results from the interviews with students revealed that: while social norms play a key role in the former point, two factors including first impression and immediacy of result have significant influence in the latter point.

In summary, influencing factors in TAM and IDT could help obtain better understanding of students' decision-making process regarding technology adoption in non-mandatory contexts. Importantly, the findings from this study revealed three initial barriers to overcome in order to improve the chance for the adoption of a voluntary system.

7.6 Synthesis of the Views from Educators and Students

The study of barriers to students' adoption of voluntary technology for learning purposes, with LPRS as a use case, revealed interesting differences in perceptions of two important groups: the target users of the application and those who have direct influence in educational contexts. Table 7.7 summarises the comparison and contrast between educators' and students' views regarding LPRS as a case study of barriers to adoption.

Barriers to LPRS uptake	**Educators' view**	**Students' view**
Long input process	Yes	Yes
Security and Data privacy	Yes	No
Unclear benefit	Yes	No
Trust issue	Yes	No
Students' needs	Yes	Raised by one student
First impression	Raised by one educator	Yes
Awareness	Raised by three educators	Yes, mainly influenced by social norms

Table 7.7: Comparison & contrast between educators' and students' perspectives of barriers to adoption of technology for learning purposes, with LPRS as a case study

There was only one point that the majority of both participant groups agreed upon: the long input process of the system. Other concerns raised by either of the two groups did not seem to be an issue for the other. For example, the educators were worried about security, trust, and unobvious benefits from the system, they did not appear to be problems to almost all students. On the contrary, factors such as first impressions and how the tool looks mattered to students, whereas they were not mentioned as an issue by most educators except for one educational designer.

It should be noted that the study was conducted with a small number of participants, from the same faculty at a university. Therefore, the findings might not be generalisable. However, the nature of the investigation was exploratory in order to contextualise the factors influencing students' adoption (as well as rejection) of new technology in an informal and utterly voluntary environment. Further inquiries are necessary to gain deeper insights into factors influential to students' adoption of voluntary educational technology by having participants from different academic backgrounds/faculties (qualitatively), and to examine/validate the initial barriers to students' adoption of voluntary technology suggested by this study (quantitatively).

7.7 Key Findings

Three main findings emerged from the study. The first finding is that in non-mandatory situations, social norms, especially influence from peers, are an influential factor in students' awareness of a new technology, their trust towards the technology and their intentions to use the newly introduced technology for learning purposes. This finding contradicts what was theorised in TAM: "Subjective norm will have no significant direct effect on intention to use when system use is perceived to be voluntary" (Venkatesh and Davis, 2000, p.188).

Secondly, the data collected showed that perceived ease of use might have a greater level of importance in a voluntary context in comparison with the role it has in a mandatory setting. Research with TAM has demonstrated that perceived usefulness is a strong determinant of intention to use; while PEOU is a significant second determinant (Venkatesh and Davis, 2000). However, the voluntary nature of a situation might increase the significance of PEOU. If an application is difficult to learn and/or use, even when the benefits gained from using it are obvious to students, there is a good chance that the application will be rejected.

Thirdly, the study provides implications for both technology acceptance theory and practice. In terms of theory, the determinants in the TAM model do not necessarily hold true in all contexts. This research provides insights into students' perception of factors affecting their adoption of a new technology in voluntary contexts. In the study in this phase, data collection was conducted with students from an IT faculty. Consequently, some of the determinants of PEUO were not mentioned by the students during the interviews as a factor influencing their decision to use and accept a voluntary technology. This provides an indication that factors of TAM need to be adapted to the specific context of a study.

With regard to practice, this study suggests that in informal voluntary situations (and especially in the present digital age), in order for the determinants in the TAM model to start taking effect, there are some initial blocks to overcome including: social norms, users' first impression of the technology, and immediacy of results (as in Figure 7.10). The first factor is the role of *social norms*, particularly influencers. For students, if someone who is an important referent vouches for a new technology, it is likely that they would incorporate the referent's belief into their own belief system and form a positive attitude towards using the technology. However, if their peers give bad reviews on a tool, there is a slim chance that it will be tried out by the students.

The second factor is about *first impression*. The first impression a student has about an application could affect their decision to adopt or reject the technology. Users often form a lasting attitude towards an application within first seconds of viewing it for the first time. If the initial impression of the application is unattractive, it is less likely that they would trust it and more likely that they will abandon the application for others which they perceive as more appealing (Reinecke et al., 2013).

Lastly, the third factor is *immediacy of results*. This concept refers to the amount of effort that students want to invest in order to get some results, with an awareness that lower effort might produce lower quality results; while higher effort is more likely to generate higher quality outputs. Without these hurdles being overcome, the influence factors in TAM and IDT might not have a chance to play their parts in the adoption of a technology.

7.8 Conclusion

This chapter presented a qualitative investigation of barriers to students' adoption of technology aiming at learning in voluntary contexts, with LPRS as a case study. By reviewing literature on technology adoption, key factors in TAM3 (Venkatesh and Bala, 2008) and the perceived attributes of an innovation (Rogers, 2010) were adopted to guide the analysis of data collected from the study with educators and students. Results from this study supported that TAM3 was an appropriate ground theory for research on technology adoption in educational context: the majority of influence factors in TAM3 were able to represent the concepts and themes from the interview data.

Importantly, the study provided an interesting implication for research on technology adoption regarding the potential initial barriers to students' adoption of technology for learning purposes in completely voluntary contexts. The very first three hurdles revealed included social norms, first impression, and immediacy of results. These blocks need to be overcome in order for a new voluntary technology to have a chance of being experimented with and later accepted by students.

Chapter 8

Conclusion & Further Research

8.1 Introduction

This chapter provides a recapitulation of the research project. The eight research questions are concisely reiterated in Section 8.2. After that, the limitations of the work are acknowledged in Section 8.3, followed by suggested directions for future work in Section 8.4. Lastly, Section 8.5 reflects on the potential impact of the work and some takeaways as a researcher.

8.2 Research Questions

As presented from the outset, this research mainly aimed at promoting the formation of informal online learning communities amongst students in higher education through providing students with suggestions on study partners with compatible characteristics. Specifically, the work involved: (i) the identification of a collection of students' individual characteristics that have been found to be important for collaborative learning and the creation of learning communities; (ii) the design and implementation of a learning partner recommender system (LPRS) that collected data about students' characteristics and preferences for the purpose of generating recommendations for compatible learning partners; (iii) the evaluation of the developed LPRS; and (iv) the identification of initial hurdles to students' adoption of technology for learning purposes in voluntary situations. With the development and evaluation of the artefact (LPRS) for the purpose of encouraging learning communities, Design Science Research was identified to be the most suitable research methodology.

In detail, there were eight sub-questions as follows:

SQ1: What characteristics do students consider important when choosing learning partners?

A set of 13 individual characteristics were reported from studies in the literature to be important for students' collaboration and the formation of online learning communities. The 13 characteristics included: motivation, self-efficacy, skills, willingness to communicate, personality, learning styles, education level, communication media, self-perception of connectedness, academic interests, learning patterns, hobbies, and demographics. A study (data collection 1) was conducted with students to explore their view on factors important to informal learning communities (groups) and to confirm the retrieved set. The first six characteristics in the aforementioned list emerged as most important – the first five factors were perceived as significant by the students, while the sixth factor has been used intensively in the literature.

SQ2: Which measures can be used to assess the effectiveness of an Online Learning Community?

Three measures have typically been used to evaluate OLCs in the literature including: system usability, learning achievement, and community-ness (Ke and Hoadley, 2009), as presented in Chapter 2 & 4. Academic achievement was categorised as out of scope for the current research; therefore, measures adopted for the project consisted of the usability of LPRS and connectedness aspect. In terms of instruments for evaluating the usability of the system, USE (Lund, 2001) and SUS (Brooke, 1996) questionnaires were used during LPRS implementation (Chapter 5) and evaluation (Chapter 6). Regarding instruments for exploring the impact of LPRS on the community-ness aspect, SoC (McMillan and Chavis, 1986) and CCS (Rovai, 2002c) were adopted during the evaluation phase (Chapter 6).

SQ3: How can a Learning Partner Recommender System (LPRS) be modelled to match students with compatible characteristics?

From the general input-process-output pattern, the model of LPRS was created to reflect the intended functionalities of the system, which were to collect data about students' characteristics and preferences, to generate matching scores, and to present recommendation results. The process of designing the conceptual model of LPRS was performed through different steps including literature review, data collection with students, preliminary design and refinement. The design of LPRS consisted of four main stages: Data Retrieval, Data Storage, Matching, and Display. Details of the LPRS conceptual model were presented in Chapter 4.

SQ4: What data sources are available for an LPRS and can be used to collect the information needed to match partners according to the identified list of characteristics?

Six out of the 13 identified students' individual characteristics, which emerged as most significant, were chosen to be integrated into the implementation of LPRS. The approach to collect data of students' characteristics used as matching criteria in LPRS included questionnaires and self-report forms (as in Chapter 5). The questionnaires adopted have been widely used in previous studies including: WTC scale (McCroskey, 1992), BFI-10 (Rammstedt and John, 2007), Self-efficacy subscale of the MSLQ questionnaire (Pintrich et al., 1991), and Felder-Silverman questionnaire (Felder and Silverman, 1988).

SQ5: Which matching algorithms can be employed to generate matching scores based on important characteristics and their significance level?

The approach to generating recommendations on study partners with compatible characteristics was profile-preference matching. The choice made aligned with the approach suggested by the previous studies in the literature that attempts to match learners with each other (Potts et al. (2018) and Prabhakar, Spanakis, and Zaïane (2017)). Moreover, the selected matching approach was remarked as suitable due to the unavailability of students' interaction data at the early stage of such a learning partner recommender system. The detailed matching algorithms implemented were provided in Chapter 5.

SQ6: How can matching results be presented to learners in a meaningful and engaging way?

A number of iterations were performed to finalise the approach to present recommendation results. Two approaches were implemented in LPRS to display the results of recommended learning partners to students. The first approach employed inline bar chart to facilitate compatibility score decomposition in a single viewport. The second version of recommendation presentation was developed, after the user acceptance test with a focus group (presented in Chapter 5), which was a tabular presentation showing recommended peers' extra information with a filtering feature. The two presentations received generally positive feedback from the students throughout the data collections (see Chapter 5, 6, 7)

SQ7: What is the impact of implementing the partner matching system in creating and increasing positive interactions amongst students?

The evaluation was performed with two participant groups: students (a pilot test and a system rollout) and educators (in-depth semi-structured interviews). It was confirmed that LPRS functioned well in a real-life context with respect to collecting data about students' characteristics and generating recommendations for compatible study partners. The responses from students (although the response rate was low) and interviews with educators showed positive feedback on the system usability and its potential to encourage informal learning communities. The low system uptake from students during the evaluation motivated the investigation of barriers to the adoption of LPRS and voluntary educational applications.

SQ8: What are the factors influencing students' adoption of voluntary applications for learning purposes?

A study was conducted with educators and students to investigate reasons for the low uptake of LPRS and factors influencing students' adoption of technology for learning purposes in voluntary situations. Some findings emerged from the study, amongst which was one about initial hurdles to overcome in order for a voluntary technology to be experimented with and eventually accepted by students. These included social norms, immediacy of results, and visual appeal. These three important factors that emerged from the investigation were identified as initial hurdles in the technology adoption decision-making process; however, they are not reflected in widely used technology adoption models/frameworks.

In consideration of the foregoing, the main research question, **"Can a learning partner recommender system (LPRS) help promote effective informal Online Learning Communities in higher education settings?"**, is addressed: It can be concluded that a recommender system which provides students with suggestions for compatible study partners holds great promise for the formation of learning groups and learning communities. The design, implementation, and deployment of the technology deserve thorough consideration, given the technology usage is ultimately voluntary so that such a system can have a chance to be experimented with and eventually accepted by students.

The main contributions of this research are as follows. Firstly, it identifies the collection of students' characteristics significant to their collaboration with others and the creation of OLCs. Secondly, the conceptual model of the learning partner recommender system is proposed, along with its implemented working instantiation, which suggests compatible study partners based on students' features and preferences. Thirdly, the work contributes to a better understanding of factors influencing students' decisions to adopt or reject a voluntary educational technology.

8.3 Limitations

Four main limitations need to be acknowledged in this research project. Firstly, an online learning community, as any learning communities, requires a certain amount of time to form, develop and maintain its cohesion. However, the major focus of the research was about stimulation of interactions amongst students with respect to both quantity and quality. Positive interaction is one of the most vital elements to the creation and development of OLCs. Although students were involved throughout all four phases of the project and the pilot test was conducted prior to the wider deployment, the duration of LPRS roll-out was limited to one teaching period (one semester, approximately four months). This limitation had a substantial effect on students' awareness of the system, spontaneity in modifying the main functionalities of the system, and consequently students' attitudes towards using the system.

Secondly, LPRS was initially proposed with 13 matching criteria, which were 13 students' characteristics. These characteristics were synthesised from literature and examined through the first data collection and analysis at the early stage of the project. Six out of the 13 were integrated into the system as recommendation criteria. The six characteristics were perceived as most important by students and extensively used in the literature to group students into teams. It is acknowledged that inclusion of different characteristics into the process of generating recommendations for study partners could help improve the relevance of the system as perceived by students, such as hobbies, interests, location and learning patterns. However, with an attempt to gain a balance between quality of recommendation results and unsatisfactorily lengthy input process, only six factors (were willingness to communicate, personality, motivation, self-efficacy, learning styles and skills) were employed as matching criteria. Other characteristics (demographics, education information, and academic interests) were used as recommendation filtering conditions. Nevertheless, the findings from phase 3 and 4 of the project, as presented in Chapter 6 and Chapter 7, show that real users (students) expect a short input process which requires little effort before receiving less refined but acceptable recommendation results.

Thirdly, it was initially postulated that Learning Analytics would take an important role in this research. However, after the initial investigation, the amount of LA data from LMSs used in the project was less than anticipated. It was critical in the development of LPRS to firstly collect data about students' characteristics since the first priority was to establish the system, make it function and investigate how the matching process performs before using LA to tune the recommendations. So, the integration of LA data from external sources was categorised as further research. That having been said, LA is ultimately one of the primary data sources for such a reciprocal recommender system but not the feature source in this research project.

Fourthly, data collections in the research were conducted with students and educators from one single faculty at a university by applying convenience sampling. Although there was an effort to recruit participants from backgrounds and expertise which was as diverse/representative as possible, the limitation regarding number of participants made it difficult to generalise the findings emerging from the research. Further work with regard to this limitation is discussed below.

8.4 Directions for Future Work

Six suggestions for future research work emerge from the results of this project and the discussions that followed.

Utilising Learning Analytics advances

There has been research which shows the potential of using Learning Analytics to help automatically identify students' characteristics such as learning styles (Jena, 2018), skills (Mah, 2016), motivation (You, 2016), and engagement (Liu et al., 2015). With data extracted from external sources, such as a learning management system, students' learning styles and/or motivation as well as basic information could be retrieved and fetched into the Learning Partner Recommender System as input. This approach could significantly enhance the system usability and objectivity of input data.

Inclusion of more attributes in recommendation generation

The original set of characteristics used as matching criteria in the learning partner recommender system consisted of 13 attributes. For the purpose of proof of concept, the six features which were remarked as most important (by students during data collection 1) out of the 13 were integrated into the actual development of LPRS. Capturing other characteristics in the process of generating recommendations for study partners might be more desirable and requires further work.

Utilisation of machine learning techniques in LPRS functionality

As presented in Chapter 5, Phase 2 of the project, the key goal of LPRS was not to maximise the number of students who are recommended and receive recommendations. Rather, the system aimed at providing students with recommendations as satisfactory as possible based on their characteristics and preferences. The explanation for this decision was also given in Section 5.2. With that said, application of machine learning could be a direction for future work regarding the technical aspects of the system. Machine learning techniques, such as approaches which are used in group formation and reciprocal recommender systems, can be studied and employed to achieve this aim.

System deployment with more diverse cohorts

The Learning Partner Recommender System was deployed to students from one faculty (Faculty of Information Technology at Monash University). Further research could be done towards deployment with students from different faculties in order to obtain insights regarding research potentials and voluntary technology adoption from different users' perspectives.

Inclusion of more evaluation metrics

One possibility for future work is related to the learning partner recommender system evaluation approach which can further study the impact on students' academic achievements and the quality of recommendations generated. Firstly, in terms of the learning performance, as discussed in sub-section 4.6, an investigation of potential impact of the research on the academic side of a learning community such as grades or assignment submissions is out of scope of this thesis. However, an understanding of the system's capability to positively affect their achievements could help promote use of the system to the students. Secondly, regarding the evaluation of recommendations generated by LPRS, more rigorous/extreme approaches are more desirable in order to obtain more factual and conclusive evidence of the system performance. A longitudinal participatory approach might be employed to study if and how the system can facilitate the creation and development of informal learning communities within a certain cohort.

Examining and/or validating initial barriers to students' adoption of voluntary technology
As stated previously, the study was conducted with a small number of participants from the same faculty at a university which led to a lack of generalisability. Further inquiries are necessary: to gain deeper insights into factors influential to students' adoption of voluntary educational technology by having participants from different academic backgrounds/faculties (qualitatively); and to examine/validate the initial barriers to students' adoption of voluntary technology suggested by this study (quantitatively).

8.5 Concluding Statement

Recommendations for study partners with compatible characteristics have great potentials for encouraging the formation of informal learning communities amongst students in higher education, as acknowledged by student and educator participants throughout six rounds of data collection of the project. In the research, a set of attributes which are relevant for consideration in generating learning partner suggestions has been identified; a working recommender system has been developed to demonstrate the concept and its feasibility; and a study was conducted to gain better understanding of barriers to students' adoption of technology for learning purposes in a fully voluntary context. Findings from the work presented in this thesis can contribute to active endeavours to the promotion of students' informal learning communities in higher education and the enhancement of their learning experience.

In hindsight, while Design Science Research was well-suited for this research project that required the creation of LPRS, it may have not anticipated users' possible behaviours regarding adoption of technology. The differences between researchers' anticipation and real users' expectations must be thoroughly considered and addressed throughout a research project in order to minimise unexpected experiences due to the gap in the two stakeholders' dispositions. Importantly, a research project can develop in directions which were not foreseen. Therefore, it is important that the researcher maintains the flexibility and willingness to explore different possibilities as they present themselves.

References

Abdullah, F. and Ward, R. (2016). Developing a General Extended Technology Acceptance Model for E-Learning (GETAMEL) by analysing commonly used external factors. *Computers in Human Behavior* 56, 238–256.

Abnar, S., Orooji, F., and Taghiyareh, F. (2012). An evolutionary algorithm for forming mixed groups of learners in web based collaborative learning environments. In: *Technology Enhanced Education (ICTEE), 2012 IEEE International Conference on*. IEEE, pp. 1–6.

Abrahams, D. A. (2010). Technology adoption in higher education: A framework for identifying and prioritising issues and barriers to adoption of instructional technology. *Journal of Applied Research in Higher Education* 2(2), 34–49.

Adomavicius, G. and Tuzhilin, A. (2005). Toward the next generation of recommender systems: A survey of the state-of-the-art and possible extensions. *IEEE Transactions on Knowledge and Data Engineering* 17(6), 734–749.

Ajjan, H. and Hartshorne, R. (2008). Investigating faculty decisions to adopt Web 2.0 technologies: Theory and empirical tests. *The Internet and Higher Education* 11(2), 71–80.

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In: *Action Control*. Springer, pp. 11–39.

Ajzen, I. and Fishbein, M. (1980). *Understanding Attitudes and Predicting Social Behavior*. Prentice-Hall.

Akyol, Z., Garrison, D. R., and Ozden, M. Y. (2009). Online and blended communities of inquiry: Exploring the developmental and perceptional differences. *The International Review of Research in Open and Distributed Learning* 10(6), 65–83.

Al-Ammary, J. H., Al-Sherooqi, A. K., and Al-Sherooqi, H. K. (2014). The acceptance of social networking as a learning tools at University of Bahrain. *International Journal of Information and Education Technology* 4(2), 208.

Alfonseca, E. et al. (2006). The impact of learning styles on student grouping for collaborative learning: a case study. *User Modeling and User-Adapted Interaction* 16(3-4), 377–401.

Allen, I. E. and Seaman, J. (2008). *Staying the course: Online education in the United States, 2008*. ERIC.

Allen, I. E. and Seaman, J. (2016). Online Report Card: Tracking Online Education in the United States. *Babson Survey Research Group*.

Amichai-Hamburger, Y. and Vinitzky, G. (2010). Social network use and personality. *Computers in Human Behavior* 26(6), 1289–1295.

Anderson, T. (2008). Towards a theory of online learning. In: *The Theory and Practice of Online Learning*. Ed. by T. Anderson. 2nd ed. Athabasca University Press. Chap. 2, pp. 45–74.

Angelino, L. M., Williams, F. K., and Natvig, D. (2007). Strategies to engage online students and reduce attrition rates. *Journal of Educators Online* 4(2), 1–14.

Arasaratnam-Smith, L. A. and Northcote, M. (2017). Community in Online Higher Education: Challenges and Opportunities. *Electronic Journal of e-Learning* 15(2), 188–198.

Arbaugh, J. B. (2007). An empirical verification of the community of inquiry framework. *Journal of Asynchronous Learning Networks* 11(1), 73–85.

Attuquayefio, S. and Addo, H. (2014). Using the UTAUT model to analyze students' ICT adoption. *International Journal of Education and Development using ICT* 10(3), 75–86.

Attwell, G. et al. (2007). Personal Learning Environments-the future of eLearning? *eLearning Papers* 2(1), 1–8.

Bagozzi, R. P. (2007). The legacy of the technology acceptance model and a proposal for a paradigm shift. *Journal of the Association for Information Systems* 8(4), 244–254.

Baker, C. (2010). The impact of instructor immediacy and presence for online student affective learning, cognition, and motivation. *Journal of Educators Online* 7(1), n1.

Balmaceda, J. M., Schiaffino, S. N., and Pace, J. A. D. (2014). Using constraint satisfaction to aid group formation in CSCL. *Inteligencia Artificial, Revista Iberoamericana de Inteligencia Artificial* 17(53), 35–45.

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist* 28(2), 117–148.

Barnes, C. and Tynan, B. (2007). The adventures of Miranda in the brave new world: learning in a Web 2.0 millennium. *Research in Learning Technology* 15(3), 189–200.

Baskerville, R., Pries-Heje, J., and Venable, J. (2009). Soft design science methodology. In: *Proceedings of the 4th International Conference on Design Science Research in Information Systems and Technology*. ACM, pp. 1–11.

Bates, T. (2014). The role of communities of practice in a digital age. Retrieved from https://www.tonybates.ca/2014/10/01/the-role-of-communities-of-practice-in-a-digital-age/.

Battalio, J. (2009). Success in distance education: Do learning styles and multiple formats matter? *The American Journal of Distance Education* 23(2), 71–87.

Baturay, M. H. (2015). An overview of the world of MOOCs. *Procedia-Social and Behavioral Sciences* 174, 427–433.

Beheshti, B. and Desmarais, M. (2014). Predictive performance of prevailing approaches to skills assessment techniques: Insights from real vs. synthetic data sets. In: *Educational Data Mining 2014*.

Bekele, R. (2006). Computer-assisted learner group formation based on personality traits. PhD thesis. Hamburg, Germany: University of Hamburg.

Bendou, K., Megder, E., and Cherkaoui, C. (2017). Animated pedagogical agents to assist learners and to keep them motivated on Online Learning Environments (LMS or MOOC). *International Journal of Computer Applications* 168(6), 46–53.

Bernard, J. et al. (2017). Learning style Identifier: Improving the precision of learning style identification through computational intelligence algorithms. *Expert Systems with Applications* 75, 94–108.

Biggs, J. B. (1989). Approaches to the enhancement of tertiary teaching. *Higher Education Research and Development* 8(1), 7–25.

Bollier, D., Firestone, C. M., et al. (2010). *The promise and peril of big data*. Aspen Institute, Communications and Society Program Washington, DC.

Boud, D., Cohen, R., and Sampson, J. (1999). Peer learning and assessment. *Assessment & Evaluation in Higher Education* 24(4), 413–426.

Boud, D., Cohen, R., and Sampson, J. (2014). *Peer learning in higher education: Learning from and with each other*. Routledge.

Boud, D. and Middleton, H. (2003). Learning from others at work: communities of practice and informal learning. *Journal of Workplace Learning* 15(5), 194–202.

Bremer, C. and Weiß, D. (2013). How to analyze participation in a (c) MOOC? In: *Proceedings of the 5th International Conference on Education and New Learning Technologies*, pp. 992–1002.

Breslow, L. et al. (2013). Studying learning in the worldwide classroom research into edX's first MOOC. *Research & Practice in Assessment* 8, 13–25.

Brewer, S. W. (2018). Come for a Job, Stay for the Socializing: Gratifications Received from LinkedIn Usage. *Online Journal of Communication and Media Technologies* 8(4), 345–361.

Brook, C. and Oliver, R. (2003). Online learning communities: Investigating a design framework. *Australasian Journal of Educational Technology* 19(2), 139–160.

Brooke, J. (1996). SUS: A "quick and dirty" usability scale. In: *Usability Evaluation in Industry*. Ed. by P. W. Jordan et al. Taylor & Francis. Chap. 21, pp. 189–194.

Brower, A. M. and Dettinger, K. M. (1998). What is a learning community?: Toward a comprehensive model. *About Campus* 3(5), 15–21.

Calhoun, D. W. and Green, L. S. (2015). Utilizing online learning communities in student affairs. *New Directions for Student Services* 2015(149), 55–66.

Cambridge, D., Kaplan, S., and Suter, V. (2005). Community of practice design guide: A step-by-step guide for designing & cultivating communities of practice in higher education. Retrieved from https://library.educause.edu/-/media/files/library/2005/1/nli0531-pdf.pdf.

Cao, Y. and Philp, J. (2006). Interactional context and willingness to communicate: A comparison of behavior in whole class, group and dyadic interaction. *System* 34(4), 480–493.

Carver, C. A., Howard, R., and Lane, W. (1999). Addressing different learning styles through course hypermedia. *IEEE Transactions on Education* 42(1), 33–38.

Chan, C. K. and Chan, Y.-Y. (2011). Students' views of collaboration and online participation in Knowledge Forum. *Computers & Education* 57(1), 1445–1457.

Chang, I.-Y. and Chang, W.-Y. (2012). The effect of student learning motivation on learning satisfaction. *International Journal of Organizational Innovation* 4(3), 281–305.

Chang, Y.-C. et al. (2009). A learning style classification mechanism for e-learning. *Computers & Education* 53(2), 273–285.

Charalambos, V., Michalinos, Z., and Chamberlain, R. (2004). The design of online learning communities: Critical issues. *Educational Media International* 41(2), 135–143.

Chatti, M. A. et al. (2012). A reference model for learning analytics. *International Journal of Technology Enhanced Learning* 4(5-6), 318–331.

Chen, M., Mao, S., and Liu, Y. (2014). Big data: A survey. *Mobile Networks and Applications* 19(2), 171–209.

Chen, S.-J. and Caropreso, E. J. (2004). Influence of personality on online discussion. *Journal of Interactive Online Learning* 3(2), 1–17.

Chintalapati, N. and Daruri, V. S. K. (2017). Examining the use of YouTube as a Learning Resource in higher education: Scale development and validation of TAM model. *Telematics and Informatics* 34(6), 853–860.

Cho, H. et al. (2007). Social networks, communication styles, and learning performance in a CSCL community. *Computers & Education* 49(2), 309–329.

Clement, J. and Vosniadou, S (2008). The role of explanatory models in teaching for conceptual change. In: *International Handbook of Research on Conceptual Change*. Ed. by S. Vosniadou. Taylor & Francis, pp. 417–452.

Clow, D. (2012). The learning analytics cycle: closing the loop effectively. In: *Proceedings of the 2nd International Conference on Learning Analytics and Knowledge*. ACM, pp. 134–138.

Cobo, C. (2013). Skills for innovation: envisioning an education that prepares for the changing world. *Curriculum Journal* 24(1), 67–85.

Cocea, M. and Magoulas, G. D. (2012). User behaviour-driven group formation through case-based reasoning and clustering. *Expert Systems with Applications* 39(10), 8756–8768.

Coffrin, C. et al. (2014). Visualizing patterns of student engagement and performance in MOOCs. In: *Proceedings of the Fourth International Conference on Learning Analytics and Knowledge*. ACM, pp. 83–92.

Cohen, E. G. and Lotan, R. A. (2014). *Designing Groupwork: Strategies for the Heterogeneous Classroom Third Edition*. Teachers College Press.

Confessore, S. J. and Kops, W. J. (1998). Self-directed learning and the learning organization: Examining the connection between the individual and the learning environment. *Human Resource Development Quarterly* 9(4), 365–375.

Costa, P. T. and McCrae, R. R. (2008). The Revised NEO Personality Inventory (NEO-PI-R). In: *The SAGE Handbook of Personality Theory and Assessment*. Ed. by G. J. Boyle, G. Matthews, and D. H. Saklofske. Vol. 2. SAGE Publications, pp. 179–198.

Cross, K. P. (1998). Why learning communities? Why now? *About Campus* 3(3), 4–11.

Cruz, W. M. and Isotani, S. (2014). Group formation algorithms in collaborative learning contexts: A systematic mapping of the literature. In: *CYTED-RITOS International Workshop on Groupware*. Springer, pp. 199–214.

Curşeu, P. L. and Pluut, H. (2013). Student groups as learning entities: The effect of group diversity and teamwork quality on groups' cognitive complexity. *Studies in Higher Education* 38(1), 87–103.

Dabbagh, N. and Kitsantas, A. (2012). Personal Learning Environments, social media, and self-regulated learning: A natural formula for connecting formal and informal learning. *The Internet and Higher Education* 15(1), 3–8.

Dancer, D., Morrison, K., and Tarr, G. (2015). Measuring the effects of peer learning on students' academic achievement in first-year business statistics. *Studies in Higher Education* 40(10), 1808–1828.

Daniel, J. (2012). Making Sense of MOOCs: Musings in a Maze of Myth, Paradox and Possibility. Retrieved from https://jime.open.ac.uk/articles/10.5334/2012-18/. Journal of Interactive Media in Education.

Darabi, A. et al. (2011). Cognitive presence in asynchronous online learning: A comparison of four discussion strategies. *Journal of Computer Assisted Learning* 27(3), 216–227.

Dascalu, M.-I. et al. (2014). Improving e-learning communities through optimal composition of multidisciplinary learning groups. *Computers in Human Behavior* 30, 362–371.

Davis, F. D. (1985). A technology acceptance model for empirically testing new end-user information systems: Theory and results. PhD thesis. Massachusetts Institute of Technology.

Davis, F. D., Bagozzi, R. P., and Warshaw, P. R. (1989). User acceptance of computer technology: a comparison of two theoretical models. *Management Science* 35(8), 982–1003.

Davis, S. (2011). *Monster Under the Bed*. Simon and Schuster.

Dawson, S. et al. (2014). Current state and future trends: A citation network analysis of the learning analytics field. In: *Proceedings of the Fourth International Conference on Learning Analytics and Knowledge*. ACM, pp. 231–240.

De Grove, F., Bourgonjon, J., and Van Looy, J. (2012). Digital games in the classroom? A contextual approach to teachers' adoption intention of digital games in formal education. *Computers in Human Behavior* 28(6), 2023–2033.

Dekker, S. et al. (2012). Neuromyths in education: Prevalence and predictors of misconceptions among teachers. *Frontiers in Psychology* 3, 429.

Dennen, V. P. (2000). Task structuring for on-line problem based learning: A case study. *Educational Technology & Society* 3(3), 329–336.

Denzin, N. K. and Lincoln, Y. S. (2005). Introduction: The Discipline and Practice of Qualitative Research. In: *The Sage Handbook of Qualitative Research*. SAGE Publications, pp. 1–19.

Department of Education and Early Childhood Development (2012). Blended Learning: A Synthesis of Research Findings in Victorian Education 2006-2011. Retrieved from https://www.education.vic.gov.au/Documents/about/research/blendedlearning.pdf.

Diaz, F., Metzler, D., and Amer-Yahia, S. (2010). Relevance and ranking in online dating systems. In: *Proceedings of the 33rd International ACM SIGIR Conference on Research and Development in Information Retrieval*. ACM, pp. 66–73.

Dietz-Uhler, B. and Hurn, J. E. (2013). Using learning analytics to predict (and improve) student success: A faculty perspective. *Journal of Interactive Online Learning* 12(1), 17–26.

Dillenbourg, P. (1999). What do you mean by "Collaborative Learning"? In: *Collaborative Learning: Cognitive and Computational Approaches*. Ed. by P. Dillenbourg. Elsevier Science & Technology Books, pp. 1–19.

Dillenbourg, P. et al. (2014). Massive Open Online Courses: Current state and perspectives. In: *Dagstuhl Manifestos*. Vol. 4. Retrieved from https://drops.dagstuhl.de/opus/volltexte/2014/4786/. Schloss Dagstuhl, Leibniz-Zentrum fuer Informatik.

Donovan, L. A. and MacIntyre, P. D. (2004). Age and sex differences in willingness to communicate, communication apprehension, and self-perceived competence. *Communication Research Reports* 21(4), 420–427.

Downes, C. (2015). Using information and communication technologies to promote participation and peer co-operation during collaborative literacy tasks for English-language learners. *Journal of Student Engagement: Education Matters* 5(1), 2–11.

Downes, S. (2007). Models for sustainable open educational resources. *Interdisciplinary Journal of E-Learning and Learning Objects* 3(1), 29–44.

Drachsler, H. et al. (2015). Panorama of recommender systems to support learning. In: *Recommender Systems Handbook*. Ed. by F. Ricci, L. Rokach, and B. Shapira. Springer, pp. 421–451.

Dresch, A., Lacerda, D. P., and Antunes, J. A. V. (2015). Design science research. In: *Design Science Research*. Springer, pp. 67–102.

Dron, J. (2007). Designing the undesignable: Social software and control. *Journal of Educational Technology & Society* 10(3).

Duncan, T. G. and McKeachie, W. J. (2005). The making of the motivated strategies for learning questionnaire. *Educational Psychologist* 40(2), 117–128.

Duval, E. (2011). Attention please!: learning analytics for visualization and recommendation. In: *Proceedings of the 1st International Conference on Learning Analytics and Knowledge*. ACM, pp. 9–17.

Dykman, C. A. and Davis, C. K. (2008). Part One - The Shift Toward Online Education. *Journal of Information Systems Education* 19(1), 11–16.

Economides, A. A. (2008). Culture-aware collaborative learning. *Multicultural Education & Technology Journal* 2(4), 243–267.

EDUCAUSE Learning Initiative (ELI) (2009). The seven things you should know about... Personal Learning Environments. Retrieved from https://library.educause.edu/-/media/files/library/2009/5/eli7049-pdf.pdf.

ElAtia, S., Ipperciel, D., and Zaïane, O. R. (2016). *Data Mining and Learning Analytics: Applications in Educational Research*. John Wiley & Sons.

Elias, T. (2011). Learning Analytics: Definitions, processes and potential. Unpublished Internal Whitepaper of Athabasca University, Canada. Retrieved from https://landing.athabascau.ca/file/download/43713.

Ellis, R. K. (2009). *Field guide to learning management systems*. Learning Circuits. American Society for Training and Development (ASTD).

Felder, R. M., Silverman, L. K., et al. (1988). Learning and teaching styles in engineering education. *Engineering Education* 78(7), 674–681.

Florenthal, B. (2015). Applying uses and gratifications theory to students' LinkedIn usage. *Young Consumers* 16(1), 17–35.

Fournier, H., Kop, R., and Sitlia, H. (2011). The value of learning analytics to networked learning on a personal learning environment. In: *Proceedings of the 1st International Conference on Learning Analytics and Knowledge*. ACM, pp. 104–109.

Gabelnick, F. et al. (1990). *Learning Communities: Creating Connections Among Students, Faculty, and Disciplines*. New Directions for Teaching and Learning. Jossey-Bass.

Gabriel, M. (2004). Learning together: Exploring group interactions online. *Journal of Distance Education* 19(1), 54–72.

Garrison, D. R. (1997). Self-directed learning: Toward a comprehensive model. *Adult Education Quarterly* 48(1), 18–33.

Garrison, D. R. (2007). Online community of inquiry review: Social, cognitive, and teaching presence issues. *Journal of Asynchronous Learning Networks* 11(1), 61–72.

Garrison, D. R., Anderson, T., and Archer, W. (1999). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education* 2(2-3), 87–105.

Garrison, D. R., Anderson, T., and Archer, W. (2001). Critical thinking and computer conferencing: A model and tool to assess cognitive presence. *American Journal of Distance Education* 15(1), 7–23.

Garrison, D. R. and Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. *The Internet and Higher Education* 7(2), 95–105.

Gerry, S., Koschmann, T., and Suthers, D. (2006). Computer-supported Collaborative Learning: An Historical Perspective. In: *Cambridge Handbook of the Learning Sciences*. Ed. by R. K. Sawyer. Cambridge University Press, pp. 409–426.

Ghorbani, F and Montazer, G. A. (2015a). Learner's motivation recognition in e-learning environment. In: *Information Engineering and Education Science: Proceedings of the International Conference on Information Engineering and Education Science (ICIEES 2014)*. Vol. 5. CRC Press, pp. 75–79.

Ghorbani, F. and Montazer, G. A. (2015b). E-learners' personality identifying using their network behaviors. *Computers in Human Behavior* 51, 42–52.

Gillani, N. (2013). Learner communications in massively open online courses. Retrieved from http://oxcheps.new.ox.ac.uk/MainSite%20pages/Resources/OxCHEPS_OP53.pdf. OxCHEPS Occasional Paper No. 53.

Glance, D. G., Forsey, M., and Riley, M. (2013). The pedagogical foundations of massive open online courses. *First Monday* 18(5), Retrieved from https://firstmonday.org/ojs/index.php/fm/article/view/4350/3673.

Gokhale, A. A. (1995). Collaborative learning enhances critical thinking. *Journal of Technology Education* 7(1), 22–30.

Goldberg, L. R. (1992). The development of markers for the Big-Five factor structure. *Psychological Assessment* 4(1), 26–42.

Goodsell, A. S. et al. (1992). Collaborative Learning: A Sourcebook for Higher Education. National Center on Postsecondary Teaching, Learning, and Assessment at Pennsylvania State University.

Goodyear, P. and Retalis, S., eds. (2010). *Technology-Enhanced Learning: Design Patterns and Pattern Languages*. Vol. 2. Rotterdam, The Netherlands: Sense Publishers.

Gosling, S. D., Rentfrow, P. J., and Swann Jr, W. B. (2003). A very brief measure of the Big-Five personality domains. *Journal of Research in Personality* 37, 504–528.

Govaerts, S. et al. (2010). Visualizing Activities for Self-reflection and Awareness. In: *International Conference on Web-based Learning*. Springer, pp. 91–100.

Graf, S. and Bekele, R. (2006). Forming Heterogeneous Groups for Intelligent Collaborative Learning Systems with Ant Colony Optimization. In: *International Conference on Intelligent Tutoring Systems*. Springer, pp. 217–226.

Graf, S. et al. (2007). In-Depth Analysis of the Felder-Silverman Learning Style Dimensions. *Journal of Research on Technology in Education* 40(1), 79–93.

Graham, C. R. (2006). Blended learning systems: Definition, current trends, and future directions. In: *The Handbook of Blended Learning: Global Perspectives, Local Designs*. Ed. by C. J. Bonk and C. R. Graham. Pfeiffer San Francisco, CA, pp. 3–21.

Graham, C. R. and Misanchuk, M. (2004). Computer-mediated learning groups: Benefits and challenges to using groupwork in online learning environments. In: *Online Collaborative Learning: Theory and Practice*. Ed. by T. S. Roberts. Information Science Publishing, pp. 181–202.

Graham, K. A., Dust, S. B., and Ziegert, J. C. (2018). Supervisor-employee power distance incompatibility, gender similarity, and relationship conflict: A test of interpersonal interaction theory. *Journal of Applied Psychology* 103, 334–346.

Gratzl, S. et al. (2013). Lineup: Visual analysis of multi-attribute rankings. *IEEE Transactions on Visualization and Computer Graphics* 19(12), 2277–2286.

Gray, B. (2004). Informal Learning in an Online Community of Practice. *Journal of Distance Education* 19(1), 20–35.

Greer, J. E. et al. (1998). Supporting Peer Help and Collaboration in Distributed Workplace Environments. *International Journal of Artificial Intelligence in Education (IJAIED)* 9, 159–177.

Gregor, S. and Hevner, A. R. (2013). Positioning and Presenting Design Science Research for Maximum Impact. *MIS Quarterly* 37(2), 337–355.

Gunawardena, C. N. (1995). Social presence theory and implications for interaction and collaborative learning in computer conferences. *International Journal of Educational Telecommunications* 1(2), 147–166.

Hahn, E., Gottschling, J., and Spinath, F. M. (2012). Short measurements of personality–Validity and reliability of the GSOEP Big Five Inventory (BFI-S). *Journal of Research in Personality* 46, 355–359.

Hawkes, M. and Romiszowski, A. (2001). Examining the Reflective Outcomes of Asynchronous Computer-Mediated Communication on Inservice Teacher development. *Journal of Technology and Teacher Education* 9(2), 283–306.

Hevner, A. and Chatterjee, S. (2010). Design Science Research in Information Systems. In: *Design Research in Information Systems*. Springer, pp. 9–22.

Hevner, A. R. (2007). A three cycle view of design science research. *Scandinavian Journal of Information Systems* 19(2), 87–92.

Hevner, A. R. et al. (2004). Design Science in Information Systems Research. *MIS Quarterly* 28(1), 75–105.

Hewitt, J. and Scardamalia, M. (1998). Design principles for distributed knowledge building processes. *Educational Psychology Review* 10(1), 75–96.

Hietanen, L. (2015). Entrepreneurial learning environments: supporting or hindering diverse learners? *Education+ Training* 57(5), 512–531.

Hiltz, S. R. (1998). Collaborative Learning in Asynchronous Learning Networks: Building Learning Communities. Retrieved from https://files.eric.ed.gov/fulltext/ED427705.pdf. ERIC.

Hoadley, C. (2012). What is a Community of Practice and How Can We Support It? In: *Theoretical Foundations of Learning Environments*. Ed. by D. Jonassen and S. Land. 2nd ed. Routledge, pp. 286–300.

Holmberg, K. (2019). Formation of Student Groups with the Help of Optimization. *Journal of the Operational Research Society* 70(9), 1538–1553.

Honey, P. and Mumford, A. (1992). *The Manual of Learning Styles*. 3rd ed. Maidenhead, Berkshire: Peter Honey.

Houston, S. K. and Lazenbatt, A. (1999). Peer tutoring in a modelling course. *Innovations in Education and Training International* 36(1), 71–79.

Hsbollah, H. M. and Idris, K. M. (2009). E-learning adoption: the role of relative advantages, trialability and academic specialisation. *Campus-Wide Information Systems* 26(1), 54–70.

Huang, F., Teo, T., and Zhou, M. (2019). Factors affecting Chinese English as a foreign language teachers' technology acceptance: A qualitative study. *Journal of Educational Computing Research* 57(1), 83–105.

Huang, X. G. (2016). Online Learning Community and its Application in the Occupational Training of College Teachers. In: *International Conference on Electronic, Information and Computer Engineering*. Vol. 44. MATEC Web of Conferences. Retrieved from https://www.matec-conferences.org/articles/matecconf/pdf/2016/07/matecconf_iceice2016_02082.pdf. EDP Sciences.

ICEF Monitor (2016). MOOC enrolment surpassed 35 million in 2015. Retrieved from https://monitor.icef.com/2016/01/mooc-enrolment-surpassed-35-million-in-2015/.

Imtiaz, M. A. and Maarop, N. (2014). A review of technology acceptance studies in the field of education. *Jurnal Teknologi* 69(2), 27–32.

Jadin, T., Gnambs, T., and Batinic, B. (2013). Personality traits and knowledge sharing in online communities. *Computers in Human Behavior* 29(1), 210–216.

Jansen, D. and Schuwer, R. (2015). Institutional MOOC strategies in Europe. Status Report Based on a Mapping Survey Conducted in October-December 2014. Retrieved from http://eadtu.eu/documents/Publications/OEenM/Institutional_MOOC_strategies_in_Europe.pdf.

Janssen, J. et al. (2007). Visualization of participation: Does it contribute to successful computer-supported collaborative learning? *Computers & Education* 49, 1037–1065.

Janssen, J. et al. (2009). Influence of group member familiarity on online collaborative learning. *Computers in Human Behavior* 25(1), 161–170.

Jena, R. (2018). Predicting students' learning style using learning analytics: a case study of business management students from India. *Behaviour & Information Technology* 37(10-11), 978–992.

John, O. P., Donahue, E. M., and Kentle, R. L. (1991). The big five inventory—versions 4a and 54. Institute of Personality and Social Research. University of California, Berkeley.

Johnson, C. M. (2001). A survey of current research on online communities of practice. *The Internet and Higher Education* 4(1), 45–60.

Joksimovic, S., Gasevic, D., and Hatala, M. (2014). Learning Analytics for Networked Learning Models. *Journal of Learning Analytics* 1(3), 191–194.

Joksimović, S. et al. (2015). How do you connect?: analysis of social capital accumulation in connectivist MOOCs. In: *Proceedings of the Fifth International Conference on Learning Analytics And Knowledge*. ACM, pp. 64–68.

Jones, R. (2007). Learning and teaching in small groups: characteristics, benefits, problems and approaches. *Anaesthesia and Intensive Care* 35(4), 587–592.

Karsenti, T. (2013). What the research says. *International Journal of Technologies in Higher Education* 10(2), 23–37.

Kaur, M. (2017). To Recognise, Realise and Differentiate the Learning Needs of Students. *Pertanika Journal of Social Sciences & Humanities* 25(2), 503–510.

Ke, F. and Hoadley, C. (2009). Evaluating online learning communities. *Educational Technology Research and Development* 57(4), 487–510.

Kear, K. (2004). Peer learning using asynchronous discussion systems in distance education. *Open Learning: The Journal of Open, Distance and e-Learning* 19(2), 151–164.

Keller, T. and Tergan, S.-O. (2005). Visualizing knowledge and information: An introduction. In: *Knowledge and Information Visualization*. Ed. by S.-O. Tergan and T. Keller. Springer, pp. 1–23.

Kellogg, K. (1999). Learning Communities. ERIC Clearinghouse on Higher Education. Retrieved from https://files.eric.ed.gov/fulltext/ED430512.pdf.

Kelman, H. C. (1958). Compliance, identification, and internalization three processes of attitude change. *Journal of Conflict Resolution* 2(1), 51–60.

Kerr, M. S., Rynearson, K., and Kerr, M. C. (2006). Student characteristics for online learning success. *The Internet and Higher Education* 9(2), 91–105.

Kerr, N. L. (1983). Motivation losses in small groups: A social dilemma analysis. *Journal of Personality and Social Psychology* 45(4), 819–828.

Khoo, E. and Cowie, B. (2011). A framework for developing and implementing an online learning community. *Journal of Open, Flexible, and Distance Learning* 15(1), 47–59.

Kilpatrick, S., Jones, T., and Barrett, M. (2003). Defining learning communities. Paper presented at the Australian Association for Research in Education. Retrieved from https://www.aare.edu.au/data/publications/2003/jon03441.pdf.

Kim, B. (2001). Social constructivism. In: *Emerging Perspectives on Learning, Teaching, and Technology*. Ed. by M. Orey. Retrieved from http://epltt.coe.uga.edu/index.php?title=Social_Constructivism.

King, A. (1993). From sage on the stage to guide on the side. *College Teaching* 41(1), 30–35.

King, W. R. and He, J. (2006). A meta-analysis of the technology acceptance model. *Information & Management* 43(6), 740–755.

Klassen, R. M., Krawchuk, L. L., and Rajani, S. (2008). Academic procrastination of undergraduates: Low self-efficacy to self-regulate predicts higher levels of procrastination. *Contemporary Educational Psychology* 33(4), 915–931.

Knowles, M. S. (1975). *Self-directed learning*. New York: Association Press.

Kolb, D (1984). *Experiential learning*. Englewood Cliffs, NJ: Prentice Hall.

Kop, R. (2011). The challenges to connectivist learning on open online networks: Learning experiences during a massive open online course. *The International Review of Research in Open and Distributed Learning* 12(3), 19–38.

Koprinska, I. and Yacef, K. (2015). People-to-people reciprocal recommenders. In: *Recommender Systems Handbook*. Springer, pp. 545–567.

Kreijns, K., Kirschner, P. A., and Jochems, W. (2003). Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: a review of the research. *Computers in Human Behavior* 19(3), 335–353.

Krzywicki, A. et al. (2015). Collaborative filtering for people-to-people recommendation in online dating: Data analysis and user trial. *International Journal of Human-Computer Studies* 76, 50–66.

Laal, M. and Ghodsi, S. M. (2012). Benefits of collaborative learning. *Procedia - Social and Behavioral Sciences* 31, 486–490.

Lang, F. R. et al. (2011). Short assessment of the Big Five: Robust across survey methods except telephone interviewing. *Behavior Research Methods* 43(2), 548–567.

Lee, Y., Kozar, K. A., and Larsen, K. R. (2003). The technology acceptance model: Past, present, and future. *Communications of the Association for Information Systems* 12, 752–780.

Levers, M.-J. D. (2013). Philosophical paradigms, grounded theory, and perspectives on emergence. *Sage Open*, Retrieved from https://journals.sagepub.com/doi/full/10.1177/2158244013517243, 1–6.

Lin, Y.-T., Huang, Y.-M., and Cheng, S.-C. (2010). An automatic group composition system for composing collaborative learning groups using enhanced particle swarm optimization. *Computers & Education* 55(4), 1483–1493.

Liu, D. Y.-T. et al. (2015). An enhanced learning analytics plugin for Moodle: student engagement and personalised intervention. In: *Proceedings of the 32nd Conference of the Australasian Society for Computers in Learning in Tertiary Education*, pp. 168–177.

Liu, X. et al. (2007). Does sense of community matter? An examination of participants' perceptions of building learning communities in online courses. *The Quarterly Review of Distance Education* 8(1), 9–24.

Liu, Y. (2010). Social media tools as a learning resource. *Journal of Educational Technology Development and Exchange* 3(1), 101–114.

Lock, J. V. (2002). Laying the groundwork for the development of learning communities within online courses. *Quarterly Review of Distance Education* 3(4), 395–408.

López-Pérez, M. V., Pérez-López, M. C., and Rodríguez-Ariza, L. (2011). Blended learning in higher education: Students' perceptions and their relation to outcomes. *Computers & Education* 56(3), 818–826.

Love, A. G. (2012). The growth and current state of learning communities in higher education. *New Directions for Teaching and Learning* 2012(132), 5–18.

Loyens, S. M., Magda, J., and Rikers, R. M. (2008). Self-directed learning in problem-based learning and its relationships with self-regulated learning. *Educational Psychology Review* 20(4), 411–427.

Lu, P. et al. (2017). The Research on Informal Learning Model of College Students Based on SNS and Case Study. *Journal of Physics: Conference Series* 820(1).

Lund, A. M. (2001). Measuring usability with the use questionnaire. *Usability Interface* 8(2), 3–6.

Lundvall, B. and Johnson, B. (1994). The learning economy. *Journal of Industry Studies* 1(2), 23–42.

MacIntyre, P. D. et al. (1998). Conceptualizing willingness to communicate in a L2: A situational model of L2 confidence and affiliation. *The Modern Language Journal* 82(4), 545–562.

Mah, D.-K. (2016). Learning analytics and digital badges: Potential impact on student retention in higher education. *Technology, Knowledge and Learning* 21(3), 285–305.

Marambe, K. N., Vermunt, J. D., and Boshuizen, H. P. (2012). A cross-cultural comparison of student learning patterns in higher education. *Higher Education* 64(3), 299–316.

Margaryan, A., Bianco, M., and Littlejohn, A. (2015). Instructional quality of massive open online courses (MOOCs). *Computers & Education* 80, 77–83.

Marquardt, L. and Oberg, D. (2011). *Global perspectives on school libraries: Projects and practices*. Berlin: De Gruyter Saur.

Martindale, T. and Dowdy, M. (2010). Personal learning environments. In: *Emerging Technologies in Distance Education*. Edmonton: Athabasca University Press, pp. 177–193.

Martins, C. B., Steil, A. V., and Todesco, J. L. (2004). Factors influencing the adoption of the Internet as a teaching tool at foreign language schools. *Computers & Education* 42(4), 353–374.

Massingham, P. and Herrington, T. (2006). Does attendance matter? An examination of student attitudes, participation, performance and attendance. *Journal of University Teaching and Learning Practice* 3(2), 82–103.

Matzler, K. et al. (2008). Personality traits and knowledge sharing. *Journal of Economic Psychology* 29(3), 301–313.

McCrae, R. R. (2009). The five-factor model of personality traits: Consensus and controversy. In: *The Cambridge Handbook of Personality Psychology*. Cambridge University Press, pp. 148–161.

McCroskey, J. C. (1992). Reliability and validity of the willingness to communicate scale. *Communication Quarterly* 40(1), 16–25.

McCroskey, J. C. and Baer, J. E. (1985). Willingness to communicate: The construct and its measurement. Retrieved from https://eric.ed.gov/?id=ED265604. Paper presented at the Annual Meeting of the Speech Communication Association, Denver, CO.

McCroskey, J. C. and McCroskey, L. L. (1988). Self-report as an approach to measuring communication competence. *Communication Research Reports* 5(2), 108–113.

McCroskey, J. and Richmond, V. (2013). Willingness to communicate (WTC). Measurement instrument database for the social science. Retrieved from http://www.jamescmccroskey.com/measures/WTC.htm.

McInnerney, J. M. and Roberts, T. S. (2004). Online learning: Social interaction and the creation of a sense of community. *Educational Technology & Society* 7(3), 73–81.

McKenzie, J. et al. (2005). *Dissemination, adoption and adaptation of project innovations in higher education*. Report. Retrieved from https://opus.lib.uts.edu.au/bitstream/10453/12236/1/2006006240K.pdf. University of Technology Sydney.

McLean, G. et al. (2020). Examining consumer attitudes towards retailers'm-commerce mobile applications–An initial adoption vs. continuous use perspective. *Journal of Business Research* 106, 139–157.

McLoughlin, C. and Lee, M. (2007). Social software and participatory learning: Pedagogical choices with technology affordances in the Web 2.0 era. In: *ICT: Providing* *choices for learners and learning. Proceedings of ASCILITE 2007 Singapore*. Singapore: Centre for Educational Development, Nanyang Technological University, pp. 664–675.

McLoughlin, C. and Lee, M. J. (2008). Future learning landscapes: Transforming pedagogy through social software. *Innovate: Journal of Online Education* 4(5), Retrieved from https://nsuworks.nova.edu/innovate/vol4/iss5/1/.

McLoughlin, C. and Lee, M. J. (2010). Personalised and self regulated learning in the Web 2.0 era: International exemplars of innovative pedagogy using social software. *Australasian Journal of Educational Technology* 26(1), 28–43.

McMillan, D. W. (1996). Sense of community. *Journal of Community Psychology* 24(4), 315–325.

McMillan, D. W. and Chavis, D. M. (1986). Sense of community: A Definition and Theory. *Journal of Community Psychology* 14, 6–23.

Means, B. et al. (2009). *Evaluation of evidence-based practices in online learning: A meta-analysis and review of online learning studies*. Report. Retrieved from https://www2.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport.pdf. Washington, DC: U.S. Department of Education.

Mehennaoui, Z. et al. (2014). A new approach for grouping learners in CSCL systems. In: *Multimedia Computing and Systems (ICMCS), 2014 International Conference on*. IEEE, pp. 628–632.

Mehrabian, A. (1971). *Silent messages*. Belmont, CA: Wadsworth Publishing.

Merhi, M. I. (2016). Towards a framework for online game adoption. *Computers in Human Behavior* 60, 253–263.

Meyer, D. (2009). OptAssign—A web-based tool for assigning students to groups. *Computers & Education* 53(4), 1104–1119.

Monash University (2017). Glossary of uni terms. Retrieved from https://www.monash.edu/get-started/orientation/glossary.

Montoya-Weiss, M. M., Voss, G. B., and Grewal, D. (2003). Determinants of online channel use and overall satisfaction with a relational, multichannel service provider. *Journal of the Academy of Marketing Science* 31(4), 448–458.

Moreno, J., Ovalle, D. A., and Vicari, R. M. (2012). A genetic algorithm approach for group formation in collaborative learning considering multiple student characteristics. *Computers & Education* 58(1), 560–569.

Morris, N. P. (2014). How Digital Technologies, Blended Learning and MOOCs Will Impact the Future of Higher Education. In: *Proceedings of the International Conference e-Learning 2014*, pp. 401–404.

Newton, P. M. and Miah, M. (2017). Evidence-based higher education–is the learning styles 'myth' important? *Frontiers in Psychology* 8, Retrieved from https://doi.org/10.3389/fpsyg.2017.00444.

Ng, E. M., Shroff, R., and Lim, C. (2013). Applying a modified technology acceptance model to qualitatively analyse the factors affecting e-portfolio implementation for student teachers' in field experience placements. *Issues in Informing Science and Information Technology* 10, 355–365.

North, S. M., Richardson, R., and North, M. M. (2014). To Adapt MOOCs, or Not? That Is No Longer the Question. *Universal Journal of Educational Research* 2(1), 69–72.

Nunamaker Jr, J. F., Chen, M., and Purdin, T. D. (1990). Systems development in information systems research. *Journal of Management Information Systems* 7(3), 89–106.

Ounnas, A., Davis, H. C., and Millard, D. E. (2009). A framework for semantic group formation in education. *Journal of Educational Technology & Society* 12(4), 43–55.

Özpolat, E. and Akar, G. B. (2009). Automatic detection of learning styles for an e-learning system. *Computers & Education* 53(2), 355–367.

Palloff, R. M. and Pratt, K. (2007). *Building online learning communities: Effective strategies for the virtual classroom.* San Francisco: John Wiley & Sons.

Panitz, T. (1999a). Collaborative versus Cooperative Learning: A Comparison of the Two Concepts Which Will Help Us Understand the Underlying Nature of Interactive Learning. Retrieved from https://eric.ed.gov/?id=ED448443.

Panitz, T. (1999b). The Case for Student Centered Instruction via Collaborative Learning Paradigms. Retrieved from https://eric.ed.gov/?id=ED448444.

Pappano, L. (2012). The Year of the MOOC. The New York Times. Retrieved from https://www.nytimes.com/2012/11/04/education/edlife/massive-open-online-courses-are-multiplying-at-a-rapid-pace.html.

Park, J.-H. and Choi, H. J. (2009). Factors influencing adult learners' decision to drop out or persist in online learning. *Journal of Educational Technology & Society* 12(4), 207–217.

Park, Y.-J. (2013). An Adaptive Match-Making System reflecting the explicit and implicit preferences of users. *Expert Systems with Applications* 40(4), 1196–1204.

Pauli, R. et al. (2008). Individual differences in negative group work experiences in collaborative student learning. *Educational Psychology* 28(1), 47–58.

Pedersen, S. and Liu, M. (2003). Teachers' beliefs about issues in the implementation of a student-centered learning environment. *Educational Technology Research and Development* 51(2), 57–76.

Peffers, K. et al. (2007). A design science research methodology for information systems research. *Journal of Management Information Systems* 24(3), 45–77.

Peltier, J. W., Schibrowsky, J. A., and Drago, W. (2007). The interdependence of the factors influencing the perceived quality of the online learning experience: A causal model. *Journal of Marketing Education* 29(2), 140–153.

Piccoli, G., Ahmad, R., and Ives, B. (2001). Web-based virtual learning environments: A research framework and a preliminary assessment of effectiveness in basic IT skills training. *MIS Quarterly* 25(4), 401–426.

Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In: *Handbook of Self-regulation.* Ed. by M. Boekaerts, M. Zeidner, and P. R. Pintrich. San Diego, CA: Academic Press, pp. 451–502.

Pintrich, P. R. et al. (1991). *A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ).* Report. Ann Arbor, MI: National Center for Research to Improve Post Secondary Teaching and Learning.

Pintrich, P. R. et al. (1993). Reliability and predictive validity of the Motivated Strategies for Learning Questionnaire (MSLQ). *Educational and Psychological Measurement* 53(3), 801–813.

Pizzato, L. et al. (2010). RECON: a reciprocal recommender for online dating. In: *Proceedings of the Fourth ACM Conference on Recommender Systems.* ACM, pp. 207–214.

Pizzato, L. et al. (2013). Recommending people to people: the nature of reciprocal recommenders with a case study in online dating. *User Modeling and User-Adapted Interaction* 23(5), 447–488.

Pizzato, L. A. et al. (2011). Finding someone you will like and who won't reject you. In: *Proceedings of the 19th International Conference on User Modeling, Adaption, and Personalization.* Ed. by K. J.A. et al. UMAP'11. Berlin, Heidelberg: Springer-Verlag, pp. 269–280.

Poon, J. (2013). Blended learning: An institutional approach for enhancing students' learning experiences. *Journal of Online Learning and Teaching* 9(2), 271–288.

Potts, B. A. et al. (2018). Reciprocal peer recommendation for learning purposes. In: *LAK'18: Proceedings of the 8th International Conference on Learning Analytics and Knowledge*. ACM, pp. 226–235.

Prabhakar, S., Spanakis, G., and Zaïane, O. R. (2017). Reciprocal Recommender System for Learners in Massive Open Online Courses (MOOCs). In: *Proceedings of the 16th International Conference on Web-Based Learning*. Springer, pp. 157–167.

Prat, N., Comyn-Wattiau, I., and Akoka, J. (2014). Artifact Evaluation in Information Systems Design-Science Research-a Holistic View. In: *Proceedings of the 18th Pacific Asia Conference on Information Systems PACIS*. Article 23.

Prinsen, F. R., Volman, M. L., and Terwel, J. (2007). Gender-related differences in computer-mediated communication and computer-supported collaborative learning. *Journal of Computer Assisted Learning* 23(5), 393–409.

Punie, Y. (2007). Learning Spaces: an ICT-enabled model of future learning in the Knowledge-based Society. *European Journal of Education* 42(2), 185–199.

Puzziferro, M. (2008). Online technologies self-efficacy and self-regulated learning as predictors of final grade and satisfaction in college-level online courses. *The American Journal of Distance Education* 22(2), 72–89.

Rammstedt, B. and John, O. P. (2007). Measuring personality in one minute or less: A 10-item short version of the Big Five Inventory in English and German. *Journal of Research in Personality* 41(1), 203–212.

Reinecke, K. et al. (2013). Predicting users' first impressions of website aesthetics with a quantification of perceived visual complexity and colorfulness. In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, pp. 2049–2058.

Resta, P. and Laferrière, T. (2007). Technology in support of collaborative learning. *Educational Psychology Review* 19, 65–83.

Richardson, J. and Swan, K. (2003). Examining social presence in online courses in relation to students' perceived learning and satisfaction. *Journal of Asynchronous Learning Networks* 7(1), 68–88.

Riel, M. and Polin, L. (2004). Learning communities: Common ground and critical differences in designing technical support. In: *Designing for Virtual Communities in the Service of Learning*. Ed. by S. A. Barab, R. Kling, and J. H. Gray. Cambridge University Press, pp. 16–50.

Rienties, B. et al. (2009). The role of academic motivation in Computer-Supported Collaborative Learning. *Computers in Human Behavior* 25(6), 1195–1206.

Rockwood III, H. (1995). Cooperative and collaborative learning. *The National Teaching & Learning Forum* 4(6), 8–9.

Rodriguez, O. (2013). The concept of openness behind c and x-MOOCs (Massive Open Online Courses). *Open Praxis* 5(1), 67–73.

Rogers, E. M. (2010). *Diffusion of Innovations*. Simon and Schuster.

Romero, C. and Ventura, S. (2007). Educational data mining: A survey from 1995 to 2005. *Expert Systems with Applications* 33(1), 135–146.

Rourke, L. et al. (1999). Assessing social presence in asynchronous text-based computer conferencing. *Journal of Distance Education* 14(2), 50–71.

Rovai, A. P. (2002a). A preliminary look at the structural differences of higher education classroom communities in traditional and ALN courses. *Journal of Asynchronous Learning Networks* 6(1), 41–56.

Rovai, A. P. (2002b). Building sense of community at a distance. *The International Review of Research in Open and Distributed Learning* 3(1), Retrieved from http://www.irrodl.org/index.php/irrodl/article/view/79/152.

Rovai, A. P. (2002c). Development of an instrument to measure classroom community. *The Internet and Higher Education* 5(3), 197–211.

Rovai, A. P. (2002d). Sense of community, perceived cognitive learning, and persistence in asynchronous learning networks. *The Internet and Higher Education* 5(4), 319–332.

Rovai, A. P. and Baker, J. D. (2005). Gender differences in online learning: Sense of community, perceived learning, and interpersonal interactions. *Quarterly Review of Distance Education* 6(1), 31–44.

Rovai, A. P. and Jordan, H. (2004). Blended learning and sense of community: A comparative analysis with traditional and fully online graduate courses. *The International Review of Research in Open and Distributed Learning* 5(2), Retrieved from http://www.irrodl.org/index.php/irrodl/article/view/192/274.

Ryan, R. M. and Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology* 25(1), 54–67.

Sahin, I. (2006). Detailed review of Rogers' diffusion of innovations theory and educational technology-related studies based on Rogers' theory. *Turkish Online Journal of Educational Technology-TOJET* 5(2), 14–23.

Saunders, B. et al. (2018). Saturation in qualitative research: exploring its conceptualization and operationalization. *Quality & Quantity* 52(4), 1893–1907.

Scardamalia, M. and Bereiter, C. (1994). Computer support for knowledge-building communities. *Journal of the Learning Sciences* 3(3), 265–283.

Scardamalia, M. and Bereiter, C. (1999). Schools as knowledge-building organizations. In: *Today's Children, Tomorrow's Society: The Developmental Health and Wealth of Nations*. Ed. by D. Keating and C. Hertzman. Guilford, pp. 274–289.

Scardamalia, M. and Bereiter, C. (2006). Knowledge Building. In: *Cambridge Handbook of the Learning Sciences*. Ed. by R. K. Sawyer. Cambridge University Press, pp. 97–116.

Schellens, T. and Valcke, M. (2006). Fostering knowledge construction in university students through asynchronous discussion groups. *Computers & Education* 46(4), 349–370.

Schoenberger, C. R. (2007). Nice to Meet You. Retrieved from https://www.forbes.com/forbes/2007/0423/066.html.

Schwandt, T. A. et al. (1994). Constructivist, interpretivist approaches to human inquiry. In: *Handbook of Qualitative Research*. Ed. by N. Denzin and Y. Lincoln. Sage Publications, pp. 118–137.

Schwartz, D. L. (1995). The emergence of abstract representations in dyad problem solving. *Journal of the Learning Sciences* 4(3), 321–354.

Seufert, S., Lechner, U., and Stanoevska, K. (2002). A reference model for online learning communities. *International Journal on E-learning* 1(1), 43–54.

Sharpe, R. et al. (2006). The undergraduate experience of blended e-learning: a review of UK literature and practice. Retrieved from https://www.heacademy.ac.uk/system/files/Sharpe_Benfield_Roberts_Francis_0.pdf. The Higher Education Academy.

Shea, P. (2006). A study of students' sense of learning community in online environments. *Journal of Asynchronous Learning Networks* 10(1), 35–44.

Shea, P. and Bidjerano, T. (2010). Learning presence: Towards a theory of self-efficacy, self-regulation, and the development of a communities of inquiry in online and blended learning environments. *Computers & Education* 55(4), 1721–1731.

Shea, P. et al. (2005). Developing learning community in online asynchronous college courses: The role of teaching presence. *Journal of Asynchronous Learning Networks* 9(4), 59–82.

Shum, S. B. and Ferguson, R. (2012). Social learning analytics. *Journal of Educational Technology & Society* 15(3), 3–26.

Siemens, G. (2005). Connectivism: A learning theory for the digital age. *International Journal of Instructional Technology and Distance Learning*, Retrieved from https://jotamac.typepad.com/jotamacs_weblog/files/Connectivism.pdf.

Siemens, G. (2012). MOOCs are really a platform. Retrieved from http://www.elearnspace.org/blog/2012/07/25/moocs-are-really-a-platform/.

Siemens, G. (2013). Learning analytics: The emergence of a discipline. *American Behavioral Scientist* 57(10), 1380–1400.

Siemens, G. and Long, P. (2011). Penetrating the fog: Analytics in learning and education. Retrieved from https://er.educause.edu/articles/2011/9/penetrating-the-fog-analytics-in-learning-and-education. EDUCAUSE Review.

Siemens, G. et al. (2011). Open Learning Analytics: an integrated & modularized platform. Retrieved from https://solaresearch.org/wp-content/uploads/2011/12/OpenLearningAnalytics.pdf. Society for Learning Analytics Research.

Sipilä, K. (2014). Educational use of information and communications technology: Teachers' perspective. *Technology, Pedagogy and Education* 23(2), 225–241.

Smith, B. L. and MacGregor, J. T. (1992). What is Collaborative Learning? In: *Collaborative Learning: A Sourcebook for Higher Education*. Ed. by A. Goodsell et al. Pennsylvania State University.

Smyth, S. et al. (2012). Students' experiences of blended learning across a range of postgraduate programmes. *Nurse Education Today* 32(4), 464–468.

So, H.-J. and Brush, T. A. (2008). Student perceptions of collaborative learning, social presence and satisfaction in a blended learning environment: Relationships and critical factors. *Computers & Education* 51(1), 318–336.

Song, L. and Hill, J. R. (2007). A conceptual model for understanding self-directed learning in online environments. *Journal of Interactive Online Learning* 6(1), 27–42.

Song, L. et al. (2004). Improving online learning: Student perceptions of useful and challenging characteristics. *The Internet and Higher Education* 7(1), 59–70.

Spoelstra, H. et al. (2013). A Team Formation and Project-based Learning Support Service for Social Learning Networks. *Journal of Universal Computer Science* 19(10), 1474–1495.

Srba, I. and Bielikova, M. (2015). Dynamic group formation as an approach to collaborative learning support. *IEEE Transactions on Learning Technologies* 8(2), 173–186.

Stacey, E. (1999). Collaborative learning in an online environment. *Journal of Distance Education* 14(2), 14–33.

Stodel, E. J., Thompson, T. L., and MacDonald, C. J. (2006). Learners' perspectives on what is missing from online learning: Interpretations through the community of inquiry framework. *The International Review of Research in Open and Distributed Learning* 7(3).

Straub, E. T. (2009). Understanding Technology Adoption: Theory and Future Directions for Informal Learning. *Review of Educational Research* 79(2), 625–649.

Strijbos, J.-W., Martens, R. L., and Jochems, W. M. (2004). Designing for interaction: Six steps to designing computer-supported group-based learning. *Computers & Education* 42(4), 403–424.

Stroebe, W. and Frey, B. S. (1982). Self-interest and collective action: The economics and psychology of public goods. *British Journal of Social Psychology* 21(2), 121–137.

Stukalina, Y. (2008). How to prepare students for productive and satisfying careers in the knowledge-based economy: Creating a more efficient educational environment. *Technological and Economic Development of Economy* 14(2), 197–207.

Šumak, B., Heričko, M., and Pušnik, M. (2011). A meta-analysis of e-learning technology acceptance: The role of user types and e-learning technology types. *Computers in Human Behavior* 27(6), 2067–2077.

Šumak, B. et al. (2011). Factors affecting acceptance and use of Moodle: An empirical study based on TAM. *Informatica* 35(1), 91–100.

Sung, E. and Mayer, R. E. (2012). Five facets of social presence in online distance education. *Computers in Human Behavior* 28(5), 1738–1747.

Swan, K. (2002). Building learning communities in online courses: The importance of interaction. *Education, Communication & Information* 2(1), 23–49.

Swan, K., Garrison, D., and Richardson, J. C. (2009). A constructivist approach to online learning: The community of inquiry framework. In: *Information technology and constructivism in higher education: Progressive learning frameworks*. Ed. by C. Payne. IGI Global, pp. 43–57.

Swan, K. and Shih, L. F. (2005). On the nature and development of social presence in online course discussions. *Journal of Asynchronous Learning Networks* 9(3), 115–136.

Tabaa, Y. and Medouri, A. (2013). LASyM: A learning analytics system for MOOCs. *International Journal of Advanced Computer Science and Applications (IJACSA)* 4(5), 113–119.

Taherdoost, H. (2018). A review of technology acceptance and adoption models and theories. *Procedia Manufacturing* 22, 960–967.

Thorley, L. and Gregory, R. (2013). *Using Group-based Learning in Higher Education*. Taylor & Francis.

Tinto, V. (1975). Dropout from higher education: A theoretical synthesis of recent research. *Review of Educational Research* 45(1), 89–125.

Tinto, V. (2000). Learning Better Together: The Impact of Learning Communities on Student Success in Higher Education. *Journal of Institutional Research* 9(1).

Tinto, V. (2006). Research and practice of student retention: What next? *Journal of College Student Retention: Research, Theory & Practice* 8(1), 1–19.

Topping, K. J. (1996). The effectiveness of peer tutoring in further and higher education: A typology and review of the literature. *Higher Education* 32(3), 321–345.

Topping, K. J. (2005). Trends in peer learning. *Educational Psychology* 25(6), 631–645.

Tu, C.-H. and Corry, M. (2002). Research in online learning community. *e-Journal of Instructional Science and Technology* 5(1).

Tuan, L. T. (2012). An Empirical Research into EFL Learners' Motivation. *Theory & Practice in Language Studies* 2(3), 430–439.

Vaishnavi, V. and Kuechler, W. (2004). Design science research in information systems. Retrieved from http://www.desrist.org/design-research-in-information-systems/.

Vallerand, R. J. et al. (1992). The Academic Motivation Scale: A measure of intrinsic, extrinsic, and amotivation in education. *Educational and Psychological Measurement* 52(4), 1003–1017.

Veerman, A. and Veldhuis-Diermanse, E. (2001). Collaborative learning through computer-mediated communication in academic education. In: *Proceedings European Perspectives on Computer Supported Collaborative Learning : Euro-CSCL*, pp. 625–632.

Venable, J. (2006). The role of theory and theorising in design science research. In: *Proceedings of the 1st International Conference on Design Science in Information Systems and Technology (DESRIST 2006)*, pp. 1–18.

Venkatesh, V. and Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision Sciences* 39(2), 273–315.

Venkatesh, V. and Davis, F. D. (1996). A model of the antecedents of perceived ease of use: Development and test. *Decision Sciences* 27(3), 451–481.

Venkatesh, V. and Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science* 46(2), 186–204.

Venkatesh, V., Thong, J. Y., and Xu, X. (2012). Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. *MIS Quarterly* 36(1), 157–178.

Venkatesh, V. et al. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly* 27(3), 425–478.

Verbert, K. et al. (2011). Dataset-driven research for improving recommender systems for learning. In: *Proceedings of the 1st International Conference on Learning Analytics and Knowledge*. ACM, pp. 44–53.

Verbert, K. et al. (2014). Learning dashboards: an overview and future research opportunities. *Personal and Ubiquitous Computing* 18(6), 1499–1514.

Vermunt, J. D. (2005). Relations between student learning patterns and personal and contextual factors and academic performance. *Higher Education* 49(3), 205–234.

Vinciarelli, A. and Mohammadi, G. (2014). A survey of personality computing. *IEEE Transactions on Affective Computing* 5(3), 273–291.

Vogelsang, K., Steinhüser, M., and Hoppe, U. (2013). A qualitative approach to examine technology acceptance. In: *International Conference on Information Systems (ICIS 2013)*.

Vygotsky, L. S. (1980). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Wang, D.-Y., Lin, S. S., and Sun, C.-T. (2007). DIANA: A computer-supported heterogeneous grouping system for teachers to conduct successful small learning groups. *Computers in Human Behavior* 23(4), 1997–2010.

Ware, C. (2012). *Information visualization: perception for design*. Elsevier.

Warschauer, M. (1997). Computer-mediated collaborative learning: Theory and practice. *The Modern Language Journal* 81(4), 470–481.

Watson, J. (2008). Blended Learning: The Convergence of Online and Face-to-Face Education. Promising Practices in Online Learning. Retrieved from https://eric.ed.gov/?id=ED509636.

Watson, W. and Watson, S. L. (2007). An Argument for Clarity: What are Learning Management Systems, What are They Not, and What Should They Become. *TechTrends* 51(2), 28–34.

Wenger, E. (2000a). Communities of practice and social learning systems. *Organization* 7(2), 225–246.

Wenger, E. (2000b). *Communities of practice: Learning, meaning, and identity*. Cambridge University Press.

Wenger, E., McDermott, R., and Snyder, W. M. (2002). Seven principles for cultivating communities of practice. In: *Cultivating Communities of Practice: a guide to managing knowledge*. Vol. 4. Boston, MA: Harvard Business School Press. Chap. 3.

Wertsch, J. V. (1984). The zone of proximal development: Some conceptual issues. *New Directions for Child and Adolescent Development* 1984(23), 7–18.

Williams, M. et al. (2011). Is UTAUT really used or just cited for the sake of it? A systematic review of citations of UTAUT's originating article. In: *Proceedings 19th European Conference on Information Systems (ECIS)*.

Wilson, B. G. (1995). Metaphors for instruction: Why we talk about learning environments. *Educational Technology* 35(5), 25–30.

Wilson, B. G. et al. (2004). Bounded community: Designing and facilitating learning communities in formal courses. *International Review of Research in Open and Distributed Learning* 5(3), Retrieved from http://www.irrodl.org/index.php/irrodl/article/view/204/286.

Wilson, S. et al. (2007). Personal Learning Environments: Challenging the dominant design of educational systems. *Journal of e-Learning and Knowledge Society* 3(2), 27–38.

Wu, J.-H., Tennyson, R. D., and Hsia, T.-L. (2010). A study of student satisfaction in a blended e-learning system environment. *Computers & Education* 55(1), 155–164.

Yan, D. et al. (2019). Usage Beliefs' Change and Interaction during Technology Acceptance of Academic Information Services. In: *Proceedings International Sports Science and Education Technology Conference (ISSETC)*, pp. 158–163.

Yang, S. J. et al. (2006). Context aware ubiquitous learning environments for peer-to-peer collaborative learning. *Journal of Educational Technology & Society* 9(1), 188–201.

Yannibelli, V. and Amandi, A. (2012). A deterministic crowding evolutionary algorithm to form learning teams in a collaborative learning context. *Expert Systems with Applications* 39(10), 8584–8592.

Yannibelli, V. D. et al. (2016). A steady-state evolutionary algorithm for building collaborative learning teams in educational environments considering the understanding levels and interest levels of the students. *Journal of Universal Computer Science* 22(10), 1298–1318.

Yen, D. C. et al. (2010). Determinants of users' intention to adopt wireless technology: An empirical study by integrating TTF with TAM. *Computers in Human Behavior* 26(5), 906–915.

You, J. W. (2016). Identifying significant indicators using LMS data to predict course achievement in online learning. *The Internet and Higher Education* 29, 23–30.

Yousef, A. M. F. et al. (2014). MOOCs – A Review of the State-of-the-Art. In: *Proceedings of the 6th International Conference on Computer Supported Education (CSEDU)*, pp. 9–20.

Yuan, L. and Powell, S. (2013). MOOCs and Open Education: Implications for Higher Education – A white paper. Retrieved from https://publications.cetis.org.uk/wp-content/uploads/2013/03/MOOCs-and-Open-Education.pdf. JISC CETIS.

Zaïane, O. R. (2002). Building a recommender agent for e-learning systems. In: *Proceedings of the International Conference on Computers in Education*. IEEE, pp. 55–59.

Zhao, C.-M. and Kuh, G. D. (2004). Adding value: Learning communities and student engagement. *Research in Higher Education* 45(2), 115–138.

Zimmerman, B. J. (2000a). Attaining self-regulation: A social cognitive perspective. In: *Handbook of self-regulation*. Ed. by M. Boekaerts, P. R. Pintrich, and M. Zeidner. Academic Press. Chap. 2, pp. 13–39.

Zimmerman, B. J. (2000b). Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology* 25(1), 82–91.

Appendix A

First Data Data Collection

A.1 Online Survey

Survey on Learning Community

Dear participants,

This survey aims to explore the study groups you form with other students (also called Learning Communities), so that your learning experience can be improved. We would appreciate your taking the time to complete the following survey. It will take approximately 15 minutes. Your responses are voluntary and will be confidential. Responses will not be identified by individual. If you wish you can elect to provide your email address for further data collection via an interview.

A cine voucher will be given randomly to those who complete the survey the earliest with email address provided. By providing a contact email you are not obliged to undertake an interview or any other data collection after the survey. The prize will not be available after one month since the survey opening date (22nd May, 2017)

Main sections covered include:
- Your general information
- Your experience on 3 forms of Learning Communities (LCs) – (1) Task-based, (2) Practice-based, (3) Knowledge-based
- Persistence & Motivation / Obstacles of LC participation
- Characteristics that you are looking for in learning partners

Thank you,

Research student: Tam Nguyen

Supervisors:
- Dr. Michael Morgan
- Dr. Matthew Butler
- Prof. Kim Marriott

* Please try to respond to all questions

*Required

General Information

Tell us a bit about you!

1. **What is your age group?** *
   Mark only one oval.
   - ◯ Under 20
   - ◯ 20 - 25
   - ◯ 26 - 30
   - ◯ Over 30

2. **Your gender?** *
   Mark only one oval.
   - ◯ Male
   - ◯ Female
   - ◯ Other

3. **Nationality?**

   ____

4. **What is your course in Monash Australia?** *

Mark only one oval.

- Bachelor of Computer and Information Sciences
- Bachelor of Computer Science
- Bachelor of Computer Science Advanced (Honours)
- Bachelor of Information Technology
- Bachelor - Double Degree
- Bachelor of Computer and Information Sciences (Honours)
- Bachelor of Computer Science (Honours)
- Bachelor of Information Technology (Honours)
- Master of Business Information Systems
- Master of Data Science
- Master of Information Technology
- Master of Networks and Security
- Master of Philosophy
- Master of Philosophy in Computer and Information Science
- Doctor of Philosophy

Experience on Learning Communities

Tell us about your experience on working with others

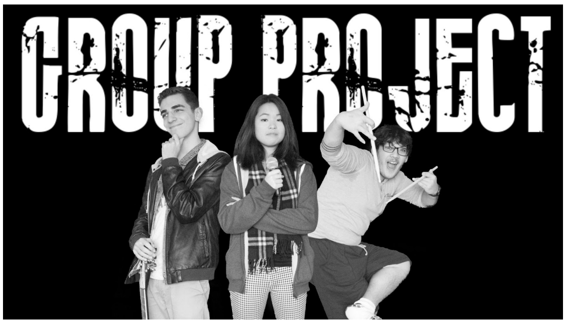
5. **Thinking back of your last year/semester, did you work with other students or on your own only?** *

Mark only one oval.

- With others
- Only by myself *Skip to question 31.*

Task-based Learning Community

Practice-based LC indicates a group of students join into a team/group to work on a certain product/task - usually for assignments



6. **Did you work with other students on group assignments?**

Mark only one oval.

- Yes
- No *Skip to question 14.*

Task-based Learning Community

7. **By whom were the groups assigned?**

Mark only one oval.

- By students - you chose the group members yourself
- By academic - teacher assigned students into groups

8. **What form of communication did you use most?**
Mark only one oval.
- Face-to-face
- Email
- Subject Discussion Forum
- Text Messages
- Other: ____________

9. **How often did you have group meetings?**
Mark only one oval.
- More than once a week
- Once a week
- Once every 2 weeks
- Once a month
- Less often
- Other: ____________

10. **How important was this type of learning community to you and your study?**
Mark only one oval.

	1	2	3	4	5	
Not at all important	◯	◯	◯	◯	◯	Very important

11. **Did you feel comfortable interacting with other participants in your group?**
Mark only one oval.

	1	2	3	4	5	
Not at all comfortable	◯	◯	◯	◯	◯	Very comfortable

12. **To what level do you think that your contribution was acknowledged by other participants in the group?**
Mark only one oval.

	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	Very much

13. **On a scale of 1-10, how satisfied were you with the group work?**
Mark only one oval.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Practice-based Learning Community

Practice-based LC indicates a group of students who come together to improve their certain practical skills or applied practice.

14. **Did you get together with other students outside of class to discuss what you were studying OR Did you participate in workshops outside the unit scope? Aim: to improve your certain skills and practice**

Mark only one oval.

- I met up with others outside of classroom to discuss our study or certain academic interests
- I participated in workshops outside of the unit scope
- Both of the above
- None of the above *Skip to question 21.*

Practice-based Learning Community

15. **What form of communication did you use most?**

Mark only one oval.

- Face-to-face
- Email
- Moodle Discussion Forum
- Text Message / Messaging Apps
- Other: ____________

16. **Regarding the practice-based learning activities, how often did you participate?**

Mark only one oval.

- More than once a week
- Once a week
- Once every 2 weeks
- Once a month
- Less often
- Other: ____________

17. **How important was practice-based learning activity to you and your study?**

Mark only one oval.

	1	2	3	4	5	
Not at all important						Very important

18. **Did you feel comfortable interacting with other participants in this type of activity?**

Mark only one oval.

	1	2	3	4	5	
Not at all comfortable						Very comfortable

19. **To what level do you think that your contribution was acknowledged by other participants in this activity?**
Mark only one oval.

	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	Very much

20. **On a scale of 1-10, how satisfied were you with the practice-based learning activities?**
Mark only one oval.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Knowledge-based Learning Community

Knowledge-based Learning Community (KBLC) indicates a group of students come together by virtue of relevant expertise and common interest.
KBLC activities often result in findings, contributions to knowledge of some area.

21. **Did you meet up with other students to do some study/research on a specific topic/concept of interest together. For example, e-Security principles, visualization?**
Mark only one oval.

- ◯ Yes
- ◯ No *Skip to question 28.*

Knowledge-based Learning Community

22. **What form of communication did you use most?**
Mark only one oval.

- ◯ Face-to-face
- ◯ Email
- ◯ Discussion forum
- ◯ Text Message
- ◯ Other: ______________________

23. **Regarding the knowledge-based activities, how often did you participate?**
Mark only one oval.

- ◯ More than once a week
- ◯ Once a week
- ◯ Once every 2 weeks
- ◯ Once a month
- ◯ Less often
- ◯ Other: ______________________

24. **How important was knowledge-based activity to you and your study?**
Mark only one oval.

	1	2	3	4	5	
Not at all important	⬭	⬭	⬭	⬭	⬭	Very important

25. **Did you feel comfortable interacting with other participants in this type of activity?**
Mark only one oval.

	1	2	3	4	5	
Not at all comfortable	⬭	⬭	⬭	⬭	⬭	Very comfortable

26. **To what level do you think that your contribution was acknowledged by other participants in this activity?**
Mark only one oval.

	1	2	3	4	5	
Not at all	⬭	⬭	⬭	⬭	⬭	Very much

27. **On a scale of 1-10, how satisfied were you with the knowledge-based learning activities?**
Mark only one oval.

1	2	3	4	5	6	7	8	9	10
⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭

Persistence of learning community

28. **Do you tend to work with different students for different tasks or same set of people that you are familiar with?**
Mark only one oval.

- ⬭ Different students
- ⬭ Same students
- ⬭ I do not have a preference

29. **Any reason for it?**

____
____
____
____
____

Motivation of Learning Communities

30. **In your opinion, what makes "working with other students” beneficial?** *
Tick all that apply.

- [ ] Social network resources ~ network of individuals with useful skills or knowledge
- [ ] Personal and diverse experience
- [ ] Mutual trust
- [ ] Timely answers to my problems
- [ ] Psychological supports from those with similar experience
- [ ] Feeling of being helpful to others
- [ ] Equipping myself with important skills for the future -- e.g., teamwork, communication skills
- [ ] Other: ______________________________

Skip to question 32.

Barriers to working with others

31. **If you have not previously worked with other students, why? ***
Tick all that apply.

- [ ] My personality - shy, introvert
- [ ] Learning preference - I find myself learn best individually
- [ ] I do not really care much about "working with others" or "learning communities"
- [ ] Busy schedule - I do not have enough time to get to know them in order to work with
- [ ] Physical location - I live far away from others
- [ ] System - Moodle does not support a suitable communication channel
- [ ] Co-learners - I have not found ones with whom I can work well with
- [ ] Atmosphere - I do not feel there is a shame-free environment where I can express myself without being judged
- [ ] Other: ______

Characteristics that you are looking for in a learning partner

Social Aspect

32. **Do you prefer working with others of your age, older or younger than you? ***
Mark only one oval.

- ( ) Same age
- ( ) Older
- ( ) Younger
- ( ) Mixed
- ( ) Other: ______

33. **Is your learning partner's age important to you? ***
Mark only one oval.

	1	2	3	4	5	
Not at all important	( )	( )	( )	( )	( )	Very important

34. **Do you prefer working with others of the same or opposite gender? ***
Mark only one oval.

- ( ) Same gender
- ( ) Opposite gender
- ( ) Both
- ( ) Other: ______

35. **Is your partner's gender important to you? ***
Mark only one oval.

	1	2	3	4	5	
Not at all important	( )	( )	( )	( )	( )	Very important

36. **Do you prefer working with others from a similar or different cultural background?** *

Mark only one oval.

- Similar
- Different
- Mixed
- Other: ______

37. **Is your partner's nationality (culture) important to you?** *

Mark only one oval.

	1	2	3	4	5	
Not at all important						Very important

38. **Do you think your partner's personality is important?** *

Mark only one oval.

	1	2	3	4	5	
Not at all important						Very important

39. **Do you prefer your partner to have similar/different personality?** *

Mark only one oval.

- Similar
- Different
- Does not matter

40. **How do you perceive yourself in terms of being connected with others students -- separated/connected** *

Mark only one oval.

- Separated
- Connected

41. **Is your partners' willingness to communicate important to you?** *

Mark only one oval.

	1	2	3	4	5	
Not at all important						Very important

42. **What form of communication do you prefer when working with others, face-to-face or online?** *

Mark only one oval.

- Face-to-face
- Online -- e.g., email, messages, video call, forum discussion
- Other: ______

43. **Do you prefer working with people with similar or different interests/hobbies?** *

Mark only one oval.

- Similar
- Different
- Mixed

44. **How is that similarity/difference in interests or hobbies important to you?** *
Mark only one oval.

	1	2	3	4	5	
Not at all important	◯	◯	◯	◯	◯	Very important

Characteristics that you are looking for in a learning partner

Academic Aspect

45. **Is it important that your partner does the same course as you?** *
Mark only one oval.

	1	2	3	4	5	
Not at all important	◯	◯	◯	◯	◯	Very important

46. **Is it important that your partner studies the same units as you?** *
Mark only one oval.

	1	2	3	4	5	
Not at all important	◯	◯	◯	◯	◯	Very important

47. **What are you academic interests?** *

48. **Is it important that your partner has similar academic interests as you?** *
Mark only one oval.

	1	2	3	4	5	
Not at all important	◯	◯	◯	◯	◯	Very important

49. **Do you prefer working with people with similar, different or complementary experience/skill?** *
Mark only one oval.

- ◯ Similar
- ◯ Different
- ◯ Complementary

50. **Are your partners' technical experience or skills important when you choose people to work with?** *
Mark only one oval.

	1	2	3	4	5	
Not at all important	◯	◯	◯	◯	◯	Very important

51. **What is your learning goal?** *
Tick all that apply.

- [ ] I want to be more active in my learning
- [ ] I want to be more independent in my learning
- [ ] I want to achieve my full potential
- [ ] I want to learn new and interesting things
- [ ] I want to really understand what I study
- [ ] I want to outperform other students
- [ ] I don't want others to think I'm not smart
- [ ] I want to study well so that I can get my dream job later on
- [ ] Other: ____________________

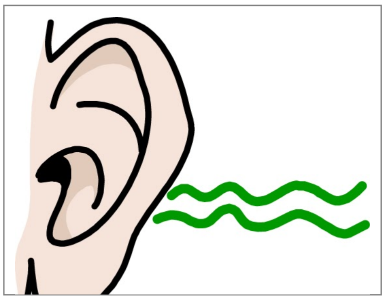
52. **Is it important that your partner has the same learning goal as you?** *
Mark only one oval.

	1	2	3	4	5	
Not at all important	◯	◯	◯	◯	◯	Very important

53. **Which way is your best learning style?** *

Tick all that apply.

- [ ] Note-taking instead of discussion, prefer illustrations & graphical presentation; tend to sit in the front in your class



- [ ] Enjoy discussion & talking to others, reading out loud helps you understand better

- [ ] Learn through doing activities, speak with your hands and body, need a lot of breaks when studying
- [ ] Other:

54. **Do you prefer your partner to have the same learning style as you?** *

Mark only one oval.

- ( ) Yes
- ( ) No
- ( ) It doesn't matter

55. **What time of a day, when do you prefer to work?** *

Mark only one oval.

- Early in the morning
- Daytime
- Late at night
- Other: ______

56. **Do you prefer your partner to have the same working pattern as you?** *

Mark only one oval.

- Yes
- No
- Doesn't matter

---

57. **When there is one task that needs to be completed, do you tend to start working on it early or take your time?** *

Mark only one oval.

- Start early
- Chilled out and take time

58. **Do you prefer your partner to have the same work practice as you?** *

Mark only one oval.

- Yes
- No
- Doesn't matter

---

59. **Among these above characteristics [Demographics -- Academic interest -- Experience and skills -- Learning goals -- Learning styles -- Learning patterns, learning practice -- Willingness to communicate -- Hobbies -- Personality], which one do you think is the most important? Why?** *

______

______

______

______

______

60. **Do you think that your learning experience can be improved when you work with those whose features are compatible with your characteristics and preference?** *

Mark only one oval.

- Yes
- No
- Maybe
- Other: ______

Learning Partner Recommender System

Most of us do not want others to tell us what to do or who to work with. However, would it be beneficial for you if we gave some you suggestions on potential learning partners based on your preferences and your matching score?

61. **Would you like to know about other students who may work well with you based on your characteristics and preferences?** *

Mark only one oval.

	1	2	3	4	5	
I'm not interested	◯	◯	◯	◯	◯	Absolutely great

62. **If you are presented with matching partners and communication tools to interact with them, would you give it a try ?** *

Mark only one oval.

◯ Yes

◯ No

Further Contact

63. **Are you happy for us to contact you for some further information?**

Mark only one oval.

◯ Yes

◯ No

◯ Other: ____________________

64. **If YES, please provide your email for us to contact you!**

____

A.2 Interview Questions

INTERVIEW QUESTIONS

This research is focusing on promoting **student-directed** learning communities by matching students based on students' characteristics and preferences. By "student-directed", I mean that a group of students voluntarily get together to work on something without the teacher's control/supervision. The goal of this interview section is to (1) investigate students' attitudes toward learning communities, (2) explore a collection of important characteristics that students look for/value in a learning partner(s), and (3) explore the need for a partner recommender system.

General demographic questions

Name – email (for contact purpose only)

Nationality, Year, Course

Warm-ups

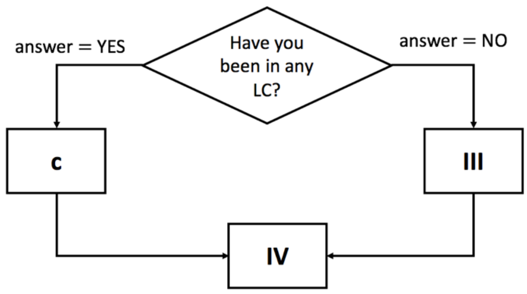
How are you?

I see that you are doing ___________ at Monash. How has your study been going?

Learning Community questions

I. Perceived sense of community in current learning environment

1. **General**
    a. Do you understand what a learning community is? – What does "Learning Community" mean to you?
    b. Have you participated or are you currently participating in any learning community?



    c. Are these communities student-directed or teacher-directed?
    d. What type of learning communities have you participated in?
2. **Fulfillment of Needs**
    a. What is/was the purpose of your participation in a learning community?
    b. What do you think you have obtained from being in that learning community?
    c. What is/was the most beneficial to you when participating?
    d. What is/was some disadvantages you think when participating in the community?
3. **Participants / Partners**
    a. Who are/were the people in your learning community?
    b. Why are you working/have you worked with those people in your learning community?
    c. What things do you value or look for in a partner (i.e. characteristics, beliefs, learning goals, etc.)?
    d. How did you go about forming the learning community?
    e. What difficulties did you have when forming your learning community?
4. **Activities / Membership**

a. What sorts of activities do you do together so that you feel you are a part of the learning community as a whole?
b. What do you do to help others feel that they are a part of the learning community?

5. **Influence**
a. How does the presence of the learning community influence your learning experience?
b. What do you think about your influence on the overall health or wellbeing of that learning community?

6. **Shared emotional/personal connection**
a. What can you say about your personal connection with other LC participants?
b. What experiences/events made you feel that you are connected with other LC participants?

II. Past experience on working with others.

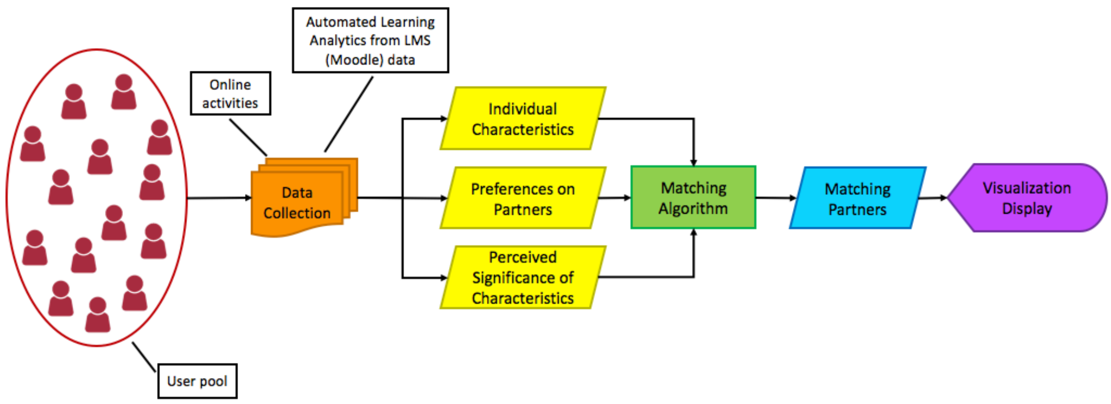
1. Tell me about the most memorable experience you had when you were learning with other students in the learning community?
2. When working with other peers, tell me about the time when it went well.
3. Tell me about the time when it did not go well when working with other peers.
4. If you had had a chance to work with different learning partners, would you have chosen others with different characteristics? / If given the choice, would you have worked with learning partners that had different skills/characteristics?
5. According to you, what are most important characteristics that you look for in a learning partner? Can you list them and rank them in order?

III. Barriers to participation in a learning community

1. What do you think are the reasons for you not being in any learning community?
2. What do you think are the benefits you would get when joining in a learning community?
3. Can you think of any idea / approach / system that can help you find others who can work well with you?

IV. Partnership Recommendation System

The following questions are about a proposed system that takes considerations into your needs, perspectives and preferences on potential learning partners and gives you suggestions on who can work well with you.



1. What do you think about such a system? Do you think that system will work?
2. What do you expect the proposed system would/should provide to you? (What do you want to see from it?) / What are your expectations of the proposed system?
3. What kind of communication tools you expect the system would provide to effectively contact recommended partners?

A.3 Ethics Application Approval Certificate

MONASH University

Monash University Human Research Ethics Committee

Approval Certificate

This is to certify that the project below was considered by the Monash University Human Research Ethics Committee. The Committee was satisfied that the proposal meets the requirements of the *National Statement on Ethical Conduct in Human Research* and has granted approval.

Project Number: 7967
Project Title: Understanding Student Learning Communities
Chief Investigator: Dr Matthew Butler
Expiry Date: 07/03/2022

Terms of approval - failure to comply with the terms below is in breach of your approval and the *Australian Code for the Responsible Conduct of Research*.

1. The Chief Investigator is responsible for ensuring that permission letters are obtained, if relevant, before any data collection can occur at the specified organisation.
2. Approval is only valid whilst your hold a position at Monash University.
3. It is 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 letterhead and the Monash University complaints clause must include your project number.
6. Amendments to approved projects including changes to personnel must not commence without written approval from MHUREC.
7. Annual Report - continued approval of this project is dependent on the submission of an Annual Report.
8. Final Report - should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected completion date.
9. Monitoring - project may be subject to an audit or any other form of monitoring by MUHREC at any time.
10. Retention and storage of data - The Chief Investigator is responsible for the storage and retention of the original data pertaining to the project for a minimum period of five years.

Thank you for your assistance.

Professor Nip Thomson

Chair, MUHREC

CC: Dr Michael Morgan, Professor Kimbal Marriott, Mrs Thanh Nguyen

List of approved documents:

Document Type	File Name	Date	Version
Explanatory Statement	Explanatory Statement_Group1	16/02/2017	1
Explanatory Statement	Explanatory Statement_Group2	16/02/2017	1
Consent Form	Consent Form	16/02/2017	1
Supporting Documentation	Interview Questions	22/02/2017	1
Questionnaires / Surveys	Learning Community Survey	23/02/2017	1

A.4 Summary of Interview Data regarding LPRS

#	Potentials	Users' needs	Challenges [C] & Suggestions [S]
S-1	*"…matching up with preferences based on characteristics is a good way to match partners. Like it takes into how compatible people are, they are more willing to work with each other. It is good because if people have a place where they can find someone to help them and learn together. Because like usually in uni, you kind of just stick to your group of friends and that's about it but sometimes your friends are not in the same units, it's like a system that you can find someone to collaborate with, it would be easier".*	*[UI] "I just want it to be easy to see the results"* *[Com] "Messaging tool…since it's more timely. I think once you get the contact, you can just exchange information"* *[Info] "Just the basic: what area they are studying, some characteristics that are similar"*	*[S] "another thing to consider is personalities having a different range of contrasting personalities may help with learning partners too"*
S-2	*"I think it could work well in terms of matching different types of workers… it could work ok with getting people with similar interests…* *I think there's nothing really online. I know something like clubs and stuff that require you physically attend which means a lot of people can't do; so I think there needs to be more of some sort of online groups."*	*[Info] "fairly simple because people know who..." [see above]* *[Com] "email address or some ability to form a group messaging system like a discussion forums or groups where you have past conversations"*	*[C] "it could work well in some circumstances; but other circumstances if you just account on preferences on partners, it might not work so well."*
S-3	*"they have similar opinion of how they should work together. I think it would be very effective because they have similar interest and they want to work with people with similar interest"*	*[UI & Info] "Not necessarily fancy but as many details as it can have about the partners that have been selected"*	

Continued on next page

Table A.1 – continued from previous page

#	Potentials	Users' needs	Challenges [C] & Suggestions [S]
S-4	*"because it's up to what the person wants in that team so you match them according to that"* *"because it's always there and you are more comfortable behind the screen than face-to-face."*	*[UI] "Simple but understandable. Not too bling"* *[Info] "How much they match with us like a percentage of matches based on skills"*	*[C] "I think it might make us pickier because you expect some types of person and you always want such type of person to be in your group but it's not how everything works in a normal world"*
S-5	*"I think the model is good, it satisfies their basic needs"*	*[Info] "What kind of project, what kind of people I'm going to work with, or some supplementary information like references, potential of the project"*	*[S] "…people wouldn't want to be asked same questions multiple times, you should make sure you ask right questions at the first place; otherwise it would be annoying"*
S-6	*"I think the basic idea may work"*	*[UI] "The interface should be simple rather than fancy, you can see everything clearly – their experience, summary information about the person".*	*[C] "I think for the quizzes about characteristics or skills, some people may lie about themselves"*
S-7	*"The groups that we don't form by ourselves, the groups that are formed for us are definitely the best, so optimising that to be even better would definitely work, I think. So I can get a list of recommended students and meet up at library and stuff. That's a good idea."*	*[Info] "…what they have in common with me, what complementary traits they have, similar subjects with me or have reached similar stage in their degree. That would be nice."* *[Com] "a better integrated message system that is probably close to an instant messaging would be better"*	*[S] "You should have options like whether they want matching, complementary, or both in their group"*

Continued on next page

Table A.1 – continued from previous page

#	Potentials	Users' needs	Challenges [C] & Suggestions [S]
S-8	*"I think if it's based on whatever preferences they had, and it goes through matching algorithm, probably they'd find a partner they were looking for."*	*[UI] "just simple"* *[Info] "just some basic description – what course they're doing, what skills they have"*	*[S] "I think you'd need a pretty big user pool"* *[S] " maybe have a lecturer recommend it to the students"*

TABLE A.1: Interviewees' responses to questions regarding the proposed learning partner recommender system

Appendix B

Adapted Questionnaires to Collect Characteristic Data

B.1 Adapted Willingness to Communicate Questionnaire

Willingness to Communicate (WTC) questionnaire

Below are 12 situations in which a person might choose to communicate or not to communicate. Presume you have completely free choice. Indicate how comfortable you would feel to communicate in each type of situation.

7 = totally comfortable; 1 = not at all comfortable

_____1. Present a talk to a group of strangers.

_____2. Talk with an acquaintance while standing in line.

_____3. Talk in a large meeting of friends.

_____4. Talk in a small group of strangers.

_____5. Talk with a friend while standing in line.

_____6. Talk in a large meeting of acquaintances.

_____7. Talk with a stranger while standing in line.

_____8. Present a talk to a group of friends.

_____9. Talk in a small group of acquaintances.

_____10. Talk in a large meeting of strangers.

_____11. Talk in a small group of friends.

_____12. Present a talk to a group of acquaintances.

(Adapted from McCroskey, 1992)

B.2 Adapted Personality Questionnaire

Personality questionnaire (BFI-10)

How well do the following statements describe your personality?

I see myself as someone who…

1. … is reserved
   Strongly disagree 1 2 3 4 5 Strongly agree
2. … is generally trusting
   Strongly disagree 1 2 3 4 5 Strongly agree
3. … tends to be lazy
   Strongly disagree 1 2 3 4 5 Strongly agree
4. … is relaxed, handles stress well
   Strongly disagree 1 2 3 4 5 Strongly agree
5. … has few artistic interests
   Strongly disagree 1 2 3 4 5 Strongly agree
6. … is outgoing, sociable
   Strongly disagree 1 2 3 4 5 Strongly agree
7. …tends to find fault with others
   Strongly disagree 1 2 3 4 5 Strongly agree
8. … does a thorough job
   Strongly disagree 1 2 3 4 5 Strongly agree
9. … gets nervous easily
   Strongly disagree 1 2 3 4 5 Strongly agree
10. … has an active imagination
    Strongly disagree 1 2 3 4 5 Strongly agree

(Adapted from Rammstedt & John, 2007)

B.3 Adapted Self-efficacy Questionnaire

Self-efficacy questionnaire (MSLQ Self-efficacy subscale)

Your self-belief about your ability in study. There are no right or wrong answer, just answer as accurately as possible. Use the scale below to answer the questions. If you think the statement is very true of you, choose 7. If a statement is not at all true of you, choose 1. If the statement is more or less true of you, find the number between 1 and 7 that best describes you.

1. I believe I will receive an excellent grade in my course.
   Not at all true of me 1 2 3 4 5 6 7 Very true of me

2. I'm certain I can understand the most difficult material presented in the readings for this course.
   Not at all true of me 1 2 3 4 5 6 7 Very true of me

3. I'm confident I can learn the basic concepts taught in this course.
   Not at all true of me 1 2 3 4 5 6 7 Very true of me

4. I'm confident I can understand the most complex material presented by the instructor in this course.
   Not at all true of me 1 2 3 4 5 6 7 Very true of me

5. I'm confident I can do an excellent job on the assignments and tests in this course.
   Not at all true of me 1 2 3 4 5 6 7 Very true of me

6. I expect to do well in my course.
   Not at all true of me 1 2 3 4 5 6 7 Very true of me

7. I'm certain I can master the skills being taught in my course.
   Not at all true of me 1 2 3 4 5 6 7 Very true of me

7. Considering the difficulty of this course, the teacher, and my skills, I think I will do well in my course.
   Not at all true of me 1 2 3 4 5 6 7 Very true of me

(Adapted from Pintrich et al., 1991)

B.4 Adapted Learning Styles Questionnaire

Learning Styles questionnaire

You may only choose one answer for each question, and you need to **answer all questions** before you can submit the form. If both answers to a question seem to apply to you, choose the one that applies more frequently throughout all your courses.

Active/Reflective

1. I understand something better after I
(a) try it out.
(b) think it through.

2. When I am learning something new, it helps me to
(a) talk about it.
(b) think about it.

3. In a study group working on difficult material, I am more likely to
(a) jump in and contribute ideas.
(b) sit back and listen.

4. In classes I have taken
(a) I have usually got to know many of the students.
(b) I have rarely got to know many of the students.

5. When I start a homework problem, I am more likely to
(a) start working on the solution immediately.
(b) try to fully understand the problem first.

6. I prefer to study
(a) in a group.
(b) alone.

7. I would rather first
(a) try things out.
(b) think about how I'm going to do it.

8. I more easily remember
(a) something I have done.
(b) something I have thought a lot about.

9. When I have to work on a group project, I first want to
(a) have a "group brainstorming" where everyone contributes ideas.
(b) brainstorm individually and then come together as a group to compare ideas.

10. I am more likely to be considered
(a) outgoing.
(b) reserved.

11. The idea of doing homework in groups, with one grade for the entire group,
(a) appeals to me.
(b) does not appeal to me.

Global/Sequential

1. I tend to
(a) understand details of a subject but may be fuzzy about its overall structure.
(b) understand the overall structure but may be fuzzy about details.

2. Once I understand
(a) all the parts, I understand the whole thing.
(b) the whole thing, I see how the parts fit.

3. When I solve Maths problems
(a) I usually work my way to the solutions one step at a time.
(b) I often just see the solutions but then have to struggle to figure out the steps to get to them.

4. When I'm analysing a story or a novel
(a) I think of the incidents and try to put them together to figure out the themes.
(b) I just know what the themes are when I finish reading and then I have to go back and find the incidents that demonstrate them.

5. It is more important to me that an instructor
(a) lay out the material in clear sequential steps.
(b) give me an overall picture and relate the material to other subjects.

6. I learn
(a) at a fairly regular pace. If I study hard, I'll "get it."
(b) in fits and starts. I'll be totally confused and then suddenly it all "clicks."

7. When considering a body of information, I am more likely to
(a) focus on details and miss the big picture.
(b) try to understand the big picture before getting into the details.

8. When writing a paper, I am more likely to
(a) work on (think about or write) the beginning of the paper and progress forward.
(b) work on (think about or write) different parts of the paper and then order them.

9. When I am learning a new subject, I prefer to
(a) stay focused on that subject, learning as much about it as I can.
(b) try to make connections between that subject and related subjects.

10. Some teachers start their lectures with an outline of what they will cover. Such outlines are
(a) somewhat helpful to me.
(b) very helpful to me.

11. When solving problems in a group, I would be more likely to
(a) think of the steps in the solution process.
(b) think of possible consequences or applications of the solution in a wide range of areas.

(Adapted from Felder & Silverman, 1988)

Appendix C

Focus Group May 2018

C.1 Ethics Application Approval Certificate

MONASH University

Monash University Human Research Ethics Committee

Approval Certificate

This is to certify that the project below was considered by the Monash University Human Research Ethics Committee. The Committee was satisfied that the proposal meets the requirements of the *National Statement on Ethical Conduct in Human Research* and has granted approval.

Project Number:	13012
Project Title:	Learning Partner Recommender System
Chief Investigator:	Dr Michael Morgan
Approval Date:	24/04/2018
Expiry Date:	24/04/2023

Terms of approval - failure to comply with the terms below is in breach of your approval and the *Australian Code for the Responsible Conduct of Research*.

1. The Chief Investigator is responsible for ensuring that permission letters are obtained, if relevant, before any data collection can occur at the specified organisation.
2. Approval is only valid whilst you hold a position at Monash University.
3. It is 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 letterhead and the Monash University complaints clause must include your project number.
6. Amendments to approved projects including changes to personnel must not commence without written approval from MHUREC.
7. Annual Report - continued approval of this project is dependent on the submission of an Annual Report.
8. Final Report - should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected completion date.
9. Monitoring - project may be subject to an audit or any other form of monitoring by MUHREC at any time.
10. Retention and storage of data - The Chief Investigator is responsible for the storage and retention of the original data pertaining to the project for a minimum period of five years.

Thank you for your assistance.

Professor Nip Thomson

Chair, MUHREC

CC: Dr Matthew Butler, Professor Kimbal Marriott, Mrs Thanh Nguyen

List of approved documents:

Document Type	File Name	Date	Version
Consent Form	FG_Consent Form	11/04/2018	1
Explanatory Statement	FG_Explanatory Statement	11/04/2018	1
Explanatory Statement	FG Registration form	17/04/2018	1
Focus Group questions	FG_Activities	17/04/2018	1

C.2 Questionnaire on Difficulties in Finding Study Partners

Difficulties in making connections & finding learning partners

1. Learning online is convenient but sometimes I find it isolating.

1	2	3	4	5
Strongly disagree				Strongly agree

2. I want to know what others are studying, but it's not easy to find out.

1	2	3	4	5
Strongly disagree				Strongly agree

3. I want to know if others are having the same problems in the same subjects I am taking, but it's not easy to find out.

1	2	3	4	5
Strongly disagree				Strongly agree

4. I want to know others' experience in the units I plan to take, but it's not easy to find out.

1	2	3	4	5
Strongly disagree				Strongly agree

5. It would be great if there was a platform where I can find someone whose characteristics fit mine so that we can learn, share ideas and improve our study together.

1	2	3	4	5
Strongly disagree				Strongly agree

6. Any difficulties regarding collaboration in study or finding learning partners which you want want to mention?

C.3 Discussion Prompt Questions

Discussion

1. Any other criteria you think is important which the system should take into account when generating commendations? (e.g., location)

2. As a system user, how much of your information are you willing to be displayed to other users?

3. What kind of information you expect to know about recommended peers? (revise the previous question)

4. Recommendation results (inline bar chart): is it easy/difficult to interpret? Color of bars?

5. What can be done to support your decision in making contact with recommended peers?

6. Is Message box feature necessary in making initial contact among users?

7. Do you have other suggestions to improve the application?

C.4 System Usability Questionnaire

Usability questions

1. LPRS has the potentials to help online students in finding learning partners.

   1 2 3 4 5
   Strongly disagree Strongly agree

2. LPRS has the potentials to help online students in exploring unknown networks which might be useful for their study.

   1 2 3 4 5
   Strongly disagree Strongly agree

3. LPRS is easy to use.

   1 2 3 4 5
   Strongly disagree Strongly agree

4. LPRS is simple to use.

   1 2 3 4 5
   Strongly disagree Strongly agree

5. Using LPRS is effortless and I could learn how to use it without written instructions.

   1 2 3 4 5
   Strongly disagree Strongly agree

6. LPRS is pleasant to use.

   1 2 3 4 5
   Strongly disagree Strongly agree

7. Overall, I am satisfied with the experience I have had with LPRS.

   1 2 3 4 5
   Strongly disagree Strongly agree

Appendix D

Pilot Test S2 2018

D.1 Ethics Application Approval Certificate

Monash University Human Research Ethics Committee

Approval Certificate

This is to certify that the project below was considered by the Monash University Human Research Ethics Committee. The Committee was satisfied that the proposal meets the requirements of the *National Statement on Ethical Conduct in Human Research* and has granted approval.

Project ID:	14490
Project Title:	Learning Partner Recommendation System
Chief Investigator:	Dr Matthew Butler
Approval Date:	28/06/2018
Expiry Date:	28/06/2023

Terms of approval - failure to comply with the terms below is in breach of your approval and the *Australian Code for the Responsible Conduct of Research*.

1. The Chief Investigator is responsible for ensuring that permission letters are obtained, if relevant, before any data collection can occur at the specified organisation.
2. Approval is only valid whilst you hold a position at Monash University.
3. It is 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 letterhead and the Monash University complaints clause must include your project number.
6. Amendments to approved projects including changes to personnel must not commence without written approval from MHUREC.
7. Annual Report - continued approval of this project is dependent on the submission of an Annual Report.
8. Final Report - should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected completion date.
9. Monitoring - project may be subject to an audit or any other form of monitoring by MUHREC at any time.
10. Retention and storage of data - The Chief Investigator is responsible for the storage and retention of the original data pertaining to the project for a minimum period of five years.

Kind Regards,

Professor Nip Thomson

Chair, MUHREC

CC: Dr Michael Morgan, Professor Kimbal Marriott, Mrs Thanh Nguyen

List of approved documents:

Document Type	File Name	Date	Version
Explanatory Statement	SR_Explanatory Statement	18/06/2018	1
Consent Form	SR_Consent Statement	18/06/2018	1
Questionnaires / Surveys	SR_Survey Questions	18/06/2018	1
Questionnaires / Surveys	SR_Interview Questions	18/06/2018	1

D.2 Tutorial Discussion

Tutorial Discussion Topics [FIT1049]

1. Importance of Learning Communities (LCs)

What is a Learning Community? A learning community refers to a group of individuals who are *linked/connected* by either geographical proximity/location or shared interest/goal/objective/purpose come together to *perform regular social intellectual interactions*, for example sharing resources or solving problems together, in an environment where they feel *comfortable*, *trusted* and *valued* to *fulfil their diverse needs* regarding learning.

Benefits of LCs?

- Connecting academic and social experiences of students in higher education (Love, 2012).
- Expanding social relations
- Challenging & enriching knowledge
- Enjoying a feeling of being connected – sense of community (McMillan & Chavis, 1986)

Activities: Prompt students to discuss

- Their opinions about:
    - What a learning community is
    - What the benefits of a learning communities are
- Who are the people that they are studying with? (to explore the current LC situation)

2. How learners' individual characteristics have impact on the formation & development of a LC (or study group)

Activities: Ask students to discuss questions such as:

- Are students' characteristics & preferences important when it comes to working in a team?
- Which characteristics are perceived (by you) as important when you work with others?
- Common difficulties when you want to find someone to learn/work with?
- Do you think learning with peers who have characteristics that fit your preferences (as well as yours fit their preferences) would help improve learning experience?

3. A tool that can help you find study partners who fit your preferences (and vice versa).

Site link: http://lprs.infotech.monash.edu:5000

Activities:

- Log on the system and explore for 5 minutes
- What features you expect in the system or would like the system to have?

References

McMillan, D. W., & Chavis, D. M. (1986). Sense of community: A definition and theory. *Journal of Community Psychology, 14*(1), 6-23.

Love, A. G. (2012). The growth and current state of learning communities in higher education. *New Directions for Teaching and Learning, 2012*(132), 5-18.

D.3 Online Survey

LPRS (Learning Partner Recommender System) feedback

Thank you for trying out the Learning Partner Recommender System (LPRS)! We hope you had a good experience with the system.

We would want to hear your feedback in order to improve the system so that it can meet your needs better. Please fill this quick survey and let us know your thoughts (your answers will be anonymous).

Your email address (**thanh.nguyen@monash.edu**) will be recorded when you submit this form. Not **thanh.nguyen**? Sign out
*Required

Perceived usefulness

1. **1. Do you think using LPRS might help you find study partners with compatible characteristics?** *

   Mark only one oval.

	1	2	3	4	5	
Quite likely	◯	◯	◯	◯	◯	Quite unlikely

2. **2. Do you think using LPRS would help expand the choice you have for study partners?** *

   Mark only one oval.

	1	2	3	4	5	
Quite likely	◯	◯	◯	◯	◯	Quite unlikely

3. **3. Do you think using LPRS would help in triggering self-reflection on your own characteristics?** *

   Mark only one oval.

	1	2	3	4	5	
Quite likely	◯	◯	◯	◯	◯	Quite unlikely

4. **4. Do you think better understanding of your own characteristics would help in collaborating with others?** *

   Mark only one oval.

	1	2	3	4	5	
Quite likely	◯	◯	◯	◯	◯	Quite unlikely

5. **5. Do you think LPRS would help with initial contact with those whom you might learn & work well with?** *

   Mark only one oval.

	1	2	3	4	5	
Quite likely	◯	◯	◯	◯	◯	Quite unlikely

6. **6. What do you think about the quality of recommendations generated by LPRS?** *

   Mark only one oval.

	1	2	3	4	5	
Quite good	◯	◯	◯	◯	◯	Quite bad

7. **7. When do you think you might want to use the system?** *
Mark only one oval.

- Beginning of semester
- Throughout the semester
- End of semester
- Other: ____________

Perceived ease of use

8. **1. How easy is it to learn to use LPRS?** *
Mark only one oval.

	1	2	3	4	5	
Very easy	◯	◯	◯	◯	◯	Very difficult

9. **2. How easy is it to navigate in the system?** *
Mark only one oval.

	1	2	3	4	5	
Very easy	◯	◯	◯	◯	◯	Very difficult

10. **3. Was the instruction on how to use the system adequate?** *
Mark only one oval.

- Yes
- No
- Other: ____________

11. **4. Did LPRS allow you to do what you want to do?** *
Mark only one oval.

- Yes
- No
- Other: ____________

Perceived satisfaction

12. **1. How likely do you think you might want to use LPRS in the future?** *
Mark only one oval.

	1	2	3	4	5	
Quite likely	◯	◯	◯	◯	◯	Quite unlikely

13. **2. Do you think LPRS is pleasant to use?** *
Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

14. **3. How confident are you in using LPRS?** *
Mark only one oval.

	1	2	3	4	5	
Very confident	◯	◯	◯	◯	◯	Not confident

15. **4. Overall, how do you feel about the experience you have had with LPRS?** *

Mark only one oval.

	1	2	3	4	5	
Very satisfied	⬭	⬭	⬭	⬭	⬭	Very unsatisfied

Perceived usability

16. **1. What do you think about the potentials of LPRS to facilitate connecting students with compatible characteristics and improving learning experience?** *

Mark only one oval.

	1	2	3	4	5	
Very positive	⬭	⬭	⬭	⬭	⬭	Very negative

17. **2. Do the system features work well with each other?** *

Mark only one oval.

- ⬭ Yes, features are well integrated
- ⬭ They are acceptable
- ⬭ No, features are not integrated
- ⬭ Other: ______________________

18. **3. How consistent do you think it is when interacting with LPRS?** *

Mark only one oval.

	1	2	3	4	5	
Quite consistent	⬭	⬭	⬭	⬭	⬭	Very inconsistent

19. **4. Do you find it easy to interpret the recommendations?** *

Mark only one oval.

	1	2	3	4	5	
Very easy	⬭	⬭	⬭	⬭	⬭	Very difficult

20. **5. Do you understand what recommendation results mean when they are presented to you?** *

Mark only one oval.

- ⬭ Yes
- ⬭ No
- ⬭ Other: ______________________

21. **6. Did the matching process behave as you expected?**

Mark only one oval.

- ⬭ Yes
- ⬭ No
- ⬭ Other: ______________________

22. **Describe the best aspect(s) of LPRS**

____

____

____

____

____

23. **Describe the worst aspects(s):**

24. **Would you want to see more features integrated into the system? What are they?**

Send me a copy of my responses.

Appendix E

System Deployment S1 2019

E.1 Ethics Application Approval Certificate

Monash University Human Research Ethics Committee

Approval Certificate

This is to certify that the project below was considered by the Monash University Human Research Ethics Committee. The Committee was satisfied that the proposal meets the requirements of the *National Statement on Ethical Conduct in Human Research* and has granted approval.

Project ID:	17951
Project Title:	LPRS User Evaluation
Chief Investigator:	Dr Michael Morgan
Approval Date:	18/12/2018
Expiry Date:	18/12/2023

Terms of approval - failure to comply with the terms below is in breach of your approval and the *Australian Code for the Responsible Conduct of Research*.

1. The Chief Investigator is responsible for ensuring that permission letters are obtained, if relevant, before any data collection can occur at the specified organisation.
2. Approval is only valid whilst you hold a position at Monash University.
3. It is 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 letterhead and the Monash University complaints clause must include your project number.
6. Amendments to approved projects including changes to personnel must not commence without written approval from MUHREC.
7. Annual Report - continued approval of this project is dependent on the submission of an Annual Report.
8. Final Report - should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected completion date.
9. Monitoring - project may be subject to an audit or any other form of monitoring by MUHREC at any time.
10. Retention and storage of data - The Chief Investigator is responsible for the storage and retention of the original data pertaining to the project for a minimum period of five years.

Kind Regards,

Professor Nip Thomson

Chair, MUHREC

CC: Dr Matthew Butler, Professor Kimbal Marriott, Mrs Thanh Nguyen

List of approved documents:

Document Type	File Name	Date	Version
Supporting Documentation	Project_Introduction	23/11/2018	1
Supporting Documentation	Interview registration form	23/11/2018	1
Consent Form	Consent Form_Interview	23/11/2018	1
Questionnaires / Surveys	Survey_W01	26/11/2018	1
Questionnaires / Surveys	Survey_W10	26/11/2018	1
Explanatory Statement	Explanatory Statement	26/11/2018	1
Supporting Documentation	Interview_W01	26/11/2018	1
Supporting Documentation	Interview_W05	26/11/2018	1
Supporting Documentation	Interview_W10	26/11/2018	1
Supporting Documentation	OHSRiskAssessment	26/11/2018	1

E.2 Evaluation Survey Week 6 S1 2019

LPRS survey

This project is focusing on promoting informal learning communities by matching students based on students' characteristics and preferences. "Informal" here means that a group of students voluntarily get together to work on something without the teacher's supervision or control.

During O-week, we introduced a Learning Partner Recommender System which is designed to provide students with suggestions on peers who are likely to work well with each other. You have been encouraged to use the system to explore the available peer source and find yourself some study partners.

The goal of this survey is to
(1) explore the sense of community among students,
(2) explore the situation in which you have been using LPRS in facilitating searching for compatible learning partners, and (3) investigate any issues emerging which might cause difficulties/obstacles in making use of the system.

Your response is much appreciated!

Your email address (**thanh.nguyen@monash.edu**) will be recorded when you submit this form. Not **thanh.nguyen**? Sign out
*Required

Basic Information

Tell us a bit about yourself!

1. **I am a ____ student** *

   Mark only one oval.

   - Local
   - International

2. **I am ____** *

   Mark only one oval.

   - On-campus
   - Off-campus

3. **I know ____ people here at Monash & in Melbourne in general** *

   Mark only one oval.

   - None
   - few [1 - 5]
   - some [5 - 20]
   - many

Sense of Community

This section is for exploring your attitudes and experiences regarding working with other peers or in a learning group.

4. **1. I usually work _______** *

   Mark only one oval.

   - With others
   - Individually
   - Other: ____________________

5. **2. How I feel about Learning Communities** *

   Mark only one oval.

	1	2	3	4	5	
Very important to my study	◯	◯	◯	◯	◯	Not at all important to my study

6. **3. In my learning group, I feel that I am encouraged to ask questions** *
Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

7. **4. I feel connected to others in my learning group** *
Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

8. **5. I feel isolated among other peers of the learning group** *
Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

9. **6. I feel that other students do not help me learn** *
Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

10. **7. I feel that members of the learning group can count on me** *
Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

11. **8. I feel confident that my learning group members will support me** *
Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

LPRS Usage

This section is for exploring the situation in which you have been using LPRS

12. **1. How often do you use LPRS after signing up?** *
Mark only one oval.

- ◯ Never
- ◯ I have used LPRS - but rarely *Skip to question 16.*
- ◯ I have used LPRS - quite often *Skip to question 27.*

Obstacles to LPRS Use

Let us know what may bug you about the system so that we can improve it

13. **Reasons for not using LPRS** *
(can choose more than 1 option)
Tick all that apply.

- ☐ I have a busy schedule and don't have time for it
- ☐ I'm not interested in finding learning partners
- ☐ I've already had learning partners whom I can work/learn with
- ☐ I'm not sure what benefits I can get from the system
- ☐ I find it cumbersome when interacting with the system
- ☐ Other: ____________

14. **2. Things that might make me more engaged with LPRS?** *
(can choose more than 1 option)
Tick all that apply.

- [ ] More user-friendly interactions (e.g., navigation, data input forms)
- [ ] More appealing user interface
- [ ] More useful features (e.g., to help communications among system users)
- [ ] More obvious benefits I can get from LPRS (i.e., what I can get from the system)
- [ ] Other: ____________________

15. **3. Any suggestions/feedback?**

____
____
____
____
____

Stop filling out this form.

Opinions on LPRS

Let us know about your experience with LPRS so far so that we can improve it

16. **1. Factor(s) affecting my low usage of LPRS** *
(can choose more than 1 option)
Tick all that apply.

- [ ] I have a busy schedule and don't have time for it
- [ ] I'm not interested in finding learning partners
- [ ] I've already had learning partners whom I can work/learn with
- [ ] I'm not sure what benefits I can get from the system
- [ ] I find it cumbersome when interacting with the system
- [ ] Other: ____________________

17. **2. Things that might make me more engaged with LPRS?** *
(can choose more than 1 option)
Tick all that apply.

- [ ] More user-friendly interactions (e.g., navigation, data input forms)
- [ ] More appealing user interface
- [ ] More useful features (e.g., to help communications among system users)
- [ ] More obvious benefits I can get from LPRS (i.e., what I can get from the system)
- [ ] Other: ____________________

18. **3. Some other criteria I think important which LPRS should take into account when generating recommendations (N/A if not applicable)** *
Mark only one oval.

- ( ) N/A
- ( ) Other: ____________________

19. **4. I am comfortable about the amount of my information being displayed to others** *
Mark only one oval.

	1	2	3	4	5	
Completely comfortable	( )	( )	( )	( )	( )	Very uncomfortable

20. **5. Kind of information I expect to know about my recommended peers** *
(can choose more than 1 option)
Tick all that apply.

- [ ] Educational information (e.g., degree, major, year, campus)
- [ ] Demographic information (e.g., nationality, gender, age)
- [ ] Their characteristics (e.g., personality, self-efficacy, motivation level, skills)
- [ ] How much we are compatible according to the system
- [ ] Other: ____________________

21. **6. I find the presentation of recommendations** *
Mark only one oval.

	1	2	3	4	5	
Very easy to interpret	◯	◯	◯	◯	◯	Very difficult to interpret

22. **7. My initial impression of the generated recommendations** *
Mark only one oval.

◯ Might be helpful in finding me some learning partners
◯ I doubt the recommendations are really helpful
◯ Other: ____________________

23. **8. How I feel about Utilisation features (i.e., Making connections, voting peers, messaging)** *
Mark only one oval.

	1	2	3	4	5	
Quite useful	◯	◯	◯	◯	◯	Quite useless

24. **9. Features in LPRS that I find useful:**

____

25. **10. What I find difficult when interacting with LPRS:**

____

26. **11. My suggestions to improve LPRS:**

____
____
____
____
____

Stop filling out this form.

Opinions on LPRS

Let us know about your experience with LPRS so far so that we can improve it

27. **1. Some other criteria I think important which LPRS should take into account when generating recommendations (N/A if not applicable)** *
Mark only one oval.

◯ N/A
◯ Other: ____________________

28. **2. I am comfortable about the amount of my information being displayed to others** *
Mark only one oval.

	1	2	3	4	5	
Completely comfortable	◯	◯	◯	◯	◯	Very uncomfortable

29. **3. Kind of information I expect to know about my recommended peers** *
(can choose more than 1 option)
Tick all that apply.

- [ ] Educational information (e.g., degree, major, year, campus)
- [ ] Demographic information (e.g., nationality, gender, age)
- [ ] Their characteristics (e.g., personality, self-efficacy, motivation level, skills)
- [ ] How much we are compatible according to the system
- [ ] Other: ____________________

30. **4. I find the presentation of recommendations** *
Mark only one oval.

	1	2	3	4	5	
Very easy to interpret	◯	◯	◯	◯	◯	Very difficult to interpret

31. **5. My initial impression of the generated recommendations** *
Mark only one oval.

- ◯ Might be helpful in finding me some learning partners
- ◯ I doubt the recommendations are really helpful
- ◯ Other: ____________________

32. **6. How I feel about Utilisation features (i.e., Making connections, voting peers, messaging)** *
Mark only one oval.

	1	2	3	4	5	
Quite useful	◯	◯	◯	◯	◯	Quite useless

33. **7. Features in LPRS that I find useful:**

____

34. **8. What I find difficult when interacting with LPRS:**

____

35. **9. My suggestions to improve LPRS:**

____
____
____
____
____

- [ ] Send me a copy of my responses.

E.3 1-minute Survey Week 6 S1 2019

LPRS survey

LPRS project is focusing on promoting informal learning communities by matching students based on students' characteristics and preferences.

We introduced a Learning Partner Recommender System which is designed to provide students with suggestions on peers who are likely to work well with each other. You have been encouraged to use the system to explore the available peer source and find yourself some study partners.

The goal of this "super short" survey is to explore the obstacle to the LPRS use so that we can improve the system uptake.

Your response is much appreciated!

Your email address (**thanh.nguyen@monash.edu**) will be recorded when you submit this form. Not **thanh.nguyen**? Sign out
*Required

Obstacles to LPRS Use

Let us know what may bug you about the system so that we can improve it

1. **Reasons for not using LPRS** *

   (can choose more than 1 option)
   Tick all that apply.

   - [ ] I have a busy schedule and don't have time for it
   - [ ] I'm not interested in finding learning partners
   - [ ] I've already had learning partners whom I can work/learn with
   - [ ] I'm not sure what benefits I can get from the system
   - [ ] I find it cumbersome when interacting with the system
   - [ ] Other: ____________________

2. **2. Things that might make me more engaged with LPRS?** *

   (can choose more than 1 option)
   Tick all that apply.

   - [ ] More user-friendly interactions (e.g., navigation, data input forms)
   - [ ] More appealing user interface
   - [ ] More useful features (e.g., to help communications among system users)
   - [ ] More obvious benefits I can get from LPRS (i.e., what I can get by using the system)
   - [ ] More prompts from the system to tell me what to do
   - [ ] Other: ____________________

3. **3. Any suggestions/feedback?**

   ____
   ____
   ____
   ____
   ____

- [ ] Send me a copy of my responses.

Powered by
Google Forms

E.4 Evaluation Survey Week 10 S1 2019

LPRS (Learning Partner Recommender System) feedback

Thank you for trying out the Learning Partner Recommender System (LPRS)! We hope you had a good experience with the system.

We would want to hear your feedback in order to improve the system so that it can meet your needs better. Please take the survey and let us know your thoughts (your answers will be anonymous).

Your email address (**thanh.nguyen@monash.edu**) will be recorded when you submit this form. Not **thanh.nguyen**? Sign out
*Required

Perceived usefulness

1. **1. Do you think using LPRS might help you find study partners with compatible characteristics?** *

   Mark only one oval.

	1	2	3	4	5	
Quite likely	◯	◯	◯	◯	◯	Quite unlikely

2. **2. Do you think using LPRS would help expand the choice you have for study partners?** *

   Mark only one oval.

	1	2	3	4	5	
Quite likely	◯	◯	◯	◯	◯	Quite unlikely

3. **3. Do you think using LPRS would help in triggering self-reflection on your own characteristics?** *

   Mark only one oval.

	1	2	3	4	5	
Quite likely	◯	◯	◯	◯	◯	Quite unlikely

4. **4. Do you think better understanding of your own characteristics would help in collaborating with others?** *

   Mark only one oval.

	1	2	3	4	5	
Quite likely	◯	◯	◯	◯	◯	Quite unlikely

5. **5. Do you think LPRS would help with initial contact with those whom you might learn & work well with?** *

   Mark only one oval.

	1	2	3	4	5	
Quite likely	◯	◯	◯	◯	◯	Quite unlikely

6. **6. What do you think about the quality of recommendations generated by LPRS?** *

   Mark only one oval.

	1	2	3	4	5	
Quite good	◯	◯	◯	◯	◯	Quite bad

7. **7. When do you think you might want to use the system?** *
Mark only one oval.

- Beginning of semester
- Throughout the semester
- End of semester
- Other: ____________

Perceived ease of use

8. **1. How easy is it to learn to use LPRS?** *
Mark only one oval.

	1	2	3	4	5	
Very easy	◯	◯	◯	◯	◯	Very difficult

9. **2. How easy is it to navigate in the system?** *
Mark only one oval.

	1	2	3	4	5	
Very easy	◯	◯	◯	◯	◯	Very difficult

10. **3. Was the instruction on how to use the system adequate?** *
Mark only one oval.

- Yes
- No
- Other: ____________

11. **4. Did LPRS allow you to do what you want to do?** *
Mark only one oval.

- Yes
- No
- Other: ____________

Perceived satisfaction

12. **1. How likely do you think you might want to use LPRS in the future?** *
Mark only one oval.

	1	2	3	4	5	
Quite likely	◯	◯	◯	◯	◯	Quite unlikely

13. **2. Do you think LPRS is pleasant to use?** *
Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

14. **3. How confident are you in using LPRS?** *
Mark only one oval.

	1	2	3	4	5	
Very confident	◯	◯	◯	◯	◯	Not confident

15. **4. Overall, how do you feel about the experience you have had with LPRS?** *

Mark only one oval.

	1	2	3	4	5	
Very satisfied	◯	◯	◯	◯	◯	Very unsatisfied

Perceived usability

16. **1. What do you think about the potentials of LPRS to facilitate connecting students with compatible characteristics and improving learning experience?** *

Mark only one oval.

	1	2	3	4	5	
Very positive	◯	◯	◯	◯	◯	Very negative

17. **2. Do the system features work well with each other?** *

Mark only one oval.

- ◯ Yes, features are well integrated
- ◯ They are acceptable
- ◯ No, features are not integrated
- ◯ Other: ______________________

18. **3. How consistent do you think it is when interacting with LPRS?** *

Mark only one oval.

	1	2	3	4	5	
Quite consistent	◯	◯	◯	◯	◯	Very inconsistent

19. **4. Do you find it easy to interpret the recommendations?** *

Mark only one oval.

	1	2	3	4	5	
Very easy	◯	◯	◯	◯	◯	Very difficult

20. **5. Do you understand what recommendation results mean when they are presented to you?** *

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Other: ______________________

21. **6. Did the matching process behave as you expected?**

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Other: ______________________

22. **Describe the best aspect(s) of LPRS**

____

____

____

____

____

23. **Describe the worst aspects(s):**

24. **Would you want to see more features integrated into the system? What are they?**

Feedback on learning groups/learning community

25. **1. Have you been able to find some learning buddies with recommendations by LPRS?** *
Mark only one oval.
   - Yes *Skip to question 26.*
   - No *Stop filling out this form.*

Feedback on learning groups/learning community (cnt)

26. **2. If yes, what form of communication have you used the most?**

27. **3. Do you get together in persons? If yes, how often do you meet?**

28. **4. How important do you think activities you have with those peers is to your learning experience?**
Mark only one oval.

	1	2	3	4	5	
Very important	◯	◯	◯	◯	◯	Not at all important

29. **5. How comfortable do you feel when interacting with the peers?**
Mark only one oval.

	1	2	3	4	5	
Very comfortable	◯	◯	◯	◯	◯	Very uncomfortable

30. **To what extent do you think you and your contributions to the learning groups/community are acknowledged by the peers?**
Mark only one oval.

	1	2	3	4	5	
Greatly	◯	◯	◯	◯	◯	Not at all

31. **Overall, on a scale of 1 to 10, how satisfied are you with the experience you have had with the peers**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Very satisfied	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Not at all satisfied

☐ Send me a copy of my responses.

E.5 Interview Procedure

INTERVIEW PROCEDURE

Duration: approximately 20 minutes

Interview Procedure Statement

This research is focusing on promoting student-directed learning communities by matching students based on students' characteristics and preferences. By "student-directed", I mean that a group of students voluntarily get together to work on something without the teacher's supervision or control.

During the orientation week, we introduced a learning partner recommender system which is designed to provide students with suggestions on peers who are likely to work well with each other. You have been encouraged to use the system, LPRS, to explore the available peer source and find yourself some study partners.

The goal of this interview is to gain deep insights into the research's impacts on the formation of learning groups/communities among students.

Focus: Insights into Research Impacts

1. Your attitude towards / appreciation of the importance of LCs regarding your study

2. Has LPRS helped you find someone to learn with / helped you engage in LCs during the semester? Any learning groups or connections formed?

3. If **No**:
    1. What do you think is the reason?
    2. What are your suggestions to change the situation?

    If **Yes**: 4 onwards

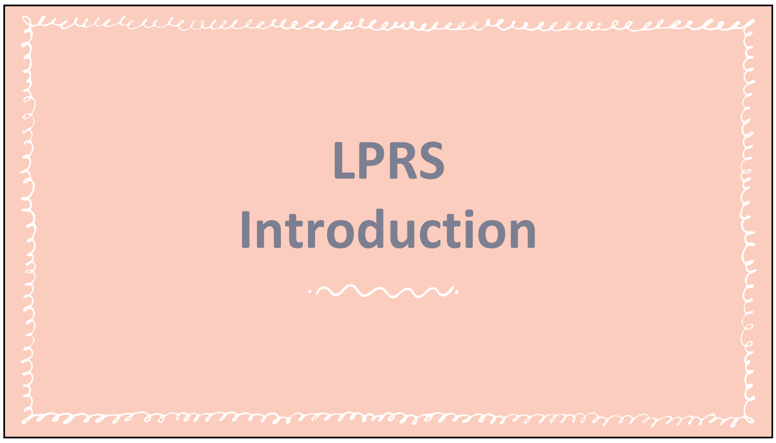
4. How has LPRS contributed to the facilitation of learning group formation process?
    1. Initial contact
    2. Connecting & Voting

5. Without the system, would the process be more difficult?

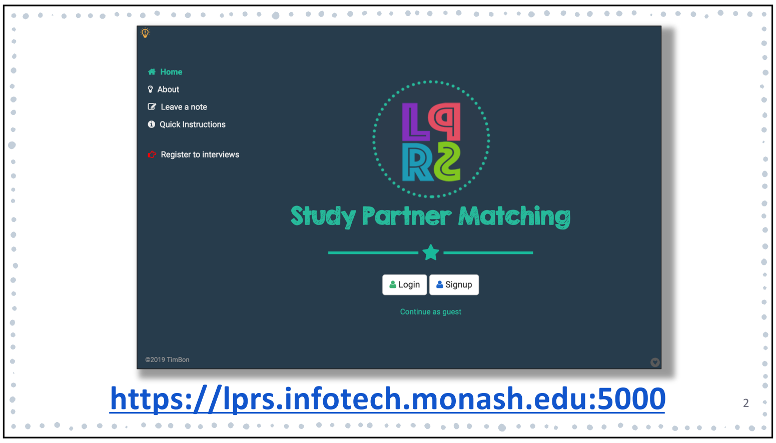
6. According to you, what can be done by the system to better support the formation of learning groups / communities among students?

7. Any feedback you want to share?

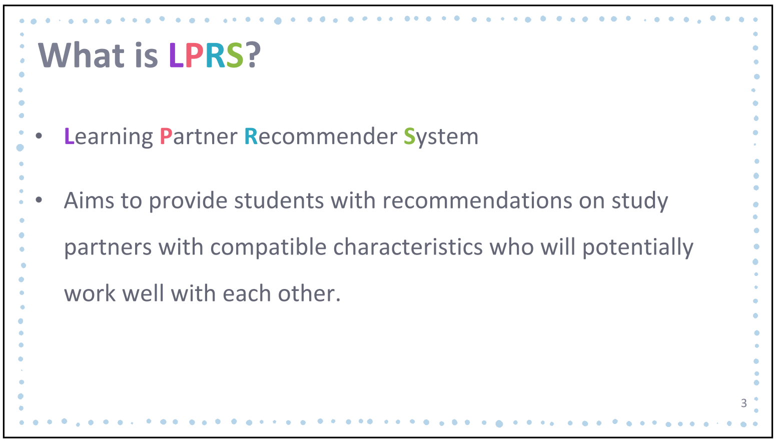
E.6 Lab Session Materials



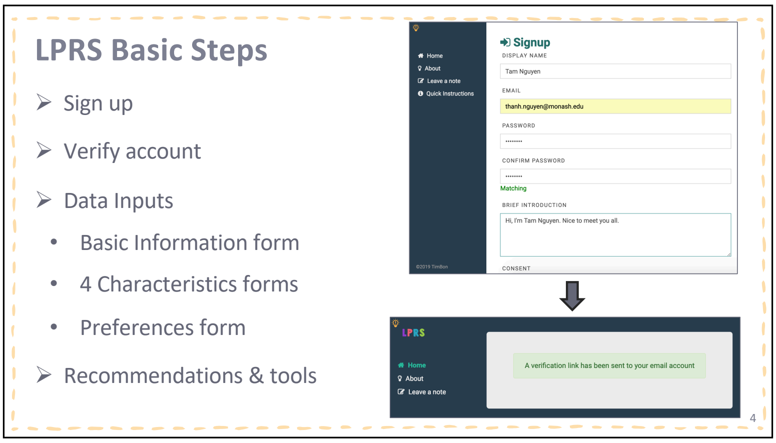
1



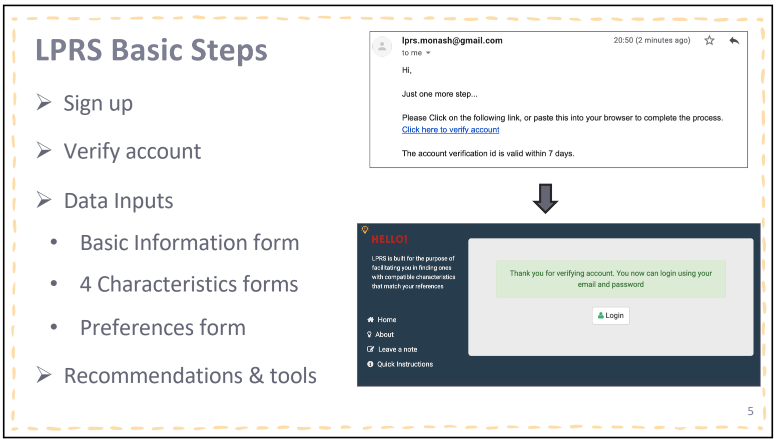
2


What is LPRS?
Learning Partner Recommender System
Aims to provide students with recommendations on study partners with compatible characteristics who will potentially work well with each other.
3

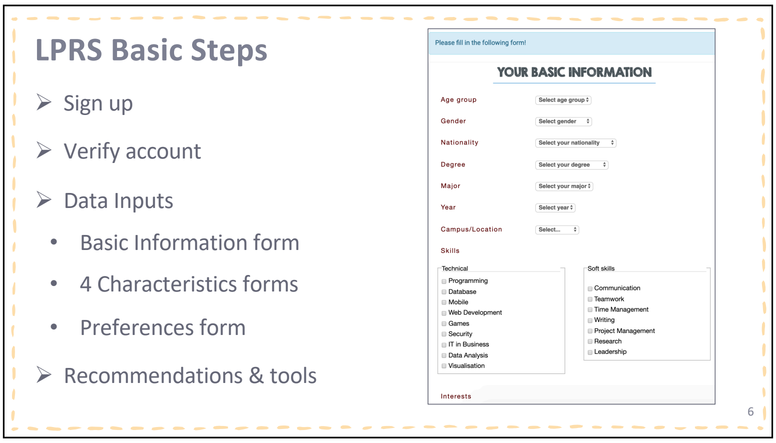
3


LPRS Basic Steps
Sign up
Verify account
Data Inputs
Basic Information form
4 Characteristics forms
Preferences form
Recommendations & tools
Home
About
Leave a note
Quick instructions
Signup
DISPLAY NAME
Tam Nguyen
EMAIL
thanh.nguyen@monash.edu
PASSWORD
CONFIRM PASSWORD
Matching
BRIEF INTRODUCTION
Hi, I'm Tam Nguyen. Nice to meet you all.
CONSENT
LPRS
Home
About
Leave a note
A verification link has been sent to your email account
4

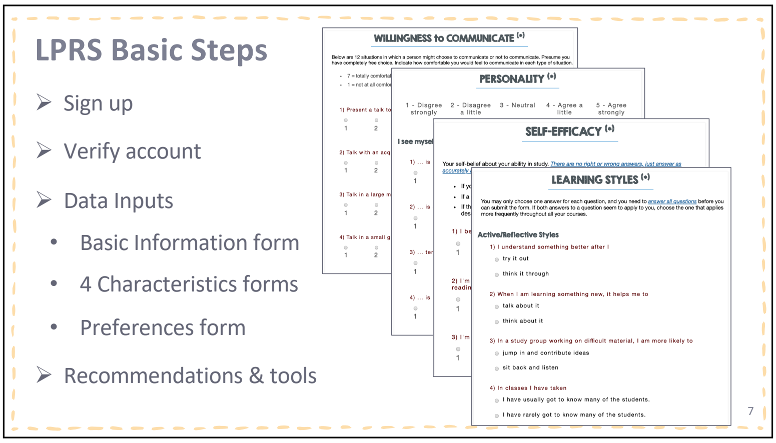
4


LPRS Basic Steps
Sign up
Verify account
Data Inputs
Basic Information form
4 Characteristics forms
Preferences form
Recommendations & tools
lprs.monash@gmail.com
to me
20:50 (2 minutes ago)
Hi,
Just one more step...
Please Click on the following link, or paste this into your browser to complete the process.
Click here to verify account
The account verification id is valid within 7 days.
HELLO!
LPRS is built for the purpose of facilitating you in finding ones with compatible characteristics that match your references
Home
About
Leave a note
Quick Instructions
Thank you for verifying account. You now can login using your email and password
Login
5

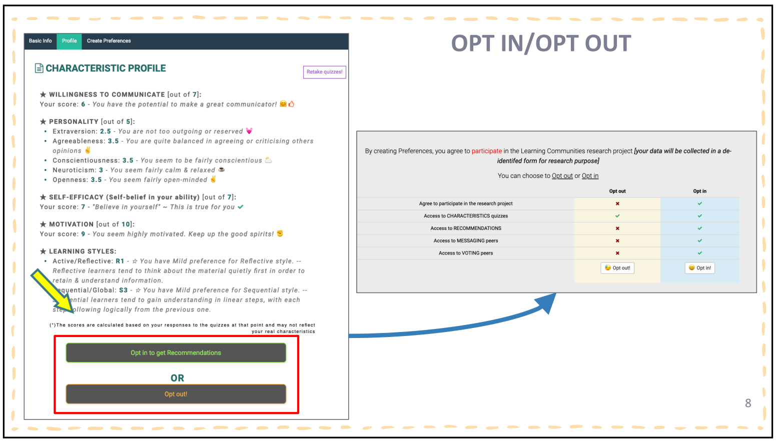
5


LPRS Basic Steps
Sign up
Verify account
Data Inputs
Basic Information form
4 Characteristics forms
Preferences form
Recommendations & tools
Please fill in the following form!
YOUR BASIC INFORMATION
Age group
Select age group
Gender
Select gender
Nationality
Select your nationality
Degree
Select your degree
Major
Select your major
Year
Select year
Campus/Location
Select...
Skills
Technical
Programming
Database
Mobile
Web Development
Games
Security
IT in Business
Data Analysis
Visualisation
Soft skills
Communication
Teamwork
Time Management
Writing
Project Management
Research
Leadership
Interests
6

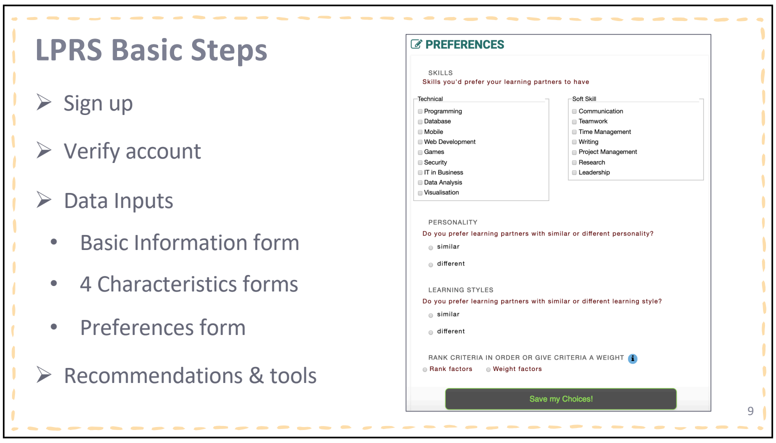
6


LPRS Basic Steps
Sign up
Verify account
Data Inputs
Basic Information form
4 Characteristics forms
Preferences form
Recommendations & tools
WILLINGNESS to COMMUNICATE (*)
PERSONALITY (*)
SELF-EFFICACY (*)
LEARNING STYLES (*)
Active/Reflective Styles
1) I understand something better after I
try it out
think it through
2) When I am learning something new, it helps me to
talk about it
think about it
3) In a study group working on difficult material, I am more likely to
jump in and contribute ideas
sit back and listen
4) In classes I have taken
I have usually got to know many of the students.
I have rarely got to know many of the students.
7

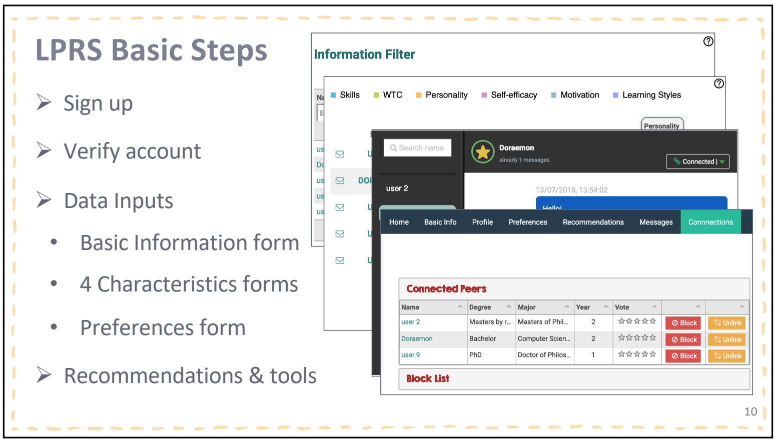
7


Basic Info
Profile
Create Preferences
CHARACTERISTIC PROFILE
Retake quizzes!
★ WILLINGNESS TO COMMUNICATE [out of 7]:
Your score: 6 - You have the potential to make a great communicator!
★ PERSONALITY [out of 5]:
Extraversion: 2.5 - You are not too outgoing or reserved
Agreeableness: 3.5 - You are quite balanced in agreeing or criticising others opinions
Conscientiousness: 3.5 - You seem to be fairly conscientious
Neuroticism: 3 - You seem fairly calm & relaxed
Openness: 3.5 - You seem fairly open-minded
★ SELF-EFFICACY (Self-belief in your ability) [out of 7]:
Your score: 7 - "Believe in yourself" ~ This is true for you
★ MOTIVATION [out of 10]:
Your score: 9 - You seem highly motivated. Keep up the good spirits!
★ LEARNING STYLES:
Active/Reflective: R1 - ☆ You have Mild preference for Reflective style. -- Reflective learners tend to think about the material quietly first in order to retain & understand information.
(*)The scores are calculated based on your responses to the quizzes at that point and may not reflect your real characteristics
Opt in to get Recommendations
OR
Opt out!
OPT IN/OPT OUT
By creating Preferences, you agree to participate in the Learning Communities research project [your data will be collected in a de-identifed form for research purpose]
You can choose to Opt out or Opt in
Opt out
Opt in
Agree to participate in the research project
Access to CHARACTERISTICS quizzes
Access to RECOMMENDATIONS
Access to MESSAGING peers
Access to VOTING peers
Opt out!
Opt in!
8

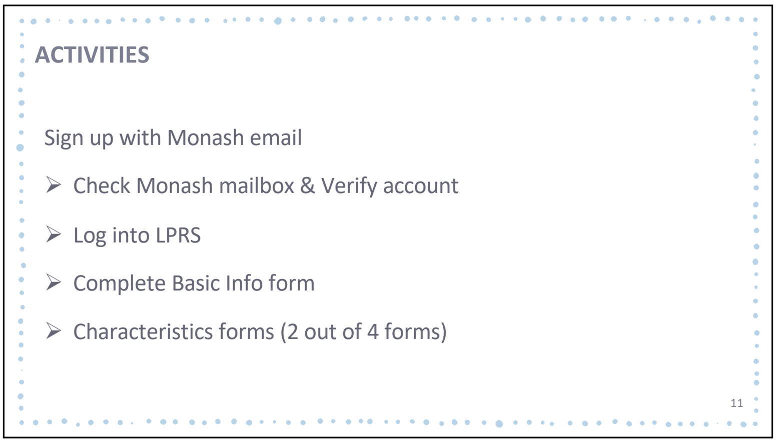
8


LPRS Basic Steps
Sign up
Verify account
Data Inputs
Basic Information form
4 Characteristics forms
Preferences form
Recommendations & tools
PREFERENCES
SKILLS
Skills you'd prefer your learning partners to have
Technical
Programming
Database
Mobile
Web Development
Games
Security
IT in Business
Data Analysis
Visualisation
Soft Skill
Communication
Teamwork
Time Management
Writing
Project Management
Research
Leadership
PERSONALITY
Do you prefer learning partners with similar or different personality?
similar
different
LEARNING STYLES
Do you prefer learning partners with similar or different learning style?
similar
different
RANK CRITERIA IN ORDER OR GIVE CRITERIA A WEIGHT
Rank factors
Weight factors
Save my Choices!
9

9


LPRS Basic Steps
Sign up
Verify account
Data Inputs
Basic Information form
4 Characteristics forms
Preferences form
Recommendations & tools
Information Filter
Skills
WTC
Personality
Self-efficacy
Motivation
Learning Styles
Doraemon
user 2
Home
Basic Info
Profile
Preferences
Recommendations
Messages
Connections
Connected Peers
Name
Degree
Major
Year
Vote
Block List
10

10


ACTIVITIES
Sign up with Monash email
Check Monash mailbox & Verify account
Log into LPRS
Complete Basic Info form
Characteristics forms (2 out of 4 forms)
11

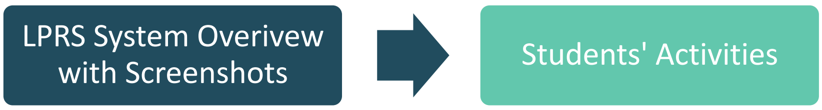
11


“
Thank you!
12

12

[LPRS Project] Lab Trainers Notes in O-week

Goal of this 10-minute session: During the Lecture session on Monday, the Learning Partner Recommender System (LPRS) was briefly introduced to students as a tool which has been developed to help them find learning partners with compatible characteristics; and from that they can form an effective informal learning group, and improve their learning experience at Monash. This session aims to encourage the students to start exploring the system – just to get them started!



LPRS System Overview with Screenshots [5 minutes]

- Go to the online system with the link provided (on your device if possible – just to show them how it looks like. OR you can just use the screenshot on Slide 2): https://lprs.infotech.monash.edu:5000.
- Please use the slides provided to give students an overview of the system:
  - What LPRS is about - suggest study partners based on students' individual characteristics and preferences [Slide 3]
  - Basic steps when interacting with the system:
    - sign up [Slide 4]
    - verify account [Slide 5]
    - complete data inputs including: Basic Information form [Slide 6], 4 characteristics forms [Slide 7] & a preferences form [Slide 8]
    - After all data inputs, students have full access to recommendations and other tools (message, connect, vote peers) [Slide 9]

Appendix F

Educator Interview Questions

Interview Questions – Educators

1. Participant's information

- What role do you have at Monash University?
- How long have you been in the position?
- How much face-to-face interaction do you have with students?
- What kind of experience do you have with students? – Teaching related, student support, etc.

2. Are you aware of your students forming learning communities which are not related to a particular assignment for a unit?

- If Yes, how do you think that works?
- How important do you think these activities are?
- What do you think is important to the students when they look to form informal learning groups?
- Do you use these characteristics/factors when forming in-class groups?

3. The researcher will present the Learning Partner Recommender System (LPRS) and run through the system

- What would you say about the system in terms of alignment with what you think might help with the formation of students' learning communities?
- Strengths and weaknesses of the system that you reckon?
    - Philosophical alignment?
    - Technical aspects / Implementation
- How do you think the system can be integrated into a particular unit?
- Any side benefit that you think the system can bring?

Explain data collection limitations / low number of participants after a series of previous data collections with positive results

- What do you think are the main reasons for low buy-in from students?
    - System itself: Technical faults; Unappealing user interface, Poor number of features, Technical support (instructions, etc.)
    - Users (students): lack of time, attitude towards learning communities, no perception of benefits from the system, gender/age/previous experience effect…
    - Context: other external factors besides the system's inherent drawbacks?
- Suggestions for improving system uptake?

Anything else you want to add?

Appendix G

Study of Barriers to Adoption

G.1 Ethics Application Approval Certificate

MONASH University

Monash University Human Research Ethics Committee

Approval Certificate

This is to certify that the project below was considered by the Monash University Human Research Ethics Committee. The Committee was satisfied that the proposal meets the requirements of the *National Statement on Ethical Conduct in Human Research* and has granted approval.

Project ID:	14490
Project Title:	Learning Partner Recommendation System
Chief Investigator:	Dr Matthew Butler
Approval Date:	28/06/2018
Expiry Date:	28/06/2023

Terms of approval - failure to comply with the terms below is in breach of your approval and the *Australian Code for the Responsible Conduct of Research*.

1. The Chief Investigator is responsible for ensuring that permission letters are obtained, if relevant, before any data collection can occur at the specified organisation.
2. Approval is only valid whilst you hold a position at Monash University.
3. It is 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 letterhead and the Monash University complaints clause must include your project number.
6. Amendments to approved projects including changes to personnel must not commence without written approval from MHUREC.
7. Annual Report - continued approval of this project is dependent on the submission of an Annual Report.
8. Final Report - should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected completion date.
9. Monitoring - project may be subject to an audit or any other form of monitoring by MUHREC at any time.
10. Retention and storage of data - The Chief Investigator is responsible for the storage and retention of the original data pertaining to the project for a minimum period of five years.

Kind Regards,

Professor Nip Thomson

Chair, MUHREC

CC: Dr Michael Morgan, Professor Kimbal Marriott, Mrs Thanh Nguyen

List of approved documents:

Document Type	File Name	Date	Version
Explanatory Statement	SR_Explanatory Statement	18/06/2018	1
Consent Form	SR_Consent Statement	18/06/2018	1
Questionnaires / Surveys	SR_Survey Questions	18/06/2018	1
Questionnaires / Surveys	SR_Interview Questions	18/06/2018	1

G.2 Interview Activities & Questions

FOCUS GROUP / INTERVIEW ACTIVITIES

Part 1. General discussion: The participants will discuss and respond to **opening questions** which are asked by the researcher.

Opening questions: The focus group is all about what would make users – students in this case – more likely to use a new introduced education tool – a system, a webpage, etc. Let's think about a social media, social networking apps (or website), or any applications that you have been using.

- What apps/websites do you use regularly for learning purposes?
- How did you start using those applications?
- What makes you keep using those applications?

Now think about some other apps/websites that you once used but for some reason, you stopped.

- What made you stop using those apps/websites?

How about the applications that you don't even want to try out at the first place?

Part 2. System interaction: The system will be presented to the participants. The participants will then

- complete data inputs (which include a basic information form, four characteristic quizzes and a preference form)
- explore system's features.

Part 3. Comments on the system: Participants will discuss and provide feedback on the system (user interface, features, ease of use, strengths and weaknesses, and so on). Prompt questions include:

- What are the benefits about the tool that you reckon?
- What do you think would be (were) barriers to system uptake?
- NOTE: link back to the points mentioned/discussed in Part 1