A Constructivist, Mobile and Principled Approach to the Learning and Teaching of Programming

A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy of Computer Science

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Declaration

I certify that except where due acknowledgement has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the thesis is the result of work which has been carried out since the official commencement date of the approved research program; any editorial work, paid or unpaid, carried out by a third party is acknowledged, and ethics procedures and guidelines have been followed.

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Dedication

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List of Publications

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Abstract

Novices in programming courses need to acquire a theoretical understanding of programming concepts as well as practical skills for applying them, but in traditional learning environments students passively listen to the lecture without proactive practice-based learning. There is a need for a constructivist approach to learning based on the ability of the learner to construct his or her own knowledge from the concepts provided by the instructors. Therefore, learning that uses a practical approach offers more in-depth understanding to students and sustains students’ attention as well as encourages students to be active players in their own learning process. The ubiquitous use of mobile devices and the evolution of mobile device technologies have led to a growing interest in these devices as pedagogical aids in a constructivist learning approach where students can immediately practice the concepts being taught in the lecture on their mobile devices.

This thesis investigates the effectiveness of a constructivist mobile-based learning and teaching approach to programming by utilising students’ mobile devices in a traditional lecture hall environment to deliver theoretical and practical components together on visualisation software. The thesis uses a mixed method approach integrating qualitative and quantitative methods through four phases of data collection and analysis. The first two phases involve studies examining students’ and lecturers’ perceptions, respectively, in order to acquire a sense of the context by examining their needs, perceptions and concerns with the constructivist mobile-based environment. Then, we design an intervention lecture in accordance with the contextual issues highlighted by the first two phases and the Seven Principles of Good Practice in Undergraduate Education developed by Chickering and Gamson as the theoretical framework. While each of these principles addresses an important aspect of any approach to enhance the learning experience of students, the employment of all principles can work as a powerful tool to develop a holistic framework for an effective teaching and learning environment.

We conduct the intervention in the third phase of the study and evaluate the participants' perceptions about the constructivist mobile-based approach on the seven principles with pre- and post-intervention surveys. In the last phase of the study, we conduct an in-depth focus group with lecturers from various universities to gather their views on the findings from the intervention.

Overall, the results support the constructivist mobile-based approach for enhancing the learning experience of programming students as it promotes active learning and encourages student engagement, but there are also some potential distractions as well as logistical issues. This thesis contributes to theoretical research on good pedagogy in computer education by proposing a mobile-based constructivist learning and teaching approach as well as an effective evaluation framework. A framework that helps educators in applying the constructivist mobile-based programming approach more effectively in alignment with the seven principles and designing and assessing constructivist mobile-based programming approach in introductory programming courses.

The research also highlights practical issues for universities and lecturers for developing a learning approach that successfully incorporates mobile devices as learning aids in the traditional lecture environment. Finally, the positive feedback from both the lecturers and students demonstrate that it can be worthwhile to adopt a constructivist mobile-based learning and teaching approach in introductory programming courses to improve academic experience.

Chapter 1 - Introduction

Programming is a complex skill to master, and learning this skill can prove to be a daunting task for a significant number of novice programmers (Ben-Ari 1998; Bennedsen & Caspersen 2006; Gomes et al. 2006; Gomes & Mendes 2008; Jenkins 2002; Robins, Rountree & Rountree 2003). In order for computer programming students to acquire conceptual understanding as well as practical skills, it is important to follow a learning paradigm that includes a hands-on and practical approach (Carter et al. 2010; Eckerdal 2009; Hadjerrouit 1999). A constructivist approach based on the ability of the learner to construct his or her own knowledge from the concepts provided by the instructors provides an active learning approach to programming courses (Ben-Ari 1998; Poindexter 2003; Von Glasersfeld 2001). However, the traditional lecture format currently utilised in the bulk of programming courses across the world are incompatible with such a constructivist approach as students passively sit in large lecture theatres listening to the lecturer without actually practicing the concepts (Huet et al. 2004).

In recent years, the evolution of mobile devices such as laptops has led to growing interest in these tools to aid a constructivist learning and teaching approach (Rogers 2004; Zurita & Nussbaum 2004). In such a technology-based learning paradigm, programming students can undertake assignments that involve immediate application of the concepts being taught during their lectures on their mobile devices (Carter et al. 2010). However, the use of these devices as learning aids is still an issue of considerable debate and a lot of work needs to be done to clarify the connection between classroom technology and student learning (McCabe & Meuter 2011). There is a growing need to explore the potential influences of mobile devices in the learning process and develop learning approaches that can successfully incorporate them as learning aids in the traditional lecture environment (Kay & Lauricella 2011).

This thesis investigates the effectiveness of a constructivist learning and teaching approach utilising laptops in a traditional lecture hall environment and the capability of such an approach in enhancing the delivery of programming courses in higher education. This chapter sets out the rationale behind the research focus and provides a glimpse of the research conducted in this study. It begins by outlining the problems of ineffective delivery confronting traditional programming lectures and describing our motivation to explore the scope of constructivist mobile-based learning and teaching approaches to provide a more effective pedagogical paradigm. As mobile-based learning is a relatively new subject in pedagogical research, the gaps in the literature are also analysed. This is followed by the aim and objectives of this research and the significance of this thesis. Lastly, the chapter describes the research process guiding the various stages of data collection and the structure of the thesis explaining the contents and topics of all the succeeding chapters.

1.1 Research Problem

Programming is a core subject in the Computer Science discipline. An undergraduate student needs to fully understand programming and acquire the requisite skills at the introductory level to be able to proceed with their degree. Robins (2010) proposed the learning edge momentum (LEM) as an alternative account of the pattern of introductory programming course (CS1) outcomes focusing on introductory levels in programming education. The central claim of the LEM is that, within a given target domain of new concepts to be learned, any successful learning makes it somewhat easier to acquire further related concepts from the domain, while unsuccessful learning makes it somewhat harder. In our context, the focus is on novice programmers. We define novice programmers as university level undergraduate students with little or no programming knowledge enrolled in introductory programming course. In introductory programming courses, novices acquire basic knowledge of programming terminology and understand its usage in coding a program. As programming is a thoroughly cumulative and practical subject, novices need to be engaged with the learning process from the first week of the course till the end of the semester.

Although programming is a critical skill for a novice learner, there is a gap between the delivery of lectures in tertiary education and the learning potential of many students (Young, Robinson & Alberts 2009). In particular, learning computer programming includes understanding static concepts, programming codes, algorithms and data, none of which are visual in form. They require extensive understanding, which can pose a challenge to novices. Instead of continually applying the learned concepts in practical exercises, many novices only do the actual practical tasks when the first formal assessment is required. When novices turn to practical application after such a long hiatus following the actual lecture, many of the finer details of the concepts escape their minds (Poindexter 2003). They may lack the understanding of basic concepts and fail to remember the right procedure to apply programming codes. Their inability to successfully complete the assignment could then lead to disappointment and disaffection with the course (D'Souza et al. 2008). In fact, many researchers have noted that while novices often sign up for programming courses in large numbers, programming courses often experience high attrition rates (Denning & McGettrick 2005; Ford & Venema 2010) and drop in class attendance over time. This shows that there is still a gap between the delivery of tertiary programming courses and the learning potential of students,

However, the lecture continues to be the main channel of delivering theories and new concepts in programming courses. Materials are delivered to a large number of students who passively listen to the lecturer and take down notes. There are many arguments for the traditional lecture format, including, cost effectiveness, efficient use of resources, and access to the most number of students. Many scholars have recently criticised the traditional lecture format as an outmoded and ineffective learning approach as it lacks interactivity, does not fully encourage active learning and does not cater to individual needs (Matheson 2008; McGarr 2009). Other major problems include poor attendance and students' perception of lectures as boring, irrelevant and time-consuming (Matheson 2008; O'Donoghue & O'Steen 2007; Wood, Burke Da Silva & Menz 2007). Although there is criticism about the traditional lecture format, course delivery in lecture theatres is predicted to remain the main pedagogical method for the foreseeable future (Dolnicar et al. 2009; McGarr 2009). In this traditional pedagogical format, students get lectures which act as a core platform for information dissemination that provides the basis for follow-up practical activities (tutorials, labs and/or some other combination). In programming courses across the world, lecturing to large groups [300+] is the expected norm, usually for economic reasons rather than pedagogic ones, which may also increase the risk of losing students through lack of engagement with their learning (Wood, Burke Da Silva & Menz 2007).

In a seminal study on pedagogical practices in programming courses, researchers find that the classroom experience is no longer central to students learning in programming courses (Sheard et al. 2013). In order to motivate current students and enhance students' learning, there is a need to develop a teaching approach that involves delivering theoretical and practical content together in the lecture environment (Matthíasdóttir 2006). An appropriate learning environment for novices must give them an in-depth knowledge of the principles of their discipline as well as practical skills of using the course content (Hwang et al. 2009).

Programming courses need to turn to a learning paradigm that stresses knowledge acquisition that employs a proactive approach where students learn the theoretical concepts and apply it in practical contexts. A constructivist approach takes into consideration the ability of the learner to construct his or her own knowledge based on the concepts provided by the instructors (Von Glasersfeld 1995). This approach has been accepted as a more appropriate method for building learners' competency when students need to grasp complex ideas (Applefield, Huber & Moallem 2001). In the traditional lecture formats currently used in programming courses, it is hard for programming students to follow such a constructivist approach with immediate application of the concepts being taught during the lecture (Van Gorp & Grissom 2001).

1.2 Research Motivation

Leading researchers in mobile learning define m-learning as learning involving the use of mobile devices (O'Malley et al. 2005a). This simple yet effective definition is also applied in this thesis. Using mobile devices with the lectures could make the learning environment more interactive and deliver knowledge in a more effective manner. Moreover, it may help to move from a lecturer-centred to student-centred approach with a hands-on practical approach to learning where students are encouraged to undertake practical exercises rather than being mere passive listeners in lectures. Also, asking students to complete practical exercises applying the concepts learnt in the lecture will promote better engagement among students and enhance formative assessment during lectures. In addition, laptops could be used by students as a device for taking notes and storing course content

Each cohort of students entering and graduating from university is characterised by varying attitudes and expectations. Students in contemporary programming courses like an interactive hands-on approach with multiple modes of access to data within flexible learning spaces (Poindexter 2003). Instructors in this changing learning environment need to adapt to meet the expectations of students (Khaddage, Lattemann & Bray 2011; Uzunboylu, Hüseyin & Ozdamli 2011). An example of the breadth of this continual change is the use of mobile devices in educational practices, which has also grown into a topic of extensive research in the last decade (Hwang & Tsai 2011).

Portable computers, such as laptops, notepads, personal assistants or smart phones, are now ubiquitous (Frohberg, Göth & Schwabe 2009; Hwang et al. 2009; Hwang & Tsai 2011; Wurst, Smarkola & Gaffney 2008). The meteoric rise of mobile device ownership has put higher education institutions in a dilemma about how to adopt these technologies to cater to the expectations of this generation of students for whom mobile devices are an integral part of life. Laptops have reached a price point where they are affordable for most higher education students (Wilen-Daugenti & McKee 2008) and today’s students are digital natives who expect to use technology everywhere (Tapscott 2010). While most students today own and use mobile devices (such as laptops), these devices are not widely utilised as practical learning aids in lectures. Pedagogical practices and learning environments undergo continual change and must adapt to such shifts in technology and capitalise on these technologies for better education outcomes.

In summary, novices need a learning environment that motivates and engages them in the learning process, but the traditional lecture delivery model does not fully encourage active learning. The main motivation of this research is to explore the capability of a mobile-learning based constructivist approach in enhancing the traditional learning environment in programming courses, where students apply and practice the concepts learnt in the lecture on set tasks on their laptops.

1.3 Research Gap

Research on pedagogical practices in lecture theatres have considered technologies that have been used in most higher education institutions, such as Personal Response System (PRS) (Duncan 2005). These technologies have been examined in the long tradition of pedagogical research focused on introducing active learning into traditional passive teaching strategies. However, the implementation of these technologies still require further research in the field of pedagogical research on computer programming (Low 2008). The technologies, which have been tested within the field of computer science, cannot thoroughly encapsulate the concepts behind effective instructional pedagogy, particularly for computer programming courses that demand high recall and application of the practical programming concepts.

The field of mobile learning is receiving increased attention from researchers and educators. Although research about the use of mobile devices in lectures is available, few have considered the applicability of mobile learning to programming courses (Sheard et al. 2009). It is ironic that pedagogical practices in programming courses have not been able to fully incorporate the use of computer devices. With the rapid advances in mobile learning, there is a need to redesign introductory computing courses to meet the expectations of a new student generation in higher education. It would be reasonable to assume that the use of computers in computer programming courses could prove to be a more effective technological and pedagogical intervention.

There are a number of successful mobile learning projects, and there is need for further investigation to verify whether mobile learning is sustainable and offers learning enhancement for all subject areas (Rajasingham 2011). Moreover, there is much research about various teaching strategies concerning computing classes, but not specifically addressing the argument of ineffective lectures such as peer instruction (Porter et al. 2011), pair programming (Brereton, Turner & Kaur 2009; Hanks et al. 2011; Salleh, Mendes & Grundy 2011) and contribution to student pedagogy (Hamer et al. 2008). We highlight our objectives in this research area in the next section.

1.4 Research Objectives

Our research in this thesis aims to conduct an intervention lecture where students use their mobile devices (in this case, laptops) in the lecture and then evaluate the effectiveness of this constructivist mobile-based learning and teaching approach to programming. In order to achieve this aim, we need to address the following objectives:

- Understand students' perceptions of a constructivist mobile-based learning approach by using mobile devices in lectures and identify advantages and challenges from students' perspectives;
- Understand lecturers' perceptions of a constructivist mobile-based teaching approach by using mobile devices by their students in lectures and identify advantages and challenges from lecturers' perspectives;
- Design and conduct a constructivist mobile-based learning and teaching programming approach that suits the targeted students and course; and
- Examine the effectiveness of the approach.

Overall, the research investigates the potential enhancement of the learning experiences of novices using their mobile devices supported with visualisation software in programming lectures. In order to achieve the research objectives, this thesis therefore will investigate the following research questions:

1. How do existing perceptions of students influence their attitude to a constructivist mobile-based learning approach in lectures?
2. How do existing perceptions of lecturers influence their attitude to a constructivist mobile-based teaching approach in lectures?
3. How can the application of a constructivist mobile-based learning and teaching approach to programming influence novice students' learning experiences during lectures?

1.5 Significance of the Research

This thesis aims to improve the delivery model of learning and teaching for novices in programming courses. It provides an understanding of computer science students' and lecturers' perceptions about mobile learning in programming lectures. This thesis contributes to theoretical research on mobile-based learning approaches and makes some practical contributions on how these methods can be employed to enhance current programming teaching practices. This research will add to the research on technological enhancement of the traditional lecture model which will increase students' understanding and engagement. It contributes to the field of computer science education by focusing on the enhancement of the academic experience of students in traditional learning environments by incorporating proactive and engaging learning exercises. This pedagogical approach can increase the competency of programming learners to subsequently help novice programmers advance their programming skills, increase motivation and better understand the concepts being taught in lectures.

The thesis will also provide an understanding of the motivations and barriers facing university lecturers and students with regard to the possibility of adopting mobile technology in programming lectures. It provides university officials and lecturers in computer science departments with empirical information on the actual benefits and disadvantages of teaching programming courses using mobile devices during lectures. The results of the intervention lecture may help lecturers strategies the manner in which they apply this kind of approach in their lectures.

Apart from its contribution to the field of Computer Science education, this research also contributes to the field of mobile learning in computing by examining its effectiveness with a theory-based evaluation. The thesis uses a well-known framework of best practices in learning and teaching in higher education for evaluating the effectiveness of a mobile learning approach in programming lectures. It contributes to the theoretical research on good pedagogy in computer education by proposing a sequential demonstration of effective application of the seven principles of good practice in undergraduate education in programming lectures. This thesis also produces a research methodology that can be used by future researchers in the field for a robust research design combining methodological triangulation (use of multiple methods to study a research problem) and data triangulation (use of variety of sources in a study).

1.6 Research Process

In this thesis, there is a focus on introducing a mobile-based learning approach in the context of a traditional delivery model of teaching and learning which contains lectures, tutorials and laboratories to teach and learn programming. As the chosen research locale in this study does not implement or support any form of mobile learning, this study conducts an intervention lecture where students use mobile devices in the lecture. Conducting this intervention in a pedagogical environment unused to mobile learning can trigger participant reactions that consider and compare the learning approaches in the traditional and intervention lecture set-up.

This research uses a mixed method approach integrating qualitative and quantitative methods in order to meet its objectives. The mixed method approach is increasingly accepted by scholars as an approach that can broaden the range of the study and deliver stable results for the themes under investigation (Creswell 2009; Tashakkori & Teddlie 1998). The research design adopts surveys with Computer Science students as a tool for quantitative data collection and interviews as well as focus group interview with lecturers provides qualitative data. This combination of methods provides better support for the results and conclusion (Sarantakos 2005).

The study went through four stages of data collection and analysis after reviewing the literature and deciding on the research methodology. The research follows a process described in the following Figure 1.1.

Phases 1 and 2 are conducted with a view to acquiring a sense of the context within which the mobile technology intervention would be tested to anticipate any challenges and increase the potential of success. The first two phases consider both the students' and lecturers' perceptions to understand their needs, perceptions and concerns with the constructivist mobile-based learning and teaching approach.

In Phase 3, we develop the surveys and the intervention lecture in accordance with the contextual issues highlighted by the exploratory studies. This phase of the study is concerned with the students' responses after the intervention lecture. In Phase 4 of the study, we conduct an in-depth focus group interview with lecturers to gather their views on the findings collected in the study and their response on the extent to which mobile-based learning was able to fulfill the seven principles of good education outlined by Chickering and Gamson. Finally, the findings from all the studies in this research are reviewed in a cohesive discussion to answer the research questions and conclude the thesis.

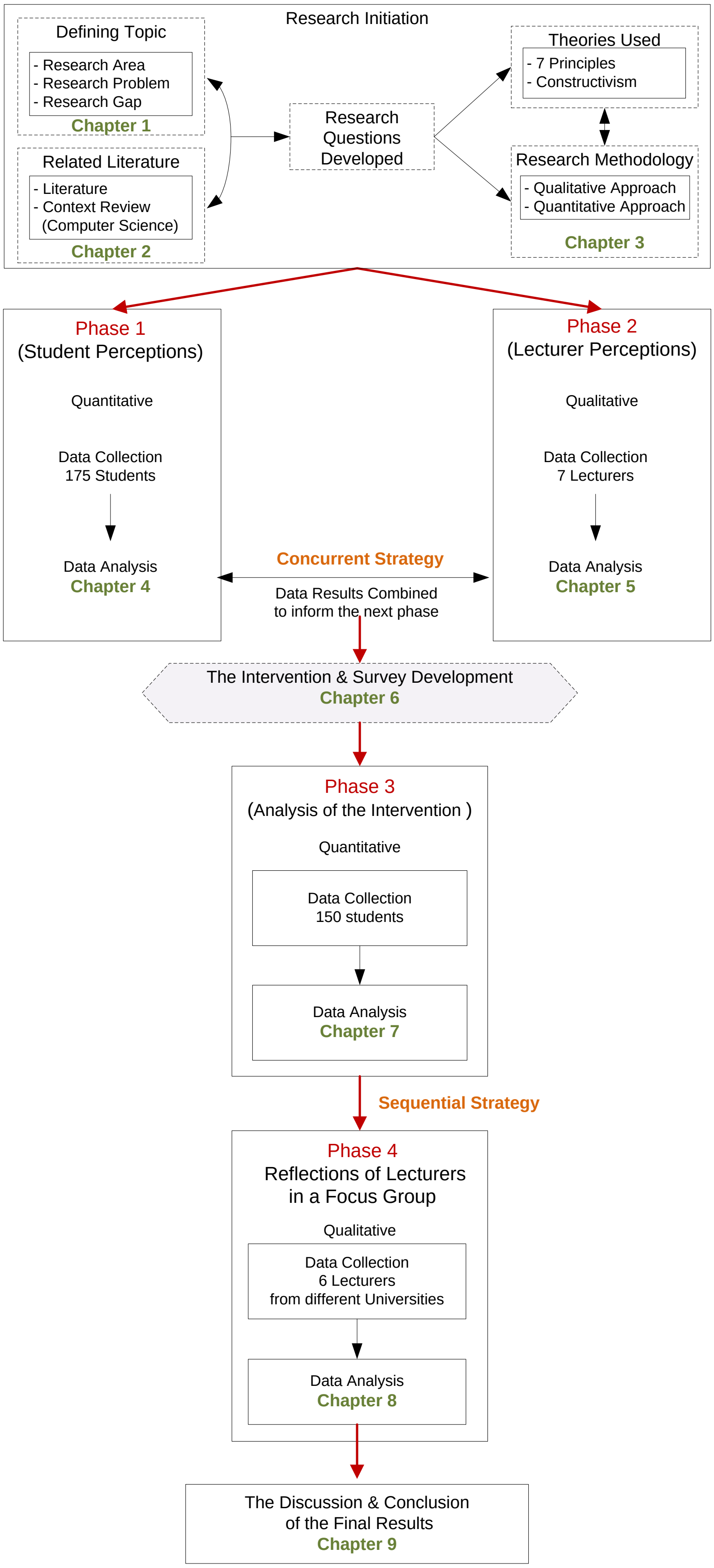


Figure 1.1: Research Process Diagram

1.7 Thesis Structure

The thesis is organised into nine chapters and structured as follows:

Chapter 1 has introduced the topic and described the research problem, research motivation, research gap, research objectives, significance of the research and the research process.

Chapter 2 provides an overview of the relevant literature on pedagogical issues in computer programming courses, including, difficulties in learning and teaching programming, traditional delivery models, constructivism theory, mobile learning, visualisation software and principles of good practice in teaching and learning.

Chapter 3 presents a detailed overview of the research methodology describing the nature of the research, the major drivers of our design approach, the environment in which the research will be conducted, and the various stages of the research process.

Chapter 4 provides an analysis of Phase 1 of the study, on students' perceptions on constructivist mobile-based learning approach. It reports the perceptions of Computer Science students about using laptop computers in conjunction with traditional lectures. Moreover, it investigates the opportunities for students to use their mobile devices in programming lectures, and considers the issues impacting their adoption from students' perceptions.

Chapter 5 provides an analysis of Phase 2 of the study. It investigates Computer Science lecturers' perceptions on constructivist mobile-based teaching approach. It reports the perceptions of lecturers about mobile device use by their students in programming lecture theatres to practice the concepts being taught. It also focuses on lecturers' teaching methods to deepen the understanding of the nature of programming lectures and highlight the problems faced by lecturers in teaching programming courses.

Chapter 6 discusses the development of the intervention and its surveys and its delivery. The findings from Phases 1 and 2 are also considered to refine the plan for an intervention in Phase 3 of the study. It explains the steps taken to prepare the lecture environment for the intervention and the development of the survey using the seven principles of pedagogy developed by Chickering and Gamson (1987) as a framework for evaluation.

Chapter 7 provides an analysis of the findings from Phase 3. It aims to evaluate the effectiveness of a constructivist mobile-based learning approach from the feedback of the students on the intervention lecture. The students' responses in the survey measure the extent to which the constructivist mobile-based learning approach experienced in the intervention lecture are aligned with the seven principles of good pedagogy.

Chapter 8 discusses the results from Phase 4 of this research. In this phase, a focus group interview was conducted with lecturers for the purpose of confirming, expanding and reflecting on the results of previous study phases (Phases 1, 2 and 3). We include participants from different universities and schools in the focus group interviews to amplify the generalisabilty and validity of the results of this research.

Chapter 9 brings together the results and discusses the evidence in direct response to the research questions posed at the beginning of this thesis. Then, it draws conclusions on the research accomplished in this thesis. Finally, the chapter ends with a note on the significance and limitations of the study and suggestions for future research.

Chapter 2 - Literature Review

2.1 Introduction

The digital age has created intense competition for innovation with information technology at the forefront in the knowledge economy (Resnick & Rosenbaum 2013). Along with the massive growth of information technology industry, computer programming has become one of the most sought after courses in tertiary education. However, many researchers have noted that while students may sign up for programming courses in large numbers, programming courses often experience high attrition rates (Denning & McGettrick 2005; Ford & Venema 2010). Educators are required to ensure that learners meet the standards and proficiency of global computer programming professionals (Rodrigo, Baker & Tabanao 2009), which demands focused acquisition of knowledge and competency for new learners of computer programming (Bennedsen & Caspersen 2007).

Educational scholars believe that the traditional delivery of computer programming instruction has not been helpful in addressing the waning graduation rate in programming courses (Lewis 2010). The traditional lecture instruction is less useful in an era where pedagogical goals have to be modified to accommodate the diverse learning needs of the student population (Matheson 2008). Lectures as a teaching method promotes passivity, which dissuades students' interest in the learning process (Matheson 2008; McGarr 2009). Scholars argue that students' engagement and motivation are achieved when the learning environment embraces an active learning process using technology as an aid for instruction (Biggs & Tang 2011).

The concept of using laptops and other mobile devices and gadgets in the educational environment is firmly established, but the concept of utilizing them to expand a student's ability to create their own learning environment is still nascent. The ability to access the Internet using wireless capabilities as well as portability has made mobile devices the favoured choice for a generation that is becoming increasingly mobile. Research shows that the benefits of mobile devices for the 21st century learner are expanding as even more schools incorporate their use into the curriculum to supplement student-learning objectives and increase academic performance (El-Hussein & Cronje 2010; Franklin 2011; Kalinic et al. 2011; Banks 2006; Dietz et al. 2003; Rogers 2004). Unfortunately, little research, if any, regarding the maximization of mobile device use in highly technical academic instructions, particularly for core courses of computer programming, has been conducted (Low 2008; ResnickFlanagan et al. 2009; Resnick & Rosenbaum 2013).

In order for computer programming students to acquire conceptual understanding as well as practical skills, it is important to follow a learning paradigm that includes a hands-on and practical approach (Carter et al. 2010; Eckerdal 2009; Hadjerrouit 1999). However, the traditional lecture format does not fully encourage active learning (Matheson 2008; McGarr 2009). While most students today own and use mobile devices (such as laptops), these devices are not obviously utilised as practical learning aids in lectures (McCabe & Meuter 2011).

This chapter aims to address the context of the research problems presented in Chapter 1 and also distinguish our own contributions to this area of research. In order to address the research problems, related research on the difficulties of the teaching and learning of programming is first reviewed. Then the complexity of the learning and teaching environment and the traditional mode of lecture delivery in higher education are discussed. Then, some strategies and technologies used to overcome the complexities of the traditional delivery of courses with relation to constructivist theory of pedagogy are discussed. This makes way for a discussion arguing for the importance of a mobile-based learning paradigm where lecturers use learning tools to aid their students' learning. There are many learning tools developed to facilitate the learning of programming. We discuss existing tools and the tool used in this research. The main goal is to evaluate the effectiveness of a teaching and learning approach that delivers theoretical and practical components together in an introductory programming lecture environment using students' mobile devices. The discussion also covers the review of the framework used for evaluation under the seven principles of best practices in undergraduate education developed by Chickering and Gamson (1987).

2.2 Challenges to Learning and Teaching Computer Programming

As an in-demand skill in the 21st century global economy, programming has been viewed as a rewarding career for most young adults. Statistical data across countries show the increasing upward trends of programming courses being required as job opportunities in this field continue to rise across different industry and business sectors (Koong, Liu & Liu 2002). However, as demand for programmers is high, so is the demand to acquire knowledge and skills about the programming concepts (Paul 2007; Vegso 2008). This scenario makes programming courses in computer science even more difficult (Robins, Rountree & Rountree 2003; Rodrigo, Baker & Tabanao 2009). The increasing need for innovation and global competition in information technology has made computer programming valuable and programming education even more difficult (Ben-Ari 1998; Bennedsen & Caspersen 2006; Gomes et al. 2006; Gomes & Mendes 2008; Jenkins 2002; Robins, Rountree & Rountree 2003).

The sub-fields of programming studies may be differentiated from two perspectives: (a) software engineering and (b) psychological or educational. The studies that focus on software engineering are usually done in groups with goals in developing effective software projects e.g. (Boehm 1981; Brooks 1995; Humphrey 1999; Mills 1993; Perlis, Sayward & Shaw 1981). The interest of our research is to describe the cognitive development of the learners' programming skills in the light of the psychological or educational perspective. This goal is consistent with the practical teaching experience that stresses the difficulty of teachers and learners respectively to teach and learn programming.

This broad field of programming education can be examined using practical teaching experiences in an introductory programming course, oftentimes called ‘‘CS1’’. In this course, the provision of an effective learning environment and experience lays a good foundation in building the programming competency of learners (McDowell et al. 2003, 2006). Consequently, the following two sections aim to understand the dynamic of learning and teaching programming and determine the processes involved in this. Understanding this basic question may provide us an idea of the factors that make programming difficult for learners.

Programming is a critical skill which a novice learner must learn in order to progress to higher level Computer Science courses (Oman et al. 1989). The skill and knowledge demands of the course have made it difficult for students leading to a high failure and attrition rate (Lewis 2010). Failure to develop this skill results in class retention (Bornat, Dehnadi & Simon 2008) and graduation attrition (Bennedsen & Caspersen 2007). Other researches postulate that more than half of freshmen students enrolled in computer science course are shifting to other computer-related majors (Paul 2007; Seymour & Hewitt 1997; Vegso 2008).

To some extent, the difficulty with learning programming emanates from the inability of the teachers to teach these skills to the learners using only abstract concepts (Rodrigo, Baker & Tabanao 2009). Subsequently, the teaching and learning difficulties of the programming course are exacerbated by the lack of institutional resources to fund research and infrastructure concerning the cognitive development of the learners enrolled in programming courses (Lewis 2010). Further, introductory programming courses are flooded with large classes, which make teaching abstraction and conceptualization even more difficult for teachers.

Since the 1970s, researchers have urged the academic community to explore programming as an area of educational interest (Sackman 1970; Weinberg 1971). There are many significant papers which have explored the methodological stance of teaching programming, including Moore and Kearsley (2005), and Tishkovskaya and Lancaster (2012) among others. There is also a large amount of research that focuses on models of cognition, comprehension, application, generation of knowledge through program, attitude, and the skills required to complete programming courses for beginners (Oman et al. 1989; Robins, Rountree & Rountree 2003; Mead et al. 2006). Our thesis focuses on the learning environment required to enhance the academic performance as well as the competency of learners particularly during their first programming course to particularly help novice programmers advance their programming skills and better understand the concepts being taught in lectures.

There has been a huge growth in academic research papers on Computer Science education in the recent decade (Maloney et al. 2010; Resnick & Rosenbaum 2013; Simon et al. 2006). This is due to the fact that Computer Science educators recognize the gap between the students' conceptual understanding and their practical skills (Lewis 2010) and the need to further understand the methods and techniques that can foster better teaching and learning of programming. The plight of programming education has been documented in various research papers that emphasize issues with the ability, aptitude, and comprehension of novice programmers along with the lack of appropriate assessment and pedagogical techniques (Sheard et al. 2009).

From these issues, scholars explore the phenomenon of teaching and learning programming within the context of the delivery of instruction (Powers, Ecott & Hirshfield 2007; Scheele 2006). Research shows that delivery of instruction using traditional modes of teaching, such as lectures and other face-to-face teaching modes only provide a form of passive instruction (Matheson 2008; McGarr 2009) which is not congruent with the current demands for active learning (Lindquist et al. 2007b; Prince 2004) and formative assessment (Laurillard 2006; Scheele 2006). Researchers suggest various teaching approaches such as literacy first, syntax-free, more student interaction, and more problem-solving to hone the knowledge and competency of students in programming languages (Simon et al. 2006). In the next section, the programming difficulties in the context of the traditional delivery model will be discussed.

2.2.1 Learning Programming

Research papers dealing with the learning and teaching of computer programming have developed and reiterated a classification of learners (Soloway & Spohrer 1989). This literature can offer comparative descriptions for various levels of proficiency existing across novice and expert programmers. The classification of programming learners is relevant to the design of an appropriate programming education curriculum (Lahtinen, Ala-Mutka & Jarvinen 2005). Other researchers noted several difficulties encountered by students of programming courses (Milne & Rowe 2002; Pane & Myers 1996), particularly novice programmers.

Novice programmers are those who have acquired a small amount of knowledge of computer programs and typically approach programming line by line rather than dealing with program structures. Their knowledge is context-specific and limited compared to the multiple applications possible with advanced computer programming knowledge (Robins, Rountree & Rountree 2003). At this beginning stage, programmers are provided with rules and directions to enable them to perform. These rules are independent and context-free in some cases, so they are apt for universal application. However, the rule-governed behaviour that characterises some novices can be extremely inflexible and limited. Novice programmers are often only able to do just what they are asked to do without questioning or adding their own ideas (Weiyu 2004), or are unable to adapt their knowledge to a different context. A novice programmer possesses just the basic knowledge of programming with much theoretical information yet little practical experience. Practice increases a novice programmer's effectiveness, correctness, and efficiency (Andre & Russell 2002).

The introductory programming courses are intended to build knowledge and capability required to progress on to the next stage. A student is not expected to become proficient or expert during the introductory courses but is expected to obtain a level of competency (Mead et al. 2006).

Research from the literature states that novice programmers should not be allowed to explore advanced programming knowledge without first reaching mastery in the introductory courses. Studies show that unlike expert programmers who require less time to design, test programs and fix small bugs, novice programmers spend much more time formulating and reformulating programs (Eckerdal 2009; Robins, Rountree & Rountree 2003). Further, they have less understanding of the chronological characteristics of program execution. Their knowledge is context-specific and is dependent on general patterns of pre-existing programming models (Kurland et al. 1986).

Researchers remain pessimistic that the inabilities of the novice programmers primarily stem from deficiencies in planning and design of curriculum (Banks 2006; Low 2008). This would be an interesting subject to discuss further considering that many studies from the programming education perspective noted the importance of exploring the delivery of curriculum content to the learners (Lister 2008; Lister, Fidge & Teague 2009; Grover, Pea & Cooper 2014). Some scholars, who consider the programming course as a practical learning subject, emphasise the importance of exposure and continuous practice in the development of programming proficiency (Maloney et al. 2010; Mohamed Shuhidan 2012).

2.2.2 Teaching Programming

The course requires instructors' sensitivity to students' engagement to learning (Krause & Coates 2008 ; Zepke & Leach 2010) . This means that motivating them to learn would require instructors to provide an environment that promotes interaction between and among the learners and the programming instructor. A discussion of teaching approaches will be presented in the subsequent section. The interconnection of sub-systems in programming has created issues in teaching (Robins, Rountree & Rountree 2003). In a field where interconnection is relevant, retention of knowledge can be a factor that hinders the success of learning the abstraction of the whole system. For instance, students' engagement with a concept at one time may not necessarily be remembered in a later period where demonstration of learning of this concept is required (Mohamed Shuhidan 2012; Parsons & Haden 2006; ResnickFlanagan, et al. 2009).

As retention is critical to the application of knowledge learned, students must be exposed to programming projects for them to be oriented in active programming skills required for any learning situation (Berglund & Lister 2010; Thadani et al. 2013). Furthermore, because the goal of the teacher to help the students create a functional program that motivates students in programming work, learning materials may need to include problem-solving (ResnickMaloney, et al. 2009; Rusk et al. 2008).

This scenario illustrates that while learning programming is hardly achievable for students, teachers are even confronted with difficulties in teaching programming courses (Berglund & Lister 2010). Introductory programming courses are expected to teach learners to do programming using formal face-to-face instruction (Robins, Rountree & Rountree 2003). However, many researches contend that though learners receive introductory courses on programming, this does not necessarily mean that they fully understand basic programming concepts (Ford & Venema 2010; Ma et al. 2007; McCracken et al. 2001; Rogerson & Scott 2010; Zhang 2010). Programming courses encompass competencies on structuring a useable program that is capable of providing information for users (Guzdial, M 2009). Thus, the ability to read and write programs cannot be directly associated with programming language competency (Guzdial, Mark & Robertson 2010).

Teaching programming needs a combined approach of lecture and practical application (Robins, Rountree & Rountree 2003). Practical learning situations supplement the theoretical discussions of teachers for students to better understand the concepts as situations are better designed for more learning to take place (Lahtinen, Ala-Mutka & Jarvinen 2005). This approach is known as *learning by doing* (Thadani et al. 2013; Wang et al. 2011; Yazici 2004) which is required to learn programming.

Lister (2008, 2011) argues for the importance of the teacher as a factor in the learning success of students in programming classes. The author recognises the gained knowledge and competency of an instructor who serves as an expert teaching his or her novice learners. However, his or her expertise may only be limited in the field of programming and the instructor may struggle to incorporate the pedagogical concepts in his or her teaching practice. Lister (2011) also provides an example illustrating that there is a possibility that a programming instructor may assume that their delivery of instruction reaches the novice programmers' full understanding. Instructors with no formal training on the pedagogy may fail to view the diversity of human's learning capabilities and needs, which require diverse teaching modalities appropriate for the learners (Lister 2008; Lister, Fidge & Teague 2009).

2.2.3 Traditional Delivery Model

The accepted pedagogical method of knowledge transfer has been centred on the traditional lecture-type structure (Dolnicar et al. 2009; McGarr 2009). This traditional learning occurs in a classroom where students passively listen to the lecturer and interact with co-learners and instructors. The need for more classroom-based assessment puts an emphasis on tutorials and laboratories in cohesion with lectures in programming education. These traditional methods have been used extensively in the delivery of instruction. The lectures provide the learners with basic understanding and conceptualization, the tutorials involve further discussion on the topic, and laboratories serve as the venue for practical applications of the lessons learned either from the lecture and/or the tutorials.

A review of literature concerning courses in higher education shows that among traditional methods of delivery of instruction, the lecture is more pervasive in use compared to other forms of instruction. Lecture is a type of pedagogical method where process of knowledge transfer engages the learners in a passive listening activity (Matheson 2008; McGarr 2009). In the traditional lecture format, learners are passive listeners. The information delivered in a lecture-type format is then validated through practical examination where learners apply the knowledge learned from the lectures. The majority of higher education institutions continue to use a combination of lectures and laboratory classes for courses that aim to build skill-based knowledge (e.g., Computer Science, Computer Engineering). This is because laboratory classes supplement the limitations of lectures and enable a practice-based learning process.

The use of laboratory classes is supported by the arguments of educators who opine that the lecture format only provides a superficial form of learning (Biggs & Tang 2011; Gibbs 1982; Laurillard, D 2006; Low 2008), where learners are obligated to memorise the facts rather than internalise the information. The lecture format may force the learners to spend time in note taking rather than engaging him or herself in a deep thinking exercise in the light of the information provided by the lecturer. There is pedagogical dissonance concerning the use and importance of lecture and laboratory classes in the student learning process. Researchers and advocates of constructive learning argue that the active engagement of the learner in practical learning tasks in laboratory classes is a more influential and effective form of knowledge transfer (Laurillard 2006; Low 2008). But it must be conceded that a traditional lecture model, however, is appropriate for transferring a structured and standard knowledge that is commonly required in standardised examinations (Dolnicar et al. 2009; McGarr 2009).

There are limitations of lecture-type instruction that have been noted in several studies that oppose the use of this model, including: (a) difficulties in sustaining attention and concentration of learners, (b) challenges in students' motivation, (c) knowledge assimilation, and (d) adaptability of instruction. We will discuss each of these factors below.

Learners' attention and concentration. The first factor states that students' attention level decreases after 10 to 30 minutes from the start of the lecture (Frederick 1986; Horgan 2003), and students' performance within 20 to 30 minutes (Warm, Dember & Hancock 1996). Studies further show that the activities should be changed every 10 to 15 minutes (Horgan 2003; Wankat &

Oreovica 2003). Other research finds that there is a relationship between distraction and length of the lecture (Risko et al. 2012). They report two experiments wherein participants watched a video recorded lecture either alone or in a classroom context. Participants responded to mind wandering probes at various times in the lecture in an effort to track variations in mind wandering over time. They demonstrate that students' mind tend to wander as the lecturer stays on the same topic to provide further explanations but rises back as the lecturer ends the class.

Motivation. The second factor relates to the lack of motivational element within lectures that can disengage students to participate in his or her learning (Scheele 2006). He argues that students are more likely to participate in a lecture that initiates extrinsic motivation, such as graded class participation and end-of-class quiz. These activities not only serve as an assessment of the knowledge learned in the lecture, they enforce students' persistence to listen to the lecturer in preparation for the classroom assessment. The students' fear of failing is the extrinsic motivation variable of students to persist in class lecture (Scheele 2006).

Another study argues that the competency of the lecturer in the delivery of instruction as well as their inability to engage students in his or her class lecture (Bligh, 1998) also affects motivation. Watt & Richardson (2012) state that teachers' motivations affect their behaviours which in turn affect students' motivation. Consequently, students' motivations influence their participation and learning achievement. Gibbs (2005) found that students can be independent learners when the lecturer implements appropriate extrinsic and intrinsic motivation strategies. The students can either refuse to fail (extrinsic) while enjoying their attendance in the class lecture (intrinsic).

*Knowledge Assimilation***.** Learners' retention of information is a challenge for teachers who use the lecture-type format of instruction. Studies show that the rate of drop in attention is reduced when presentation is varied (Young, Robinson & Alberts 2009). Good attention and retention can only be expected during the first 15 minutes of a lecture. Educators who believe in this empirical finding implement a break every 15 minutes during the lecture in order to sustain attention and retention throughout his or her hours of lecture (Horgan 2003). This 15-minute break can be spent on activities such as group discussion and rehearsal which can engage students' interest as the class resumes again.

Adaptivity of instruction. There is a paucity of formative assessment activities in traditional lectures that can gauge the extent of knowledge the students learned in the class including the issues concerning students' learning styles (Scheele 2006). Learning issues persist when the mode of instruction does not support conversation between the instructor and the students (Laurillard 2006).

As a response to the limitations of traditional lectures in the delivery of instruction, scholars advise the adoption of interactive lectures that can engage and motivate students (Laurillard 2006; Low 2008). The integration of interactive elements in the traditional lecture format sustains the attention of students, allows them to identify a more convenient style of learning, and provides opportunity for student and lecturer to identify and resolve issues of learning (Biggs & Tang 2011; Bligh 1998; Gibbs 2005; Laurillard 2006). These basic tenets concerning the interaction between the lecturer and learners imply the importance of a conversational mode of learning.

This argument forms the basis of Laurillard's conversational framework (Laurillard 2006). The conversational framework is a theoretical construct that postulates the importance of conversation as an activity to engage learners in an active learning process such that learners can construct their own knowledge with the assistance of the lecturer. Laurillard (2006) states that learners should be given the opportunity to articulate their understanding and to construct the knowledge based on how the learner sees and understands the concept. Section 2.3 provides a more detailed discussion concerning constructivist learning.

2.3 Constructive Alignment

Constructive alignment is a pedagogical approach appropriate for implementation in higher education institutions (Biggs & Tang 2007). The pedagogical method and learning assessment in constructivist learning are designed to ensure that all elements of learning are appropriately supported by the system (Biggs & Tang 2011). It incorporates continuous evaluation of learning outcomes to assess the level of students' knowledge acquisition.

Constructive alignment consists of two dimensions: (a) teachers' strategies to promote student learning, and (b) students' learning strategies to promote their own learning (Jackson 2002). The constructivist learning and teaching paradigm is based on the teachers' ability to plan and execute activities that allow students to learn the desired lesson. However, both of the terms can either be used by the students or teachers depending on how and where the process of construction emanates (Cope & Staehr 2005; Thadani et al. 2013).

As the term suggests, constructive alignment and techniques associated with good teaching aim to allow for deep learning (Biggs & Tang 2011). Jackson (2002) posits that constructivist learning can improve the current educational system by facilitating a more engaged and proactive style of learning in higher education institutions. The concept suggests that learning comes from the ability of the learners to grasp the concept behind the application. This is crucial in developing the ability of learners to recite, reflect and apply information. In summary, the learning of students emanates from their interest to learn the more difficult concepts based on what they have experienced and learned (Treleaven & Voola 2008; Yazici 2004).

While the abstract nature of lessons in programming concepts can make learning difficult for students, especially those still at an introductory level, learning that uses a practical approach offers more in-depth understanding to students (Carter et al. 2010; Eckerdal 2009; Hadjerrouit 1999). It is apparent that there is a need for a teaching method that guides the students in the analysis and design of activities that have not been previously discussed and solved (Borrego & Cutler

2010). For these reasons, researchers particularly in the fields of science and mathematics education promulgate the use of constructivism as a basic concept behind constructive alignment to engage students in an active learning environment where the construction of object-oriented knowledge considers both the knowledge of the instructor as well as the prior experiences and knowledge of the learner (Borrego & Cutler 2010). We therefore consider the use of constructivism in teaching and learning programming for novice learners.

2.3.1 Constructivist Learning in Programming

Within educational contexts there are several philosophical meanings of constructivism (Matthews 1998, 2002), as well as personal constructivism (Von Glasersfeld 1995; Piaget, Brown & Thampy 1985; Piaget & Busino 1976), social constructivism (Vygotsky 1978), and radical constructivism (Von Glasersfeld 1995). While products of constructivist doctrines seek to understand the multidimensional aspect of human learning, our study uses the original theory of constructivism postulated by Piaget based on an assumption that learning occurs upon the students' application of the knowledge.

Piaget's theory of constructivist learning has had a wide-ranging impact on learning theories and teaching methods in education and is an underlying theme of many education reform movements. Piaget's theory of development based on a philosophy of constructivism views cognitive development as a process in which learners actively build systems of meaning and understanding of reality through their experiences and interactions (Piaget 2008). In this view, the learner actively constructs knowledge by continually assimilating and accommodating new information. Based on this proposition, knowledge acquisition is not simply a process of "discovering" innate ideas, nor is it a process of storing facts that are encoded from the environment. Knowledge literally creates knowledge as one's biological predisposition interacts with personal experience (Piaget 1970).

The constructivist view of knowledge changed education research by bringing a shift in emphasis from knowledge as a product to knowing as a process

(Jonassen 1991). This property of constructivism is capable of causing a lasting and meaningful change in the structure of formal education. Application of constructivism to instructional design has certain advantages, including the acquisition of deeper levels of understanding (Heafner & Friedman 2008), providing more meaningful learning outcomes through more meaningful learning contexts, more independent problem-solving capabilities, more flexibility in both design and instruction activities, and supporting the learners with an ability to apply their learning in non- academic contexts (Karagiorgi & Symeou 2005; Russell & Schneiderheinze 2005). Despite the merits cited for constructivist learning, the translation of constructivism into practice constitutes an important challenge for instructional designers as there is no specific constructivist instructional model that is able to fit all fields of education (Karagiorgi & Symeou 2005). Therefore, it is necessary for specialist educators in each individual field of education to develop specific models of their own based on general guidelines of constructivist educational theory (Andjomshoaa, Islami & Mokhtabad-Amrei 2011). In the field of computer education, a technology-related learning environment serves as an alternative constructivist approach in providing learner-centred delivery of abstract concepts with the use of simulated reality and visual presentation (Cope & Staehr 2005; Karagiorgi & Symeou 2005; Thadani et al. 2013; Wang et al. 2011)

2.3.2 Constructivist Learning and Use of Technology

Previous research demonstrates that the inability of the lecturer to sustain students' attention is a major issue confronting educators (Cronjé 2006; Hirumi 2002; Vrasidas 2000). Educators need to re-think and redesign lectures by using constructivist approaches that can sustain students' attention as well as encourage students to be active players in their own learning process. Maltby, Gage and Berliner (1995), for instance, introduce ten methods to eliminate students' boredom and encourage them to participate in the lecture. These methods include varying stimuli, changing communication channels, introducing physical activity, using humor, showing enthusiasm, asking questions, encouraging student self-questioning, promoting intimacy, supporting note taking, and using handouts. These methods can help the lecturer to establish a sense of connection and interaction with his or her students.

In this regard, the use of technology has made the goal of establishing students' connection and interaction easier than before. The system of lecture feedback for instance is easily managed when lecturers allow their students to interact with them through their gadgets (Poirier & Feldman 2007). This way, lecturers can assist the learners navigate and cope with the abstraction and difficulty associated with grasping programming concepts (as discussed in Section 2.4.1). Lectures with the aid of technology, help the instructors eliminate barriers to active learning such as large class population or spacious lecture theatres. The benefits of using interactive lecture technologies are that they can: (a) encourage active student involvement and engagement in classes, (b) enable a lecturer to give immediate feedback to students, (c) give lecturers the ability to monitor student progress, and (d) enables teaching to adapt to student needs (Eison 2010; Keyser 2000).

Several lecture technologies are used in most higher education institutions nowadays. Low (2008) has reviewed some lecture technologies that have been tested in programming courses. These technologies include: (a) *Personal Response System* (*PRS*), (b) *ConcertStudeo*, (c) *MessageGrid*, and (d) *Ubiquitous Presenter*. *PRS* is an interactive lecture technology that is commonly used in American universities (Duncan 2006). *PRS* allows interaction in the lecture, which reduces associated problem of passivity among students associated with traditional lectures. Research shows that the advantages of *PRS* only occur if the pedagogy integrating the PRS is effective and appropriate. They are providing: (a) the students the opportunity to personally assess their performance in knowledge acquisition of a particular content of the lecture, and (b) the opportunity for teacher to receive an immediate assessment concerning their learning outcome (Duncan 2006). However, scholars argued that the PRS system is not flexible in the provision of question and answer interactions particularly the limitations of answers to submitted questions (Scheele 2006) and multiple-choice questions (Biggs & Tang 2007). This means that assessment questions should be prepared specifically for the expected acquired knowledge of the course considering the targeted technology.

ConcertStudeo is also a lecture technology with functions similar to PRS, but the system has been enhanced to provide a more functional use. *ConcertStudeo* was developed in Germany by the Fraunhofer Institute for Integrated Publications and Information Systems (IPSI) (Dietz et al. 2003). *ConcertStudeo* functions for smaller classrooms with electronic blackboards, which can support PowerPoint presentations. The system was designed to reduce inefficiencies in the expository lecture.

MessageGrid (Pargas, Levin & Austin 2005), developed by Pargas of Clemson University, functions as a system that (a) solicits questions, (b) engages students in classroom activity that can supports the learning goal of the day, (c) assesses student comprehension, (d) provides exercises that stimulates interest for peer learning, and (e) integrates animations in the lecture materials (Pargas 2005).

The most recent lecture technology had been the *Ubiquitous Presenter (UP)* originally designed as an extension project of the University of Washington's Classroom Presenter (UWCP) (Dufresne et al. 1996). This technology has been designed to provide students with access to the lectures and other learning materials from the lecturer. The system is supported by technologies such as tablet PCs and laptop, where learning content can only be accessed in similar network, server, and web browser (Lindquist et al. 2007a). Students also have the opportunity to submit answers to open-ended questions by electronic ink drawings and keyboard to participate in the lecture interaction (Denning et al. 2006).

As this review shows, lecture technologies have been developed to address inefficiencies in programming lectures, but there are still issues and problems that require further studies (Low 2008). From the perspective of this study, one such gap is the inability of the technology to provide a learning environment that allows students to view and test the appropriateness of their programming code. In a computer programming course, a technology that enables students to simultaneously apply the knowledge presented to them by their lecturer in active tasks would be an effective step towards attaining desired learning outcomes (Carter et al. 2010; Eckerdal 2009; Hadjerrouit 1999). With this type of technology, students are able to reflect, generate answers, and apply deep knowledge (Biggs & Tang 2011). This approach empowers the students to apply the knowledge by revising programming codes that may not be appropriate in a given programming system. By encouraging the students to participate and actively respond to their knowledge acquisition, programming tasks would be made easier, interesting, and motivating (Jenkins, J et al. 2012a; Pears & Rogalli 2011).

Despite the technologies used to enhance the passiveness of lectures, there are some approaches also used in higher education. The exploration of effective teaching techniques brought the integration of computers in the students' learning process. The use of computers in the construction of knowledge aided the development of students' self-direction and independence. As such, when the Internet has been made available for public use, educators offered courses that either depend on online instruction such as "online learning" (Anderson 2008; Collison et al. 2000; Flowers 2001), "electronic learning" (Pankratius & Vossen 2003; Ronteltap & Eurelings 2002) and "MOOC: Massive Open Online Courses" (Mackness, Mak & Williams 2010; Skiba 2012) or combine face-to-face lecture with online learning activities. Among the popular terms used to refer to courses that integrate the traditional lecture with online modalities are "hybrid learning", "blended learning", "studio-based learning", "flipped classroom" and "mobile learning". The following paragraphs will describe each of those terms.

Hybrid learning is an approach used by educators to replace some learning modules of the traditional face-to-face classroom work with online learning activities (Brown 2001; McCray 2000). A hybrid course integrates, reinforces, elaborates, and complements traditional face-to-face classroom sessions, instead of duplicating or adding components of what is taught in the classroom (McFarlin 2008; Olapiriyakul & Scher 2006).

Blended learning is a formal education approach that combines a traditional face-to-face learning environment with technologically arbitrated learning (Jeff & Gary 2003; Reay 2001; Rooney 2003). This method is based on a new theoretical and philosophical approach to instruction where there is convergence of the traditional classroom to incorporate strengths of the traditional face to face and the contemporary online learning in a more synergistic way to create a more congruent approach that addresses the needs and demands of contemporary students (Aspden & Helm 2004; Garrison & Kanuka 2004).

Studio-based learning is another form of blended learning that focuses on the development of problem-solving skills. Studio-based learning originated in the field of architectural engineering, which integrates collaborative learning to help students in the development of computing and designing skills (Docherty et al. 2001; Hundhausen, Narayanan & Crosby 2008). Today, studio-based learning uses graphical presentation of the step-by-step process in accomplishing certain tasks (Carbone & Sheard 2002; Hendrix et al. 2010).

Flipped classroom or flip teaching instruction is the newest form of blended learning which integrates learning content via the video lectures that are viewable at home (Tucker 2012). Flip teaching attempts to solve issues of homework or assignments assigned to accomplish at home (Bergmann & Sams 2010). With this approach, the teacher can now supervise the students' independent work and provides guidance instead of lecturing (Berrett 2012).

The interest of our study is to bridge the empirical gap in understanding the effectiveness of adding the use of technology to the lecture environment so that it can enhance traditional face-to-face model of teaching and learning. We aim to propose a form of active and practical learning using technology that can help programming students acquire the required knowledge and skills to graduate with both conceptual understanding and practical experience. Our study proposes to move beyond the use of blended or hybrid learning with the use of the new emerging paradigm of mobile learning. Research shows that mobile learning technologies have been the standard tool in several universities for engaging and motivating students in learning (Franklin 2011; Frohberg, Göth & Schwabe 2009; Kalinic et al. 2011). The subsequent section describes the concept and relevant development of knowledge concerning mobile learning.

2.4 Mobile Learning

Today's society has fully integrated technology into almost every aspect of daily life. Thousands log on to the Internet to perform a variety of tasks such as checking e-mail, banking, job hunting, or just generally surfing the net. Technology has become such an integral part of our society that it is often hard to imagine a day without the Internet or the computer (Atzori, Iera & Morabito 2010). Cooper (2006) states that 25% of the new jobs by 2010 will be technology-based. As Cooper asserts, computer ownership is also leading to vast improvement in academic test scores as many families are starting to invest in computer connections and wireless networks at homes. Access to the Internet has become just as important as the consumption of food, and is therefore leading to an ever-widening gap in the digital divide between students from the developed and developing countries.

Mobile learning is a new emerging paradigm of knowledge acquisition. Scholars define the 21^{st} century as a *mobigital virtual space* where people can learn and teach at anytime and anywhere. The use of mobile devices in the process of teaching and learning has been a significant variable in the success of mobile learning (El-Hussein & Cronje 2010; Franklin 2011; Kalinic et al. 2011). The following sub-sections explore the different aspects of mobile learning, from its definition to its advantages and disadvantages.

2.4.1 Use of Mobile Learning in Higher Education

In education, mobile learning is the knowledge and the process of acquiring knowledge through wireless mobile technologies such as "mobile phones, personal digital assistants (PDAs), or laptop computers" (O'Malley et al. 2005b).

Other scholars define mobile learning as “e-learning through mobile computational devices: Palms, Windows CE machines, even your digital cell phone” (Quinn 2000). Wood (2003) defines the term as the usage of information technology devices in teaching and learning. Based on these definitions, it can be suggested that the explicit use of technology for learning differentiates mobile learning from other forms of learning. However, these definitions are vague, which misleads educators in categorizing formal and informal learning. Nevertheless, the involvement of mobile technologies, regardless of whether the intention is to gain formal or informal learning, can be considered as mobile learning. Some other works classify the relationship of learning to learners, and define it as any kind of learning that takes place in an unusual environment with wireless or mobile technologies (O'Malley et al. 2005b). Many research initiatives have explored the use of mobile learning technologies in the classroom to overcome the limitations of passive learning approaches in traditional lectures. Although almost all mobile technologies can provide either informal or formal learning, scholars state learning technologies as those gadgets with the capability to provide and process scholarly knowledge. These include personal digital assistance devices (PDAs), netbooks, laptops, tablets, iPads, e-readers such as the Kindle or Nook (El-Hussein & Cronje 2010; Franklin 2011; Kalinic et al. 2011).

The revolutionary shift from traditional approaches to learning to mobile learning has also been brought about by students who encourage faculty to change and consider the adaption of mobile learning (Lai 2011). As such, integration of technology within the classroom may need the participation of program leaders particularly in the development of strategies for implementation on top of the required discipline of the usage of technology (Percival & Percival 2009). These strategies may need to consider effective technology integration variables such as technical support, instructors’ proficiency of computer, beliefs, behaviour, and attitudes among others to ensure that there is significant positive direct effect on technology integration within the classroom (Pierson 2001). Teachers’ awareness, knowledge of the technology, personal biases, management of new knowledge, consequences of adoption, collaboration among teachers, and re-focusing of new teaching methods are factors affecting the successful integration as well as the effective use of these technologies between and among the students and teachers (Roblyer, Edwards & Havriluk 2006).

There are several issues to consider in technology integration in higher education given the complex nature of implementing technology integration (Roblyer, Edwards & Havriluk 2006). The integration process may require focused activities on content, pedagogy and technology (Koehler, Mishra & Yahya 2007). These focus areas should be valued as “transactional and co-dependent construction” in order that planners can predict nuance variables that may affect the integration of technology (Koehler, Mishra & Yahya 2007). In addition, instructional planning initiative using technological pedagogical content knowledge (TPACK) structure guides the educational leaders in appropriately identifying the system of technology integration within the context of the learning pedagogy (Harris & Hofer 2011). As such, all possible contextual factors including governmental, administrative, and financial requirements need to be considered when planning for technology integration.

The benefits of these technologies to learning such as learning motivation, engagement, interaction, and increased levels of performance have not been really delivered to students in the classrooms even though technologies form a part of their daily lives of the 21st century students (Avenog˘lu 2005). Laptops, tablets, and similar devices such as PDA, can be more feasible as mobile learning technologies, while other devices such as smartphones are simply perceived as communication tools (Croop 2008). Several studies confirm these findings and suggest that the lack of empirical research on the classification of devices for mobile learning and the lack of pedagogical and theoretical definitions of mobile learning that can help educators overcome any difficulty in implementing mobile learning and mobile learning technologies. The benefits and limitations of the mobile learning, readiness of students and instructors, and factors that affects the adoption and implementation of mobile learning have not been fully explored in the current literature (Franklin 2011; Wang & Shen 2012). Recognising this gap would require understanding the most popular mobile device that supports the use of mobile learning in lectures since the early 21th century. On the top of the list is the use of laptop which ranks as the most popular mobile gadget for pedagogical purposes (Statistica 2013) which will be discussed in the next section. As advances in mobile technology have brought a plethora of mobile devices into the market, this section will particularly highlight why laptops have been chosen as the pedagogical tool in lectures.

2.4.2 Use of Laptops in Lectures

Cellular phones and other high tech gadgets such as PDAs, netbooks, laptops, tablets, iPads, and e-readers had made learning even more accessible with lesser guidance from an instructor (Kalinic et al. 2011). Studies have shown the wide popularity of the use of this technology among the youth sector has played a role in promoting the use of laptops in the classroom by students as well as teachers (Cheon et al. 2012; Park, Nam & Cha 2012). As discussed previously, the opportunities and preferred learning styles of students urge educators to align the curriculum appropriate for the 21st century type of students (Jeng et al. 2010). In the other hand, with budgets tight, many institutions are hoping to bring technology into the classroom without having to shell out for a device for each student. A solution for many has been to make classes BYOD (an acronym of 'Bring Your Own Device'), which allows students to bring laptops, tablets, and smartphones from home and to use them in the classroom and share them with other students (Scarfò 2012; Bell 2013). In this review, we focus on the use of laptops as gadgets to support mobile learning.

Researchers in the era of laptop use in classrooms have failed to establish whether laptop use in a learning situation is advantageous or detrimental to the teaching and learning process (Annan-Coultas 2012; Liu 2007; Wurst, Smarkola & Gaffney 2008). On the one hand, it is argued that the use of laptops during lectures improves students' grasp and comprehension of the subject by providing flexible interaction (Nilson & Weaver 2005). But other scholars find that the use of laptops adds complexity to the learning process and those students who use the devices gain less from their instructors (Hembrooke & Gay 2003; Ni & Branch 2004). Also, there is a lack of research investigating the introduction of the use of laptops in areas of higher education that currently do not support mobile learning (Kay & Lauricella 2011).

Universities require clarity in the use of technology in a learning situation, as the usage levels of laptops by students for recording notes and accessing materials during a lecture is rapidly becoming the norm: "the laptop should be noticed only when it is absent" (Campbell & Pargas 2003). However, Fried (2008) advises that the faculty should set some limitations or control on the use of laptops by students when the technology is distracting and the students do not engage with the learning experience. This advice is supported by Demb, Erickson and Hawkins-Wilding (2004) who studied students' perceptions regarding the use of laptops at Ohio's Dominican University. They surveyed students in the first year of their laptop initiative, and examined six factors, including academic success, study habits and faculty utilisation. The authors found a positive result, reporting that "*by helping faculty better integrate the technology, and by responding to student requests for more choice, the value of the computer to student academic experience is likely to be enhanced even further*" (ibid, p. 400). This shows that technology can offer unprecedented opportunities to explore new learning paradigms when the technology is blended successfully into the lecture (Barak, Lipson & Lerman 2006).

Despite the fact that many technological devices essentially operate as a computer, there has been no unified system that accounts for the usage of every computer gadget (Tapscott 2010). However, studies on ownership of these gadgets ranks the laptop as the primary gadget used for learning and instruction (Demb, Erickson & Hawkins-Wilding 2004). Several studies have explored the factors confronting the use of laptops in higher education institutions (Campbell & Pargas 2003; Tapscott 2008). On top of the factors urging the use of laptop is computer mobility (Simonaitiene & Kutkaityte 2013), which provides the learner access to a wide range of information any time any place. In a similar way, teachers use laptops to modify methods of teaching. All this has created a need for scholars to explore the benefit and negative consequences that laptop use can contribute to student learning (Pargas & Weaver 2005).

Several studies justify the use of laptops in academic lectures by exploring the factors of the usage. The first factor relates to the usefulness of the technology in improving the performance of a target work (Kay & Lauricella 2011; Lindroth & Bergquist 2010). Modern day students are digital natives who conduct many of their everyday communication tasks on computers. An Australian study in 2009 shows that the laptop is a necessity in the daily life of Australian students (Dyson, Litchfield & Lawrence 2009). The study suggests that educators in the country have to align the curriculum to provide students the opportunity to use their laptops at school. Simonaitiene & Kutkaityte (2013) investigated the factors that influence the use of laptops in university studies and found a range of benefits, including: usefulness, ease of use, social influence, facilitating conditions, mobility, informal learning, and obstacles. Barak et al. (2006) studied the effects of wireless networks in a studio class using laptops to enhance "*student-centred, hands-on, and exploratory learning, as well as meaningful student-to-student and student-to-instructor interactions*" (ibid.p.245). The authors found that students were highly positive toward the use of laptops during lectures. The researchers agreed with Campbell and Pargas (2003) on the advantages of requiring laptops in certain courses. Theses included instant feedback for questions and answers, animation and visualisation applications to assist students better understand learning materials, collaborative learning exercises for students to facilitate their ideas, and the use of online materials for problem solving. Another study designed in a civil engineering course supported the proposition that sharing wireless laptop computers between students improved group collaboration, specifically in discussion (Nicol & MacLeod 2005). From a teachers' point of view, Weaver and Nilson (20005) concluded that laptops can be a leading tool for instructors to engage their students and gain more responses than traditional learning materials.

On the other hand, highlighting the many disadvantages of laptop use in classrooms, researchers agree that laptops can distract students during lectures, particularly when they access non-academic material and their attention wanders from the topic at hand (Fried 2008; Hembrooke & Gay 2003; Wurst, Smarkola &

Gaffney 2008). For example, Barak et al. (2006) found that apart from the positive aspects of laptop use during lectures, some 15 per cent of students were distracted. Bugeja (2007) argues that when the lecturer requires students' attention, laptops and other devices should be turned off. Wurst et al. (Wurst, Smarkola & Gaffney 2008) studied the use of university-supplied laptops across cohorts of business degree students. Comparing their results with a control group, the researchers did not detect a significant difference in academic achievement for those with a laptop and those without. Further, a study by Brubaker (2006) examined faculty perceptions about using wireless laptops in higher education learning situations. They found that three-quarters (77%) of the instructors in the faculty agreed that laptops distract students in class. Interestingly, a few (5%) banned laptops in their lecture theatres and over one-third (38%) supported a university policy that faculty could order the laptops to be turned off during classes. He concluded that it is important to consider the pedagogical purposes when choosing technology and then it can assist in improving the learning environment.

Although there is considerable researches on the use of laptops in classrooms, a only a few studies have considered the use of mobile devices in the context of computer programming education (Sheard et al. 2009). For example, Barak, Harward, Kocur, and Lerman (2007) investigate the effectiveness of an innovate project that integrate lectures with in-class demonstration on different instructional strategies comparing traditional teaching with models of studio format. They find that in both its extensive and partial active learning modes, students' learning was enhanced. Pears & Rogalli (2011) included live development of code in an interactive lecture setting in their programming learning pedagogy to make many aspects of program development and debugging explicit for students. They use mJeliot to enhance interactivity and student engagement by using the system mobile users to make prediction about execution behavior of code executing. mJeliot allowed the teacher to engage students in predicting parameter binding in methods calls and return values. Bruhn & Burton (2003) created studio teaching to help students better understand Java programming concepts during classroom presentations. In the studio based teaching students are required to have either a laptop or desktop computer to work with in the classroom. They found that the studio teaching method helps the average to poor students achieve the most while high achieving students seem to do just as well with the typical lecture. They also report concerns about the extensive to equip the labs with computers and the time needed in the classroom for active learning.

2.4.3 Advantages and Disadvantages of Mobile Learning

Recent research concerning mobile learning shows that students' achieve positive learning outcomes when appropriate mobile learning technologies are incorporated in the classroom lectures (Avenog˘lu 2005; Motiwalla 2007; Yılmaz 2011). For instance, adopting tablet technology in postsecondary education has been found to help students in taking notes during lectures and doing desk research during class (Mang & Wardley 2012). Similarly, the use of laptops aids students to follow-through the discussion of the lecturers (Cismaru & Cismaru 2011). When used in classroom activities, laptops are also beneficial to students in terms of improving skills on note taking, organization of thoughts, and collaboration (Kay & Lauricella 2011).

Researchers believe that mobility of the technology and learner-generated learning are the critical elements of mobile learning (Sharples, Taylor & Vavoula 2005). Other than its capability to perform several functions, mobile technologies can provide information storage and channel device that is able to assist learners in the processing of raw information (Kalinic et al. 2011).

The convenience of mobile devices in accessing information has become the most effective avenue for educators to achieve collaborative learning in classroom activities (Huang, Jeng & Huang 2009; Järvelä et al. 2007). Using these mobile devices, lecturers can collect feedback from learners who simultaneously listen to the lecture while posing questions relative to what they heard (Järvelä et al. 2007). Mobile devices motivate and engage students in learning as these devices aid their participation in the discussion as well as the flow of the communication (Stone, Briggs & Smith 2002). With mobile devices for learning, the response time in the delivery of the clarifications reduces the factors that negatively affect the learners' engagement in classroom activities such as frustration and social presence.

Mobile learning devices have also been reported to enhance students' performance and motivation (Cavus & Ibrahim 2009; de-Marcos et al. 2010; Rau, Gao & Wu 2008). Other than the direct effects of mobile learning on students, educators postulate that (a) portability (Jones, Issroff & Scanlon 2007; Kukulska-Hulme & Traxler 2005) and (b) cheapness (Wilen-Daugenti & McKee 2008) are the main reasons behind the popularity of mobile learning. In recent years, almost all individuals own or use mobile devices for their communication needs. Given the ubiquity and convenience of mobile devices, educators can capitalise on it to improve student interaction in classroom activities. The working environment is made more engaging and interactive with mobile learning in some cases, while students can participate in a class on their mobile devices without even leaving their home in other cases (Croop 2008).

While these advantages of mobile learning favour the implementation of such programs in an academic institution, several issues have been identified to oppose its execution. Many note that the size of the screen is not convenient for the completion of learning activities (El-Hussein & Cronje 2010; Kalinic et al. 2011; Suki et al. 2011). Other issues include the technical limitations of these technologies such as battery lives (Riad & El-Ghareeb 2008), nontechnical knowledge of users (Corbeil & Valdes-Corbeil 2007; Franklin 2011), ability to simultaneously open several programs that can distract attention and interruption of knowledge acquisition (Cheon et al. 2012; Fried 2008; Suki et al. 2011), and imposing the role of teachers to use mobile devices within the classroom premises (Sølvberg & Rismark 2012).

Despite issues of accessibility to technology, the potential that technology holds for mitigating the negative aspects of passive teaching strategies are worth exploring (ChanLin et al. 2006). Passive learning exercises such as lectures and reading limits the learners' engagement in exploring creative concepts. Research shows the value of technology integration in improving the learning experiences of students (Cox 2013). However, technology should not be a tool that can replace the advantages of the face-to-face contact with students (Saunders & Gale 2012). These devices can work as an adjunct tool to complement effective face-to-face teaching (Laurillard 2008). The use of technology in coursework can enhance students' learning experiences in many ways. These technologies enrich the knowledge of students and extend lessons from face-to-face teaching beyond lecture time. They can prove useful when acquisition of knowledge requires using books and other traditional learning materials, and when there is a need to improve learning design by exploring other learning approaches using mobile technologies (Saunders & Gale 2012).

The alignment of educational curriculum that integrates technology includes the use of effective and efficient computer programming software that is beneficial to the students' academic performance in programming classes (Kay & Lauricella 2011). Software is an important element in constructive learning as well as in controlling learning distractions and other potential factors that hinder success in learning process. The subsequent section describes the importance of visualization software.

2.5 Visualisation Software

Students in computer programming find that writing programs can be quite difficult when compared to solving mathematics equations (McCracken et al. 2001). Researchers further claim that despite being classified as easy, reading programs and tracing code (Lister et al. 2004), and designing software (Chen et al. 2005) can prove to be difficult for novice programmers. Given these difficulties, technological learning aids with the use of visualization can prove useful. Learning aids with visual representations of textural and graphical descriptions can make it easier to follow complicated abstract theories and concepts behind a system of knowledge.

Educators and designers describe visualization as anything that provides graphical representations with simple to complex animations of an object and/or concepts (Ben-Ari 2001). With visualizations, new knowledge can be integrated to old knowledge to generate a new set of information (Hyrskykari 1993). However, in the context of programming education, visualization supports novice programmers in understanding these through visualizing the behavior of a program (Rajala et al. 2009). These novice programmers are either exposed to dynamic or static visualization, where dynamic visualization allows the student to see the process of program execution while static visualization allows them to see stages in that process as static slides. In the process of dynamic visualization, the behavior of the code and the associated changes and relationship behind the parts of the code are highlighted. A recent example of visualization that is dynamic is Jeliot3 (Moreno et al. 2004). Static visualization tools, on the other hand, descriptively visualise the structure and the interrelationships of the objects within the overall structure. BlueJ, for example, is a popular static program visualization tool (Kölling et al. 2003).

2.5.1 Visualization Tools

Over the years, programmers have recognised the need to design an appropriate visualization system that is capable of illustrating abstract programming concepts (Gómez-Albarrán 2005). Oechsle and Schmitt (2002) developed *JavaVis* with capabilities to visualise objects and sequencing diagrams, Hundhausen and Brown (2007) developed *ALVIS LIVE!* inspired from the *WYSIWYC* (What You See Is What You Code) model, and Carlisle, Wilson, Humphries, and Hadfield (2005) developed *Raptor*, a tool that considers the utilization of dataflow diagrams. This visualization tool is patterned on an animation algorithm that presents the structures and algorithms within a system. Programmers have also begun to design tools with more animation, such as, *JHAVE* (Grissom, McNally & Naps 2003), *BALSA-II* (Brown & Marc 1988), *ZEUS* (Brown 1991), *XTANGO* (Stasko 1992), and *TRAKLA2* (Nikander et al. 2004).

Jeliot3 program has been used in the distance learning program at a university in Finland. The tool was used to cater to the needs of students enrolled in the virtual module of the Computer Science program. It was found that students who performed well in class used the *Jeliot3* tool, but patterns of tool utilization of *Jeliot3* have not been fully supported by students, and many of the students continued to use other similar tools to check their programming competency (Kannusmäki et al. 2004). Other notable issues in the tool reported by students is the quality of the animated objects, technical competency of the editor concerning the use of the tool, the appropriateness of the codes for students' level of proficiency on programming.

PeerWise, a programming software that assists students in acquiring knowledge-based information through multiple-choice programming questions, was used in Auckland (New Zealand) (Denny, Luxton-Reilly & Hamer 2008a). In this software, the student-programmer can test the rate of learning difficulty of his or her peers (Denny, Luxton-Reilly & Hamer 2008b). It was found that overall performance of students enrolled in programming is associated with his or her contributions in the multiple choice he or she comprehended in the exercise (Denny et al. 2008). Multi-User Programming Pedagogy for Enhancing Traditional Study (*MUPPETS*) is also an important software that encourages interactions in interactive learning in a virtual environment (Phelps, Bierre & Parks 2003), while *Alice* software motivates students to learn programming in an animated 3D environment (Pausch et al. 1995).

Other research supports the contentions of programming educators concerning the use of visualization tool in demonstrating programming algorithms (Hundhausen, Douglas & Stasko 2002). Review of 24 empirical studies further shows that research on visualization focuses mainly on the technical abilities of the tool in illustrating models rather than the actual benefits of learning a specific model. Furthermore, the authors support the contentions of existing research that successful programmers engage in two or more visualization tools to support various dimensions of programming knowledge (Hundhausen, Douglas & Stasko 2002).

2.5.2 ViLLE Visualization Tool

In 2007, Rajala, Laakso, Kaila, and Salakoski developed a visualization tool called *ViLLE* that is able to visualise the behavior of the code within the programming system (Rajala et al. 2007b). The authors describe it as a "*language-independent visualization tool aimed at providing a more abstract view of programming*" (Rajala et al. 2008, p.2). Consistent with the limitations of other tools in teaching programming, the authors designed the program in a way that can be utilised for independent learning. *ViLLE* has an in-built syntax editor that can be modified by anyone who intends to re-create a new programming language. Currently, the tool includes languages such as Java, C++, and a pseudo language predominantly used in basic programming courses. The tool is able to provide two languages which helps students to compare two simultaneous processes that can illustrate program outputs along with the changes in variable values. The tool is user-friendly, effective, and clarifies code lines indicated by textual descriptions (Rajala et al. 2008). The concern of the authors of *ViLLE* is to describe the variables according to their role in the program (Sajaniemi 2002). However, despite the considerations in designing the program that can be used for independent learning, students' ability for full understanding concerning the role of the variables depends on the ability of the developer to integrate necessary domains of teaching (Nikula et al. 2007).

The significant contribution of ViLLE in the improvement of academic performance of students enrolled in programming courses is its immediate assessment function (Rajala et al. 2008). ViLLE is a language-independent platform that immediately provides feedback concerning errors in language programming (Rajala et al. 2007b). As such, the objective concerning the potential enhancement of the learning experience of students in traditional face-to-face lecture can be achieved using ViLLE software.

Based on the discussion of the preceding sections of our review, teaching and learning of programming can prove to be a challenging task for both lecturers and students. Approaches designed on the basis of constructivist techniques of learning are needed to impart theoretical understanding and practical skills in programming. The evolution of mobile devices such as laptops has led to growing interest in these tools to aid a constructivist learning and teaching approach. However, the process of technology integration with teaching and learning practices has been difficult to implement without pedagogical guidelines grounded on empirical evidence (Arbaugh & Hornik 2006). There is a need to develop an appropriate pedagogical framework to consider how constructivist learning models using technology actually perform in terms of improving students' academic performance in programming classes. The following section discusses the Seven Principles of Good Practice in Undergraduate Education developed by Chickering and Gamson (1987) as a framework of our research.

2.6 The Seven Principles

Several evaluation frameworks have been cited in recent studies on education and pedagogy. Evaluation of good teaching practices needs appropriate guidelines and/or framework for evaluation (McMillan 2007). Studies show that while pedagogical techniques may help teachers improve their teaching approaches, the findings of these studies concludes that these techniques are not the sole method of ensuring good teaching (Cannon & Newble 2000; McMillan 2007; Ramsden et al. 2007). Scholars suggest that a deeper dimension of teaching requires principle of good teaching for effective learning in higher education (Porter & Brophy 1988). There are several studies on the pedagogical practices of educators in various fields (Grant & Thornton 2007; Page & Mukherjee 2000). However, review of these practices reveal that in the field of education, the Seven Principles for Good Practice in Undergraduate Education by Chickering and Gamson (1987) encapsulates all traditional and online teaching practices (Arbaugh & Hornik 2006; Chizmar & Walbert 1999). Chickering and Ehrmann (1996) find the need to update the original work of the seven practices to include the role of information technologies in the pedagogical practice of educators. They state that "*if the power of the new technologies is to be fully realised, they should be employed in ways consistent with the seven principles*" (Chickering & Ehrmann 1996, p.3).

The principles cited by Chickering & Gamson (1987) have been developed using the views and experiences of educators who have been actively working to meet the changing demands of student learning. The principles that are considered most effective in teaching students include:

1. "encourage contact between students and faculty;
2. develop reciprocity and cooperation among students;
3. encourage active learning; gives prompt feedback;
4. emphasise time on task;
5. communicate high expectations; and
6. respect diverse talents and ways of learning" (Chickering & Gamson 1987, p.3).

While each of these principles addresses an important aspect of any approach to enhance the learning experience of students, the employment of all principles can work as a powerful tool to develop a holistic framework for an effective teaching and learning environment (Grant & Thornton 2007; Bangert 2004; Winegar & Director-Card 2000; DeBard & Guider 2000; Lord & Bishop 2001; Arbaugh & Hornik 2006; McCabe & Meuter 2011; Page & Mukherjee 2000).

***1. Good Practice Encourages Student-Faculty Contact*.**

Chickering and Gamson (1987) postulate that "*frequent student-faculty contact in and out of classes is the most important factor in student motivation and involvement*" (Chickering & Gamson 1987, p.4). Consistent with the available literature, an established relationship of student and his or her instructor is crucial in the success of students. For instance, several studies report the involvement of instructors in the academic activities of students and motivating them as a critical component of the learning experience of students (Anderson & Price 2001; Kember & McNaught 2007; Myers et al. 2007). One study found a strong correlation between faculty and student contact and teaching effectiveness (Sorcinelli 1991). This means that as the availability of faculty for students' consultation is high, the higher the academic performance of the student.

However, Lazaros and Davidson (2013) claim that given the large class size in the traditional lecture environment, interaction between students and lecturer can be difficult.

In terms of the integration of technology in higher education, the learning experiences of students are very significant when students establish a direct contact with their instructor (Saunders & Gale 2012). Batts, Colaric & McFadden (2006) investigate students and instructors perceptions in selected undergraduate online courses relative to the Seven Principles. They found that the students and instructors perceived the usefulness of the Seven Principles and agreed on the perception of their use in selected online undergraduate education courses.

***2. Good Practice Encourages Cooperation among Students*.**

Cooperative learning is a method of teaching that articulates the importance of groups in accomplishing an academic activity (Keyser 2000; Pinho, Bowman & Freitas 2008). Chickering and Gamson stress the effectiveness of students' cooperation by their responses to the activities that are meant to improve learning. The authors claim that, "*Learning is enhanced when it is more like a team effort than a solo race. Good learning is usually collaborative and social, not competitive and isolated*" (Chickering & Gamson 1987, p.4).

A review of the literature suggests that cooperative learning should be integrated into all the curricula of higher education (Foss, Oftedal & Løkken 2013; Pinho, Bowman & Freitas 2008). Empirical evidence relates the intellectual and social benefits whith the students in cooperative learning can achieve (Johnson, Johnson & Stanne 2000; Magnesio & Davis 2010; Sorcinelli 1991). In their 1996 study, the context of cooperative learning has been expanded to include information technology (Chickering & Ehrmann 1996). The authors claimed that while traditional student-led methods can improve the students' ability in the application of concepts, attitudes, and motivation, the use of technology can also enhance students' interaction encouraging them to interact with their co-learners. They also say that "*study groups, collaborative learning, group problem solving,* *and discussion of assignments can all be dramatically strengthened through communication tools that facilitate such activity*" (Chickering & Ehrmann 1996, p.4). Based on this observation, they explain the need to include the role of information technology in the pedagogical practices of the educators.

Among the notable developments in the area of cooperative learning in programming is the use of pair programming, an agile software development technique of two programmers working together at a workstation. Pair programming requires a programmer-driver and a programmer-navigator, which oftentimes switch roles to determine areas of weaknesses each of them might have (Nagappan et al. 2003b). The programmer-driver is responsible for code writing while the latter is responsible for reviewing the code for possible glitches and future improvement. The tasks of both the programmers are critical in programming as both maintain quality of work according to standards and logical value (McDowell et al. 2006).

Pair programming is an effective technique for generating effective programming designs with fewer glitches and bugs and improving retention rates and students confidence when compared to programming done by single programmers (Braught & Wahls 2008; Brereton, Turner & Kaur 2009; Cockburn & Williams 2000; Salleh 2008; VanDeGrift 2004). Pair programming can offer alternative programming designs that are simpler and more maintainable than those of a single programmer who may not be able to see predictable problems in future use of the program (Salleh, Mendes & Grundy 2011; Williams & Kessler 2003). Furthermore, knowledge sharing is more evident in pair programming as two programmers are consciously able to generate programming techniques and practices that they may not have known without their collaborative undertaking (Williams & Upchurch 2001). The sharing of knowledge and conscious reviews of work can increase the morale and confidence of the two programmers.

***3. Good Practice Encourages Active Learning*.**

In defining the importance of strategies of the instructors to facilitate an active learning environment, Chickering and Gamson (1987) state,

> "*Learning is not a spectator sport. Students do not learn much just sitting in classes, listening to teachers talk, reading prepackaged assignments, memorizing, and then spitting out answers. They must talk about what they are learning, write about it, relate it to past experiences and apply it to their daily lives. They must make what they learn part of themselves"* (Chickering & Gamson 1987, p.5).

Many scholars stress on the value and advantages of active learning which involves activities that provide the learners with the autonomy and control over their learning experiences (Machemer & Crawford 2007; Prince 2004; Smith et al. 2005; Walker et al. 2008) and with relation to lifelong learning (Lord et al. 2012) Indicators of active learning within classroom management include active interaction, common objectives shared and accomplished by teams, students' regular attendance in class, and students' participation in classroom discussion (Walker et al. 2008).

As Bonwell & Eison (1991) scrutinise further the work of Chickering and Gamson (1987), they have identified the characteristics of an active learning environment as being that:

1 Students are involved in more than listening;
2 Less emphasis is placed on transmitting information and more on developing student skills;
3 Students are involved in higher-order thinking (e.g., analysis, synthesis, evaluation);
4 Students are engaged in activities (e.g., reading, discussing, writing); and
5 Greater emphasis is placed on students' exploration of their own attitudes and values (Bonwell & Eison 1991).

Chickering and Ehrmann (1996) claim that with the increase use of technologies, there is a need to harmonise the two interrelated concepts to further encourage the creation of active learning. The authors advise that technologies should be evaluated as a tool that, if used appropriately, can improve academic performance.

***4. Good Practice Gives Prompt Feedback*.**

In the 1987 version of the seven principles, Chickering and Gamson (1987) highlight that "*knowing what you know and don't know sharpens learning, Students need appropriate feedback on performance to benefit from courses*" (Chickering & Gamson 1987, p.5). The establishment of feedback mechanisms in teaching ensures that learning goals have activities that direct the daily classroom activities of the instructor. In this system, there is the need for the instructor to conduct academic diagnosis before, during, and after the semester.

Recent literature on this principle re-conceptualised the concept of feedback and introduced the concept of formative assessment to describe a similar concept yet consider the role of information technology (Black & Wiliam 2009). Formative assessment encompasses the type of information that is used to provide feedback on the activities undertaken in a class by teachers and/or students to adjust their teaching and learning activities (Black & Wiliam 2009). Task Evaluation and Reflection Instrument for Student Self-Assessment (*TERISSA*) is one such feedback technique used in higher education classrooms. It improves students' Good Teaching Scale (GTS) score, students' mark in their final examination and also helps teaching staff with feedback on students understanding of the course materials (Belski 2007; Harlim, de Silva & Belski 2009).

Research that evaluates the effect of teacher's feedback on the attitude and achievement of students found that "*immediate, corrective, and supportive feedback is central to learning*" (Hattie & Jaeger 1998, p.19). Prompt feedback has been recognised as one of the strengths of computer-based learning (Kift & Moody 2009). Based on the results of these studies, Chickering and Ehrmann

(1996) clearly identify the role of technology in ensuring that delivery of feedback is prompt and effective. The authors claim that with technology, the instructors can provide critical and confidential observations to students, which makes the interaction more personalised compared to class observations. As early as 1996, the authors recognised that computers

> "*can provide rich storage and easy access to student products and performances…keep track of early efforts, so instructors and students can see the extent to which later efforts demonstrate gains in knowledge, competence, or other valued outcomes*" (Chickering & Ehrmann 1996, p.5).

One of the common technological tools used for providing feedback in classrooms is "Clickers", a small device that allows students to electronically submit their answers (Duncan 2005). With Clickers the lecturer presents questions to the class and allows students to enter responses individually or in groups as answers to multiple-choice questions. Then, the responses are aggregated and displayed usually as histogram to the class in real time. Although Clickers can increase engagement among students, improve their learning and increase class attendance (Duncan 2006; Hall 2013; Lantz 2010; Morling et al. 2008), they do not support individual feedback for technical exercises (Hall 2013; Mayer et al. 2009).

5. Good Practice Emphasises Time on Task.

This principle stresses the combined value of time and energy in the academic learning of the students. Chickering and Gamson (1987) state that:

> "*time plus energy equals learning. There is no substitute for time on task. Learning to use time well is critical for students and professionals alike… Allocating realistic amounts of time means effective learning for students and effective teaching for faculty*" (Chickering & Gamson 1987, p.5).

In early studies using the seven principles, it was found that instructors who are able to manage their time effectively in classroom activities are also effective in their teaching (Sorcinelli 1991). Sorcinelli (1991), who did much work on evaluating the seven principles, claimed that from the late 1980s onwards, there has been no study in the literature that has provided compelling evidence that time spent on learning affects learning. The important variables to be considered in correlating time with performance are the quality of the learning techniques used to learn and the quality of time spent for learning.

***6. Good Practice Communicates High Expectations*.**

Drawing on the proverb, "*expect more and you will get more*", Chickering and Gamson (1987) state that expectation serves as an intrinsic motivation for any individual to progress in any endeavor he or she wants to accomplish. The authors suggest that academically unprepared students are unwilling to do hard work, while academically prepared students were even more motivated to study and invest more time in learning. The authors assert that, "*expecting students to perform well becomes a self-fulfilling prophecy when teachers and institutions hold high expectations of themselves and make extra efforts*" (Chickering & Gamson 1987, p.5-6).

As early as 1984, researchers claimed that expectations of an individual drive his or her performance to success (Berliner 1984, as cited in Sorcinelli 1991). Chickering and Ehrmann (1996) state that "*new technologies can communicate high expectations explicitly and efficiently*" (Chickering & Ehrmann 1996, p.6). In this matter, technology can act as a tool to drive expectations with computers providing automated messages to the users on tasks accomplished and yet to be accomplished. However, Chickering and Ehrmann (1996) also state that "*criteria for evaluating products and performances can be more clearly articulated by the teacher, or generated collaboratively with students*."

***7. Good Practice Respects Diverse Talents and Ways of Learning*.**

Finally, the last principle suggests that addressing the diversity of learning needs in the student population is equally important for effective teaching. Chickering and Gamson (1987) argue that differences exist in almost all dimensions of human lives, and this means that we need to include the differences of individuals in acquiring learning as well as information processing. The differences of learners' intellectual and social abilities influence the instructors' pedagogical practices, which in turn can affect the learning environment. For instance, students who are computer proficient may be allowed to attend online classes, while those who are still in the process of learning the use of computers may be advised to attend computer class then be allowed to attend the online learning platform. In the context of technology integration, Chickering and Ehrmann (1996) state that technology can provide learners with various options concerning their preferred learning environment. The authors describe the relations of technology as "*learn[ing] in ways they find most effective and broaden their repertoires for learning*" (Chickering & Ehrmann 1996, p.6).

According to Chickering and Gamson (1987), "*students need the opportunity to show their talents and learn in ways that work for them*" (Chickering & Gamson 1987, p.7). Students' autonomy concerning their learning activities encourages them to further explore and acquire knowledge in the most convenient way possible. This principle has been considered as the ultimate framework binding all the seven principles of good teaching. This means that as instructors aspire to meet the learning needs of their student, the higher their motivation in using diverse teaching approaches becomes, the higher the chances that students achieve their academic goals.

2.6.1 Use of the Seven Principles in Educational Research

In this section, the work of Chickering and Gamson (1987) will be discussed along with insights from several other scholars who reviewed the principles of key instructional practices. For example, Grant and Thornton (2007) used the seven principles of good practice in teaching to explore and identify best practices used by fulltime and part-time faculty in adult centered online learning environments. They surveyed the faculty using Teaching, Learning and Technology (TLT) and confirmed the usefulness of the practices to students. The seven principles have been used in several higher education studies that deal with the use of the technology. The majority of the learner-centred instructional practices that comprise the seven principles framework are clearly focused on constructivist-based teaching practices. (Bangert 2004). For instance, one study examined the seven principles using the experiences of faculty in the delivery of a course through the web (Winegar & Director-Card 2000). The author developed an instrument that surveys the teaching strategies of web-based instructors. The study found that the highest scoring among the principles that motivate and engage students in learning is giving prompt feedback (Winegar & Director-Card 2000).

DeBard and Guider (2000) conducted a survey using the seven principles that intended to reveal the perceptions of the faculty members on the effectiveness of the online instruction. The authors found that effective teaching and learning requires active participation of students in solving problems, assessment of their own learning, discussing this learning with the teacher, and the teacher's reflection over the learning experiences of the students. Lord and Bishop (2001), assessed the effectiveness of the laptop initiative in a certain college using the seven principles. They found that with the use of laptops increased the interest of students toward learning. The study suggests that teachers may need to maximise the availability of technology to interact with students.

Arbaugh and Hornik (2006) examined 24 graduate business courses in two American universities using the framework of Chickering and Gamson (1987). Arbaugh and Hornik postulated that in courses dealing with business, there has been a scarcity of applicable frameworks that are able to explore web-based as well as classroom-based teaching modality. The authors believed that Chickering and Gamson's framework can determine the status and current needs of faculty training that can adequately prepare them to handle online teaching. Results of the study suggested the applicability of five principles of practice in a classroom-based undergraduate course to web-based graduate course.

A recent study by McCabe and Meuter (2011) explored faculty and students usage of classroom-based management software and investigate students' perceptions of their learning based on the seven principles. They found that although students enjoy using the classroom-based management software but they did not see the tool as highly effective at enhancing the learning experiences and suggested that faculty need to consider the connection between the seven principles and the specific technology tools (McCabe & Meuter 2011). Page and Mukherjee (2000), in their article, reported on a successful implementation of the seven principles in two undergraduate business courses. They argued that their experience reveals that each course needs a different implementation strategy regarding the seven principles because student needs are different.

2.7 Summary

Mobile devices, such as laptops, have been used significantly for lecture note taking and follow-through, but they are rarely used as an effective mobile device for lecture delivery with simultaneous exercise. Integrating laptops as a learning device in programming courses where students practice the concept being taught in the classroom can help to improve learning outcomes for students. Using the seven principles, the present study intends to evaluate the effectiveness of this approach using mobile devices such as laptops in learning and teaching introductory programming courses. Recent studies on the seven principles applied in educational research indicate the need for the articulation of these good practices in the context of technology integration in classrooms. The majority of studies reviewed in this chapter either analyse these seven principles in the context of use of mobile device for online learning or traditional face-to-face instruction. There is a lack of studies that focus on these practices with the use of mobile technology within the classroom or lecture theatre setting, particularly, with programming students who use mobile devices in programming courses.

The next chapter describes how this is done.

Chapter 3 - Research Methodology

3.1 Introduction

This research has been conducted in four phases to systematically examine the effectiveness of a constructivist mobile-based learning and teaching approach in computer programming courses. This chapter describes the research methodology used for all these stages, including, research method, population and sample, instruments, and procedures for data collection and data analysis. The chapter begins with a general review of the different research worldviews and methods to justify the choice of a mixed-method approach to answer the research questions in this study. The research objectives and processes of the four different phases of the study along with the research strategies adopted at each stage are described. This is followed by sections on each phase of the study describing the data instrument and the procedures involved in collecting and analysing data for each phase of the study.

3.2 Research methodology

Methodology for the primary research of this thesis requires the assessment of the various forms of data collection and analysis within an overall methodological framework. There are two key methodological approaches available for researchers to use: quantitative and qualitative. Researchers may often employ a third form of research which is mixed method design. Generally, quantitative research specifies numerical assignments to the phenomena under study, whereas qualitative produces narrative or textual descriptions of the phenomena under study (VanderStoep & Johnson 2008). In a qualitative methodology, a researcher is the primary instrument for data collection and analysis, whereas, the quantitative method uses different techniques for collecting data and analyses data using statistical tests (Creswell 2009). The following discussion identifies each design model, its advantages and disadvantages, as well as criteria to assist in the selection of an appropriate research design (see Table 3.1).

Table 3.1: Characteristics of Quantitative and Qualitative Research Design

Characteristics	Quantitative	Qualitative
Type of data	Describes the phenomena numerically	Describes the phenomena in a narrative fashion
Analysis	Statistics are descriptive and inferential	Identification of major theme
Scope of inquiry	Specific questions or hypotheses	Broad, thematic concerns
Primary advantage	Large sample, statistical validity, accurately reflects the population	Rich, in-depth, narrative description of sample
Primary disadvantage	Superficial understanding of participants' thoughts and feelings	Small sample, not generalised to the population at large

Source: Vanderstoep & Johnston 2009, p.7

3.2.1 Mixed Methods Research

Some scholars believe that quantitative and qualitative designs are fundamentally opposed in nature, while others opine that they represent different ends of a same continuum (Newman 1998). If we follow the second view, then mixed method design can be said to comprise the whole continuum because it integrates the elements of quantitative and qualitative design (Creswell & Plano-Clark 2007). A mixed method design is an approach that combines both quantitative and qualitative research and methods to understand a research problem. A mixed method design to enquiry combines or associates with both quantitative and qualitative forms (Creswell & Plano-Clark 2007). Linking quantitative and qualitative data provides several advantages. It enables confirmation of results from each method via triangulation of data and richer details can be extracted to enhance the research analysis and outcomes (Miles & Huberman 1984). The mixed method approach is increasingly accepted by scholars as an approach that can broaden the range of any research and deliver stable results for the themes under investigation (Creswell & Clark 2007; Tashakkori & Teddlie 1998). The following factors support the adoption of a mixed methods approach:

- Using mixed methods research allows for an exploratory inductive process that begins with empirical evidence of the particular phenomena and proceeds to a level of abstraction, theorisation, generalisation and deductive confirmation for hypothesis testing (Rocco et al. 2003).
- A mixed method approach increases the study's validity with triangulation of data and increases validity and interpretability, showing different facets of a phenomenon (Greene, Caracelli & Graham 1989).
- The quantitative data may provide numerical answers to the research question, but there is a need to understand the factors that are more relevant to the study.
- This two-pronged approach can add depth and breadth to inquiry results and interpretations, and mitigate the effects of inconsistent qualitative and quantitative findings (Rocco et al. 2003).

Considering these advantages, our research uses a mixed method approach integrating qualitative and quantitative methods. The research design of this thesis involves surveys with Computer Science students as a tool for quantitative data collection and interviews as well as focus group interviews with Computer Science Lecturers as qualitative tools. This combination of methods provides better support for the results and conclusions (Östlund et al. 2011; Sarantakos 2005) to highlight the pertinent factors that impact mobile learning integration in introductory computer programming courses.

3.2.2 Qualitative Approach

Qualitative research explores the viewpoints of respondents through detailed descriptions of their actions and grounded understanding of the richness of meaning associated with their observable behaviour (Cozby & Bates 2011). Qualitative researchers usually collect data through interviews or observations in the form of written or spoken words, actions, and visual images. Such in-depth data derived from qualitative methods is considered to have greater strength in terms of richness, exploration and description (Myers 2013; Neuman 2006).

Being concerned with words rather than numbers, qualitative research is characterised by four main features:

- it has an inductive view of the relationship between theory and research;
- it lays stress on understanding the social world through examination of the interpretation of that world by study participants;
- it is associated with constructivism, implying that social properties are outcomes of the interactions between individuals (Bryman & Bell 2007); and
- it contributes "ideas instead of variables" (Neuman & Kreuger 2003, p.146).

Researchers take an inductive approach, creating new concepts as part of their analysis and deriving their conclusions based on interpretation. Qualitative analysis has some failings in that data are not tested to verify whether the results are statistically significant or the results occur due to chance (Smallbone & Quinton 2004).

Our research uses interviews and a focus group interview with lecturers as part of the qualitative approach in the second and fourth phases of the study. The interviews in Phase 2 aim to investigate lecturers' perceptions about the possibilities of adopting mobile devices in lectures. The focus group interviews in Phase 4 investigate the lecturers' perceptions about the effectiveness of the actual practice of using mobile devices in programming lectures.

3.2.3 Quantitative Approach

Unlike the qualitative approach, the quantitative research method measures relationships between variables to make valid and objective descriptions of an issue (Neuman 2006). Focusing on specific behaviours that can be easily measured, quantitative researchers collect data using large samples to generate principles that can be generalised to the larger population (Sloane-Seale 2009). Further, objectivity is served by minimising interaction with participants, so the interpretation of the results is not affected by the researcher's personal biases (Newman 1998). Data generated from the quantitative process is analysed using descriptive or inferential statistics to test hypotheses and determine if significant relationships or differences exist (Muijs 2010; Taylor 2005). However, quantitative questionnaires, because the answers are usually pre-coded, lack the depth and insight of a qualitative study (Sloane-Seale 2009). The development of standard questions by researchers can lead to structural bias and false representation. In addition, answers will not necessarily reflect how people really feel about a subject and in some cases might just be the closest match. In addition, the questions should be very carefully constructed and worded without any redundancy or double-barrelled. It should be very clear, direct and should address only one point at a time. (Neuman 2006).

Our research uses surveys as part of the quantitative approach as it is able to determine quantitative data capable of statistical analysis through direct questions. The surveys are widely distributed among the target population (to students). The aim of the survey questions is to investigate students' perceptions of the possibilities in adopting mobile devices in lectures and then students' perceptions of the actual practice for examining the effectiveness of implementing mobile devices in lectures.

3.3 Research Phases

This thesis aims to conduct an intervention with a lecture where students use their mobile devices in the lecture and then evaluate the effectiveness of a constructivist mobile-based learning and teaching approach to programming. The intervention is designed to deliver theoretical and practical components together in a lecture environment using students' mobile devices (in this case, laptops) and visualisation software. With this purpose in mind, the empirical research in this study was conducted in four phases using a variety of research strategies to first examine the perceptions of the students and lecturers, then, evaluate the effectiveness of the proposed approach. All four phases used in this research need to be executed using appropriate research methodologies. In this part of the chapter, various options for data collection and analysis according to the needs and objectives of each phase of the study are discussed.

3.3.1 Procedure and Objective of the Study Phases

Phases 1 and 2 of our research are designed to develop an understanding of the advantages of and barriers to using mobile technologies in lectures for programming education. The two phases are carried out with first the students and then the lecturers, and are described in Chapter 4 and Chapter 5, respectively. The results of those two phases are used to inform the third phase of the study. We consider the results of Phases 1 and 2 to develop the intervention in Chapter 6: Intervention and Survey Development. Then, we conduct Phase 3 of the study with a quantitative survey where students evaluate the intervention, described in Chapter 7: Intervention Analysis. Lastly, Phase 4 of this research discusses the results confirming, expanding and reflecting on the findings of previous phases through a focus group interview with the lecturers in Chapter 8: Lecturers' Reflections. (see Figure 1.1 in Chapter 1).

The four phases in this research are conducted to answer the following three research questions:

1. How do existing perceptions of students influence their attitude to a constructivist mobile-based learning approach in lectures?
2. How do existing perceptions of lecturers influence their attitude to a constructivist mobile-based teaching approach in lectures?
3. How can the application of a constructivist mobile-based learning and teaching approach to programming influence novice students' learning experiences during lectures?

Phase 1 answers the first question, Phase 2 answers the second question and Phases 3 and 4 address the third question.

After finalisation of the research methodology, approvals for conducting the research with lecturers and students were obtained from the Science Engineering and Health College Human Ethics Advisory Network (CHEAN), RMIT University (see Table 3.2). The details of the ethics approvals are provided in Appendix 1, 2 and 3.

Table 3.2: Ethics Approvals

Date	Number	Ethics approval purpose	Appendices
4th May 2009	BSETAPP 09 – 09	Phase 1: Students' Perceptions	Appendix 1
11th February 2011	A&BSEHAPP 85–10	Phase 2: Lecturers' Perceptions	Appendix 2
		Phase 3: Intervention Analysis	
1st May 2013	A&BSEHAPP 85 – 10	Phase 4: Lecturers' Reflections	Appendix 3

3.3.2 Research Strategies for the Study Phases

There are several strategies within the quantitative, qualitative, and mixed method design approaches that can be used in various combinations in various phases of the study. Bryman and Bell (2007) state that

> "*there are differences between quantitative and qualitative research in terms of research strategy … it is a useful means of organizing research methods approaches to data analysis*" (Bryman & Bell, p.626).

However, each research strategy has strengths and weaknesses (Creswell 2009; Stephens 2009) which are summarised in Table 3.3 in the next page.

Table 3.3: Matrix of Research Strategies

Strategy	Relevant approach	Key features
Experimental	Quantitative (a)	Determines if specific treatment influences an outcome. Used in laboratories and where measurements are recorded. Termed field experiment when focus is groups or singles Advantage: Small number of variables can be isolated and intensively studied Disadvantage: May lead to limitation in generalisation, as treatment might not be representative.
Non-experimental or survey	Quantitative (a)	Offers numeric description of trends, attitudes or opinions of population by sampling Advantage: The results of the study can be generalised from a sample to population. Disadvantage: Research bias may be occur if respondents do not provide accurate responses.
Ethnographic	Qualitative (a)	Focuses on studying individuals' lives based on stories. Type of participatory observation, using conversation analysis and other techniques Advantage: Offers in-depth insight to human life Disadvantage: Time consuming at data collection; difficult to generalise from one study
Case Study	Qualitative (a)	In-depth study of event, activity or individuals; time-sensitive for data collection. Advantage: Provides more reality in qualitative research and can analyse more variables per study. Disadvantage: Focuses on one event which limits generating unified model.
Phenomenological	Qualitative (a)	Identifies the phenomena described by study participants. Develops patterns and relationships of meaning through understanding lived experiences Advantage: Assists in understanding What and How questions to determine topic boundaries. Disadvantage: Variation in participants' understanding of phenomena make analysis difficult.
Sequential mixed method	Mixed Method (b)	Used to elaborate or expand the results of one method to another. Qualitative data can be collected and analysed followed by quantitative data (or vice versa) to generalise results to the population. Advantage: Data can be generalised to the population and offers in-depth understanding Disadvantage: May require more time than a single method approach.
Concurrent mixed method	Mixed Method (b)	Applying mixed method for comprehensive analysis of the research problem. Both forms of data to be collected at the same time and then integrated into overall results. Advantage: Smaller forms of data can be embedded into larger one to collect different forms Disadvantage: One form of data may not support others and lacks relationships under analysis
Transformative mixed method	Mixed Method (b)	Strategy which uses a theoretical lens as overarching data. Advantage: Provides a 'framework for topics of interest, methods for collecting data and outcomes or changes anticipated by the study' Disadvantage: It should engage theoretical framework as a basis for research process.

Source: Stephens 2009 (a); Creswell 2009 (b)

The *Concurrent* mixed method, listed under the mixed methods approach in Table 3.3, is adopted for our research for Phases 1 and 2 because it is aligned with the purpose of those two phases. Phase 1 and 2 are focused on understanding students' and lecturers' perceptions of the use of mobile devices in lectures. In these two phases, we collect qualitative and quantitative data from both students and lecturers. The data gathered from these two studies helps us to perform comprehensive analysis of our research problem and design of the intervention. The *Sequential* mixed method is used for Phases 3 and 4. Here, the focus group interview is conducted after the intervention for the purpose of elaborating and expanding the results of quantitative data to qualitative observations that can help us generalise the data to the population and provide an in-depth understanding of the results. The analysis chapters (Chapters: 4, 5, 7 and 8) include both the quantitative and qualitative data analysis. Chapter 6 includes the discussion of the combined results from Phases 1 and 2. The presentation of the ideas will be explained sequentially from the quantitative to the qualitative analysis and the comparison between all phases is discussed in Chapter 9: discussion and conclusion.

3.4 Phase 1, Student Perceptions

The aim of this phase is to investigate the perceptions of Computer Science students about a constructivist mobile-based learning approach in lectures. It investigates how students perceive the use of laptop computers in conjunction with traditional programming lectures. Moreover, it considers the level of readiness of laptop use among the student population and any connection between demographic characteristics and the level of readiness. It also examines the opportunities and challenges that the students perceive in the adoption of mobile devices in programming lectures. Thus, this phase of the study is planned to answer the following research questions:

- *What is the level of students' readiness for adoption of a constructivist mobile-based learning approach using laptops in lectures?*
- *What are the students' perceptions of the constructivist mobile-based learning approach using laptops in lectures?*
- *What are the advantages, disadvantages, opportunities and challenges of constructivist mobile-based learning approach using laptops in lectures from the students' point of views?*
- *How can students' demographics and readiness affect students' use of constructivist mobile-based learning approach using laptops in lectures?*

3.4.1 Phase 1 Data Instrument

In general, researchers use questionnaires and surveys to collect data from a sample population for detailed information about their personal attributes, attitudes, beliefs, and past or intended future behaviours (Cozby & Bates 2011). The technique is used to identify and examine patterns emerging from the analysis of the variables under investigation. This model involves the development and the assessment of variables, and the analysis of these variables. Survey research is conducted with the size and makeup of the target population in mind, a greater range of data collected improves the generalisability of the study's findings (Velde, Jansen & Anderson 2007).

In this phase (Phase 1), a quantitative survey including some open-ended questions is selected as the data collecting instrument. Questions for a pilot survey are first proposed, then, a pilot study is conducted and its results are analysed to improve the reliability of the survey and establish the design of the main survey (Bryman 2012). The pilot survey is conducted with seven students as a pilot study. Adjustments are made to ensure that questions are clear and valid responses are received.

The survey (see Appendix 4) consists of 13 questions. Data relating to the demographic profile of the respondents are collected from questions 1 to 4, including: attendance type, age, program type and gender. Questions 6 to 9 are composed to gather data on access to laptops. Question 10 is based on a 5 point Likert scale "strongly agree, agree, do not know, disagree and strongly disagree" with six statements regarding students' views. The last section includes open-ended questions, with questions 11 and 12 asking respondents to list some advantages, disadvantages, opportunities, and challenges for laptop use, and 13 providing space for any additional comments. The open-ended questions are added to elicit broad responses (Creswell 2009; Tashakkori & Teddlie 1998).

3.4.2 Phase 1 Data Collection

In this section, we explain the procedure for survey data collection used in the study. A total of 370 questionnaires was distributed by paper in semester 1, 2009, of which 175 were returned, making a response rate of 47%, which is representative of the population (Bryman & Bell 2007). A plain language statement (see Appendix 5) was prepared as a covering letter explaining that the survey would be conducted to seek students' opinions on the formal introduction of mobile devices into the School of Computer Science and Information Technology. No personal information was required and participation was purely voluntary and anonymous. The letter and survey were printed and collated. Ethics permission was obtained for an in-class survey of postgraduate and undergraduate students enrolled in three courses in School of Computer Science and Information Technology at RMIT University. These three courses are core to the Computer Science curriculum, and so students enrolled in these three courses may be considered as typical representatives of the body of Computer Science students in the University.

3.4.3 Phase 1 Data Analysis

After collecting the surveys, the data was manually transferred to SPSS (Statistical Package for Social Science) version 17. The analysis of the quantitative data uses descriptive, frequency and correlation tests. It describes the background of the participating students and lists percentage of laptop ownership among the students and willingness to take them to lectures. It also correlates students’ demographic characteristics with their perceptions using Pearson Chi-squared and Standard Multiple Regression tests.

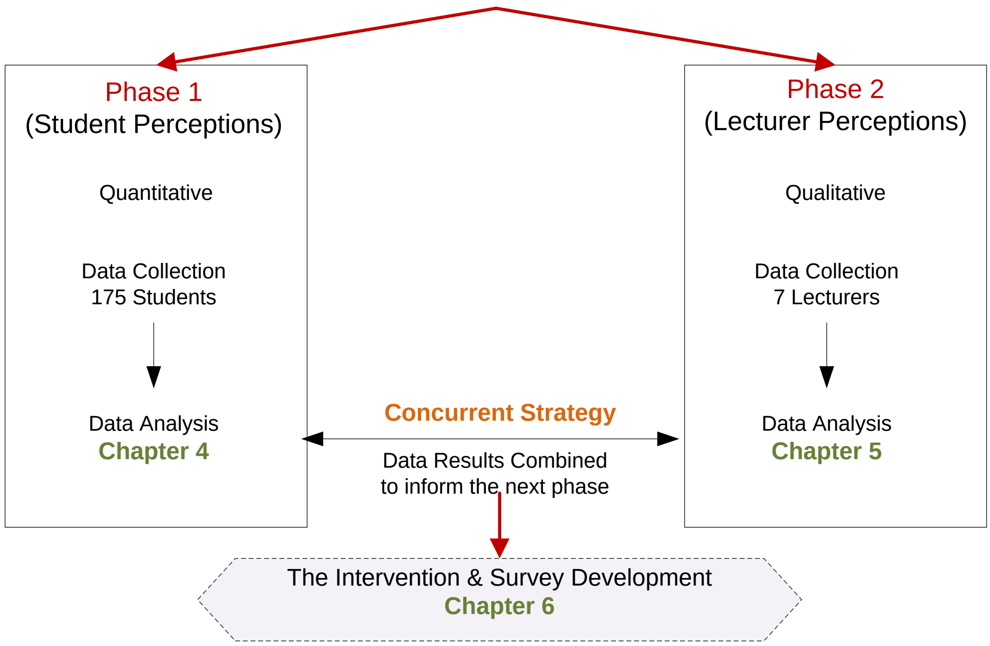
In order to devise the use of laptops during lectures, we needed to assess the current and desired use of technology in lectures to understand and address any issues in adoption. The analysis of the open-ended responses including advantages, disadvantages, opportunities and threats uses SWOT and TOWS as analytical tools. The SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis has been long acknowledged in many industries and education fields as an analysis that is widely used when building strategies for implementing a particular project (Felton 2004). It can assist administrators form a view of the current situation within their institution and make the required decision more easily (Balamuralikrishna & Dugger 1995). For example, the University of Warwick uses the SWOT analysis in combination with its application of strategy to do "resource-based planning" (Dyson 2004, p.631). In our research, we design of the open- ended questions to provide responses to be used as the input to SWOT.

The data gathered from 150 students was entered into an Excel spreadsheet on the basis of the main four themes of advantages, disadvantages, opportunities and threats. Sub-themes were extracted under each of the main themes which constructed the input of SWOT. We note that several respondents expressed similar notions and views.

TOWS is a derivation of the SWOT analysis, and is used as a cross-functional matrix to develop strategic options from the analysis (Weihrich 1982). A further analysis is used in this methodology for drawing a set of recommendations and extending them to implementation. TOWS analysis has been used in this context to manage the data from the SWOT analysis, clarify the ideas further and devise recommendations.

3.5 Phase 2, Lecturer Perceptions

Phase 2 of the study is concerned with investigating Computer Science lecturers' perceptions about a constructivist mobile-based teaching approach in lectures. It investigates the perceptions of the lecturers about mobile device use by their students in programming lecture theatres to practice the concept being taught. It also focuses on lecturers' teaching methods to deepen our understanding of the nature of programming lectures and problems in teaching programming. As in practical applications, the distribution of the sample mean is assumed to be normal if the sampling size is larger than 30 (Chang, Huang & Wu 2006; Mood 1950) and we target all lecturers (around ten) involved in delivering programming courses for qualitative data. Qualitative data were collected through interviews with seven lecturers who consented to do the interview. The qualitative data informs and confirms the results of the quantitative data through the concurrent triangulation design of the mixed method approach by collecting both qualitative and quantitative data simultaneously. As Creswell (2009) describes, in Concurrent Triangulation Design "*the researcher collects both quantitative and qualitative data concurrently and then compares the two databases to determine there is convergence, differences, or some combination*" (Creswell 2009, p.213). The use of this strategy saves time and offers greater understanding of the phenomena (Creswell 2009). After analysing the quantitative data of the student survey, we employ one-to-one interviews with lecturers. This technique is used to enhance the study's validity and explore the criteria that should be considered in the use of mobile-based learning and teaching approaches in programming lectures (see Figure 3.1).



Source: Adapted from (Creswell 2009, P.210)

Figure 3.1: Concurrent Triangulation Design

The analysis of the data aims to identify how lecturers think about using mobile devices in lectures in their teaching methods. This phase of the study is guided by the following questions:

- *What are the lecturers' teaching methods for the delivery of programming lectures?*
- *How ready are the lecturers for a constructivist mobile-based teaching involving the use of laptop computers by their students during lectures?*
- *What advantages and disadvantages do lecturers perceive in the constructivist mobile-based teaching approach using laptops in lectures?*
- *How can lecturers' existing teaching methods affect their tendency to adapt the constructivist mobile-based teaching approach?*

3.5.1 Phase 2 Data Instrument

The instrument used in this phase is a semi-structured one-to-one interview format comprising themes and questions based on the research model (Creswell

& Plano-Clark 2007; Miles & Huberman 1984). An interview is a social research method with the primary aim of describing and understanding perceptions, interpretations, and beliefs of a selected sample from the target population (Carey 2012). Carey has listed the benefits of interviews, such as allowing in-depth discussions with the study participants, ensuring time-efficiency in collecting data, and facilitating one-on-one interviews to gather pertinent data. Interviews must be structured in such a manner that the interviewee answers the interviewer's question without embellishment.

We use semi-structured interviews with open-ended questions (see Appendix 6) in a flexible manner (Flick 2009). While an unstructured interview simply presents the research problem to the interviewee, without control of the direction of the response, a structured interview is too rigid. Semi-structured interviews allow us to follow interesting and unexpected points raised by interviewees that can be pursued to gather further information. Interviewing can cease when the interviewer feels that the data has reached a saturation point and no new information or themes are being generated (Flick 2009).

3.5.2 Phase 2 Data Collection

The interviews are conducted in the first semester of the year 2011 with each lecturer individually in their office at appropriate times in the School of Computer Science and Information Technology at RMIT University. The schedule of each interview is very similar as each respondent is asked questions to ascertain their current teaching practices, their views on use of mobile devices by students during lectures, and benefits and challenges arising from such use. All lecturers involved in delivering programming courses are invited to participate by email. We targeted ten lecturers, seven of them accepted the invitation to explore their experiences and views on integrating mobile devices into their programming lectures, then time is organised for interviews with each participant. The data was collected in semi-structured interviews allowing the instructors to freely express their views but within the parameters of some predetermined questions and themes. The lecturers were given the plain language statement and consent form (see Appendix 7) before commencing the interview. The duration of each interview was approximately 30 minutes. Six interviews were audio-recorded as one of the interviewees did not consent to a recorded interview, so we took down notes of the participant's responses in this case.

3.5.3 Phase 2 Data Analysis

The data were transcribed and entered into NVivo9, a qualitative data analysis software package produced by QSR International (QSR International 2012). NVivo9 can be used by qualitative researchers working with very rich text-based and/or multimedia information that can require deep levels of analysis on small or large volumes of data. In NVivo, the coding of the data can be made visible in the margins of documents so that the researcher can see which codes have been used where at a glance. It also allows the researcher to write memos about particular aspects of the documents and create links between relevant pieces of text in different documents (Bazeley & Jackson 2013; Welsh 2002). The whole document of the data can be loaded in the software and a coding tree or hierarchy can be created and analysed. Given these features and strengths, NVivo is used for interpretive analysis in this study to extract themes relating to lecturers' teaching methods and perceived benefits and challenges that the instructors reported on the use of mobile technology in computer programming lectures. The feedback from the respondents was arranged and coded for common themes to facilitate analysis and comparison with the literature. Our data is classified into two major themes based on the content of the data and the purpose of this phase of the study. Flick (2009) explains that content analysis of transcribed and other textual data involves a systematic search for words and concepts that match a coding structure (categories) established from the research problem or research questions. NVivo can help us in organizing the themes and sub-themes by highlighting a specific text through reading the data transcribed and relate it to the proper themes or sub-themes created. The reliability and validity of the data collected in any qualitative research is of prime importance (Creswell 2009). The transcribed data are subjected to further iterations until we are certain that all the connotations of a statement are extrapolated and no further meaning can be derived from the texts. Also, we checked the data to ensure that the meanings of the codes are free from shift or drift in definition (Carey 2012; Flick 2009) by reading the data transcribed several times. Categories were then searched for themes that may be used to show trends or conclusions from the categorisations (Creswell 2009). These processes resulted in findings and conclusions that address the research problem or answer the research questions.

We also used rich and detailed descriptions to convey the findings of the research. Rich and detailed descriptions, providing cohesive information about all facets of the collected data, make it more realistic and coherent (Creswell 2009). Also, we spent extensive time in the field, conducting field research for about four years throughout our research process by extensive reading, publishing, attending conferences. Creswell (2009) stresses the importance of spending time in the field as it helps convey details about the site and people under research that lend credibility and accuracy to its findings. Furthermore, we did not edit negative or odd findings that ran counter to the theme under discussion and presented them all without bias. The findings of both Phase 1 and 2 were crucial in designing and developing the intervention, so they are discussed in Chapter 6: Intervention and Survey development.

3.6 Phase 3: The Intervention

The purpose of this phase of the research is to evaluate the effectiveness of the constructivist mobile-based learning and teaching approach. Using the seven principles of pedagogy developed by Chickering and Gamson (1987) as a framework, it examines the effectiveness of this form of course delivery combining lectures with mobile devices and the visualization software ViLLE (Rajala et al. 2008). Further, this phase takes notes of the results found from the previous two Phases 1 and 2. The surveys designed for this phase are aimed at answering the third research question: *How can the application of the constructivist mobile-based learning and teaching approach to programming* *influence on students' learning experience during lectures?* In addition, the following questions guide the intervention surveys:

- *How is the current traditional programming lecture approach aligned with the seven principles of good practice in tertiary education?*
- *Is the application of the constructivist mobile-based learning programming approach during lectures effectively aligned with the seven principles of good practice in tertiary education?*
- *To what extent is the application of the constructivist mobile-based learning programming approach better aligned with the seven principles compared to the traditional lecture approach?*
- *How do students perceive the application of the constructivist mobile-based learning programming approach during lectures in terms of their satisfaction and motivation?*

3.6.1 Phase 3 Data Instrument

The research is conducted at the School of Computer Science and Information Technology, RMIT University, where the use of laptops in lecture theatres is not compulsory and the infrastructure in the lecture theatres does not support the use of mobile devices. We use three surveys to gather information on students' learning experience. A pre-intervention survey (see Appendix 8) is distributed to all students one week before the intervention. Subsequently, two versions of a post-intervention survey are distributed at the end of the intervention lecture session, one to be completed by students who participated in the intervention (denoted as PS1, see Appendix 9) and another to be completed by students who did not participate in the intervention (denoted as PS2, see Appendix 10).

The pre-intervention survey and PS1 have been designed on the basis of the seven principles. Therefore, the survey questions include two statements for each principle. For example, two statements regarding encouraging contact between students and faculty, two statements regarding developing reciprocity and cooperation among students and so no. The survey has 14 statements made up of 7 pairs of statements to represent each principle in addition to the demographic questions at the beginning of the surveys. For these statements, the students are asked to indicate their level of agreement on a Likert scale ranging from 1 “strongly disagree” to 5 “strongly agree”. The median response of 3 is considered neutral. At the end of the pre-intervention survey, the students are asked if they would be willing to participate in the intervention of laptop use. They are also asked to give their thoughts on the use of mobile devices during programming lectures.

The post-intervention survey (PS2) aims to investigate opinions of the students who are in the intervention lecture but did not participate in it. The survey has four parts. The first part contains questions on demographic information. The second part contains a question about their reasons for refusal of participation. The third part contains a set of statements about the intervention. The last part includes one open-ended question asking for any opinions or suggestions on this form of constructivist mobile-based environment. Whilst qualitative research may use face-to-face discussions using a list of closed questions, semi-open or open-ended questions, we are constrained by time and circumstances and determine to use a section of a questionnaire to gain the descriptive data. The open-ended questions allow respondents to freely express their views on any aspects of the research issue. A detailed explanation of the development of the three surveys and this phase (Phase 3) are discussed in detail in Chapter 6: Intervention.

3.6.2 Phase 3 Data Collection

We target students enrolled in introductory programming course, with a total of 250 enrolled students in Semester 1, 2011. A constructivist mobile-based learning and teaching programming approach is organised for the intervention using laptop computers with ViLLE visualization software during the lecture (Rajala et al. 2008). Detailed information on the selection of the students and the course are also discussed in Chapter 6. Both quantitative and qualitative data are collected in this phase. We take observational notes during the intervention lecture, but we are not involved in the teaching of the course. Paper-and-pencil surveys are designed and distributed to students. Plain language statement is given to all students before filling the surveys (see Appendix 11). 150 students complete the pre-intervention survey one week before the intervention. 54 students complete the post-intervention survey (PS1) and 50 students completed the post-intervention survey (PS2) at the end of the intervention lecture.

3.6.3 Phase 3 Data Analysis

SPSS version 19 is used for quantitative data entry and analysis. Moreover, the qualitative data from the open-ended questions are analysed to extract themes relating to perceived benefits and challenges reported by the students. The data analysis chapter (Chapter 7: Analysis of the Intervention) explains the pre-intervention survey, the two post-intervention surveys and a comparison between these surveys in detail.

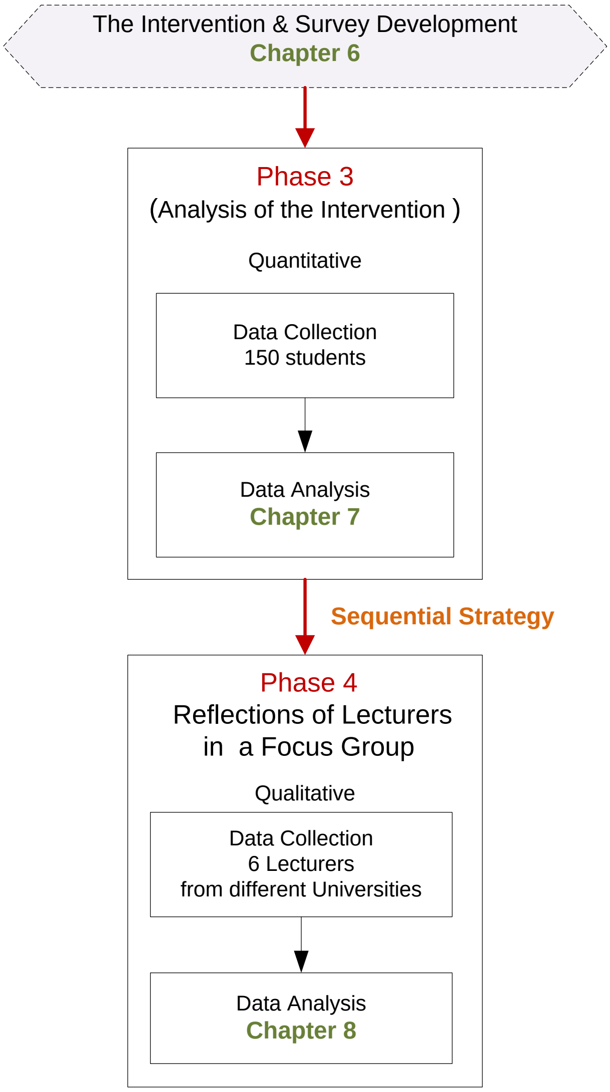
A number of statistical tests to score independent and dependent variables have been selected based on the research questions (Creswell 2009). Statistical tests involve analysis and collation of descriptive information as well as correlations and regression of the different variables to inform the study and interpret the results. A linear regression test is used to investigate possible relationships between students' traits and their responses to the seven principles. It is also used to find relationships between students' willingness to participate and their traits to provide a deeper understanding of the factors that might influence students' responses of this question. Moreover, a one-sample t test is conducted on the scores for the seven principles in the post-intervention survey. A set of hypotheses with a null as well as an alternative hypothesis for each principle is developed. Hypothesis testing is done using P-value by comparing it with an α set at .05 level of significance.

The pre-intervention survey and PS1 have been designed on the basis of the seven principles. Therefore, the survey questions include two statements for each principle. For example, two statements regarding encouraging contact between students and faculty, two statements regarding developing reciprocity and cooperation among students and so no. It is necessary to check the reliability of the two statements under each principle and their representativeness of the core idea and concept of the principle. Therefore, a reliability analysis is run on the pre- and post-intervention survey data to determine the internal consistency of the survey instrument. The initial reliability is calculated for each principle of the survey using Cronbach's Alpha to determine the internal consistency of the two statements within each principle and the reliability coefficient across all the statements within the principles (Briggs & Cheek 1986).

3.7 Phase 4: Reflections of Lecturers in a Focus Group

The purpose of this phase is to address the third research question. It aims to confirm, expand and reflect on the results of Phase 3 as well as Phases 1 and 2 to some extent. We include participants from different universities and schools to amplify the generalisabilty and validity of the study. A focus group interview is conducted with 6 programming lecturers from different universities within the state of Victoria in Australia. The lecturers are asked general questions and specific questions about our findings during the focus group interview. The phase describes the methods used and the key themes that emerged. The main findings based on the analysis of the themes are presented.

Unlike the strategy used between Phases 1 and 2, the *Concurrent Strategy*, a *Sequential Explanatory Strategy* is used between Phases 3 and 4. Sequential Explanatory Strategy is a popular strategy for mixed method approach which usually appeals to researchers with strong quantitative leanings (Creswell 2009). In this strategy, we first collect the quantitative data and analyse it, then build on these results for a qualitative study (see Figure 3.2). Creswell (2009) states that "*a sequential explanatory design is typically used to explain and interpret quantitative results by collecting and analysing follow-up qualitative data*" (Creswell 2009, p. 211). Creswell's statement captures the main purpose of conducting this supplementary study using a qualitative focus group interview.



Source: Adapted from Creswell 2009, P.209
Figure 3.2: Sequential Explanatory Strategy

3.7.1 Phase 4 Data Instrument

A focus group interview is "*a qualitative method with the primary aim of describing and understanding perceptions, interpretation, and beliefs of a selected population (to) gain understanding of a particular issue from the perspective of the group participants*" (Khan & Manderson 1992, p.57). Liamputtong (2010) lists several reasons for a researcher to select focus group interviews:

- It enables in-depth discussion and involves relatively small groups of participants;
- Participants have specific interests which can provide greater detail;
- The interactions between the participants are a unique feature for focus group, in as much as their point of views can be clearly justified;
- The researcher can discover some hidden or unexpected information which may have significance on the research outcomes;
- The interactions encourage some participants to remember issues that cannot occur in a one-on-one interview;
- Reduces misunderstanding of the research questions by participant which may lead to different points of view; and
- Saves time and cost of conducting one-on-one interviews

The participants are asked to reflect on the general efficacy of our approach, the results of the study gathered so far, and asked how such results could be confirmed and/or expanded. The interview questions aim to gather demographic information and exploratory and confirmatory responses for the last phase of the study (see Appendix 12).

3.7.2 Phase 4 Data Collection

Before discussing the final remarks on this research we conduct a supplementary focus group with the lecturers to confirm and inform the entire research. The focus group is conducted in May 2013. To inform the quantitative research findings, there is a need for understanding the results that are more relevant to the study. The sample for a focus group interview is never random as participants are required to have a similar interest and understanding of the interview topic (VanderStoep & Johnson 2008). The focus group participants are sourced from their universities' websites to join the focus group interview. The access to these websites is open to the public and does not need one to have special permission. We are advised that a focus group should include a group of six to ten participants, under the guidance of a moderator, with an interview duration of about one and a half to two hours (Bryman 2012). An invitation letter is sent to 60 programming lecturers from different universities in Victoria. Aiming at a large target population could help ensure the availability of consenting respondents and also improve the diversity of the sample. Six respondents agree to contribute to the interview, but one informed us that they would not be able to attend the focus group at the appointed time. So we schedule a separate interview for that participant at her office on a convenient date and time.

Before the focus group begins, the moderator provides a plain language statement and consent form for each participant (see Appendix 13). Participants are informed that their participation is completely voluntary and they have a right to withdraw partially, completely and/or are free to refuse to answer any questions at any time. The moderator starts the focus group discussion. The focus group moderator begins by introducing himself, welcoming and thanking the participants for their attendance, then, gives a brief summary about the topic of this research and what is required from the participants. All focus group responses are digitally recorded and transcribed with the permission of the participants.

3.7.3 Phase 4 Data Analysis

The qualitative data collected from the focus group is analysed using interpretive analysis technique (Liamputtong 2010). This technique allows the researcher to code themes investigated before in the previous phase, or discuss emergent themes from the comments made by the participants. As expected, the focus group interview helps us infer new ideas and findings, which will be discussed in Chapter 8. Technically, we transcribe the focus group interview data into NVivo10 software for interpretive analysis. We start to interpret the grouped quotes under their themes, then, we group those themes under main themes. The eight major themes include interaction and feedback, collaboration, expectations, novices vs. non-novices, software features, preparation time, resources and active learning with sub-themes for each.

3.8 Scope of This Research

There are certain limitations and boundaries of the research methodology explained above that limit and define the scope of this research. The data collection and analysis in our research design is based on students' self-reflection in evaluating the constructivist mobile-based learning and teaching approach to programming. While no information regarding students' scores and assessment results are collected and analysed, as a first step an initial understanding of students' perceptions is important. Also, we only implement one lecture session at one locale and based the main part of the research in Phase 3 on that. Conducting one intervention lecture is a challenging task in itself as it involves a lot work. The aim is also to focus on one locale to get a deep sense of the task of organising and designing such learning and teaching approach in an environment that does not support the use of mobile devices in lectures. However, following the intervention, we conduct an in-depth discussion with lecturers from different universities and schools. Thus, our research provides valuable findings on how Computer Science students as well as lecturers perceive the move to mobile learning in their teaching and learning of programming and how such a transformation can be achieved. Moreover, our research also produces a research methodology that can be used by future researchers in the field for a robust research design combining methodological triangulation and data triangulation which supports the paradigm pluralism in computing education research as argued by Thota, Berglund and Clear (2012).

In addition, in Phase 3 of the study we were unable to match individual students' responses before and after the intervention as their identities on the survey are kept anonymous due to ethical consideration. As a result, it is not possible to apply independent t-test for evaluating differences as an experiment with a control group. However, a comparison before and after the intervention based on the mean values is analysed in conjunction with the findings of Phase 4 which reveals many considerations and valuable findings for our research.

3.9 Summary

This chapter has set out in detail the methodological procedures for all four phases of the study undertaken for the primary research. Having reviewed the methodological considerations stipulated by other scholars regarding research worldview and methodology, our research select a mixed method approach using concurrent and sequential strategies involving a four-phased research study. The chapter has shown the structure of each phase of the study, its research goals, methods of data gathering and analysis. Chapters 4, 5, 7 and 8 show the results of the analysis conducted on the four phases with reference to the research questions. These procedures are placed in context of previous research and existing body of knowledge. Then, conclusions are made about the best approach to enhance the learning and teaching of programming courses using mobile devices in the lecture theatre.

Chapter 4 - Student Perceptions

4.1 Introduction

This chapter reports the results from the analysis of the first phase guided by the first research question: *How do existing perceptions of students influence their attitude to a constructivist mobile-based learning approach in lectures?* This chapter examines the context in which an intervention is to be tested on in a later stage of the research. It considers needs, perceptions and concerns of Computer Science students to design a constructivist mobile-based learning and teaching programming approach to anticipate any issues and increase the potential of success of the intervention lecture.

Phase 1 reports on the perceptions of Computer Science students about using laptop computers in conjunction with traditional lectures. Quantitative data are collected through a survey (see Appendix 4). We design our survey in three sections: the first section considers students' demographic characteristics. The second section asks questions on the level of readiness of laptop use and usage patterns of laptops among students. The third section consider questions which were formulated on the basis of six important parameters derived from the literature, which include increasing engagement (Kay & Lauricella 2011; Lindroth & Bergquist 2010; Pargas & Weaver 2005), improving learning (Barak et al. 2007; Campbell & Pargas 2003), encouraging collaboration (Simonaitiene & Kutkaityte 2013), potential for distraction (Fried 2008; Hembrooke & Gay 2003), ubiquity of laptops (Demb, Erickson & Hawkins-Wilding 2004; Wurst, Smarkola & Gaffney 2008) and using laptops for non-educational tasks (Hammer et al. 2010; Hembrooke & Gay 2003). The last section includes some open-ended questions. The correlations between students' demographic characteristics and perceptions have also been outlined. The investigation begins with a brief descriptive analysis of the demographic profile of the sample used in this study. Finally, the open-ended questions are analysed and discussed. Thus, this phase is subjected to answer the following questions:

- *What is the level of students' readiness for adoption of a constructivist mobile-based learning approach using laptops in lectures?*
- *What are the students' perceptions of the constructivist mobile-based learning approach using laptops in lectures?*
- *What are the advantages, disadvantages, opportunities and challenges of constructivist mobile-based learning approach using laptops in lectures from the students' point of views?*
- *How can students' demographics and readiness affect students' use of constructivist mobile-based learning approach using laptops in lectures?*

4.2 Participant Profile

A total of 370 surveys were distributed of which 175 were returned, making a response rate of 47%, which is quite high and can be considered to be representative of the population (Bryman & Bell 2007). The demographic profile of the students contains information related to study load, gender, age, and program. The response rate for the four questions regarding the participants profile is high as all 175 participants answered the questions. The results show that male participants outnumber female participants, constituting 86% and 14% of the student cohort respectively. Attendance records show that 91% are full-time students, 75% of the respondents are under 25 years of age and 70% are enrolled in an undergraduate course. Table 4.1 summarises the results.

Table 4.1: Student Demographics, n= 175 Students (Percentage %)

Study Load	Full Time	91
	Part Time	9
Gender	Male	86
	Female	14
Age	Average	21 Years
Program	Undergraduate	70
	Postgraduate	30

4.3 Laptop Ownership/Use

In this section students are asked three questions. First, they are asked if they had access to laptop by answering ‘Yes’, ‘No’ or ‘Willing to buy one’, and if they did not have one they are asked why. Second, students are asked if they are willing to take their laptops to university, and their answers are scaled from ‘Always’ to ‘Not at all’, and if answers are ‘Not at all’ or ‘Rarely’, they are asked to select an answer from a given set of choices to answer why. Third, they are asked their perceptions on university support for purchasing a laptop.

4.3.1 Access to Laptop

Access to a laptop computer is a critical criterion of the students’ readiness. The data shows that the majority of the students (85%) owned a laptop. Of the remaining 15%, 5% were willing to purchase the machine, while 5% prefer using a desktop computer, 3% are unable to afford it and the remainder says they do not use laptops as they have other means of access.

4.3.2 Willing to Take Laptop to Lectures

Students’ willingness to take a laptop to lectures is also another important criterion of students’ readiness, which can affect the success of implementation of laptops as a learning tool in lecture. The result shows that 77% of respondents usually or occasionally brought or would be prepared to bring their laptops to lectures. Those respondents who indicate that they have a laptop but would not take it to lectures offer the following reasons (n = 78):

- Too heavy to carry (20% of total sample)
- I do not see a benefit in using a laptop in lecture theatre (14% of total sample)
- Computer labs are enough for me (14% of total sample)
- I have concerns about the loss, theft or breakage of the laptop (9% of total sample)

- I do not know how to connect to the university's wireless network (4% of total sample)
- My smart or mobile phone does the job (2% of total sample)

4.3.3 Assistance in Purchasing a Laptop

The results show that 65% agree that the university can assist in their purchase of a laptop by providing a discount. Moreover, of those willing to purchase the equipment, the majority prefer the university's offer. However, 35% of the sample do not agree with university-assisted computer purchase, and of these 3% mention concerns regarding the brand and specifications of a university-supplied laptop.

4.4 Quantitative Analysis of the Scale Survey Questions

The survey then proceeds to investigate students' perceptions of the learning experience during lectures using laptops in contrast to traditional lectures. This part of the questionnaire contains questions based on the six pedagogical aspects identified from previous literature. They are designed to reflect a balanced view of the pros and cons of the use of laptops as a learning tool in lectures. Student responses to the questions will be described in the following sub-sections in order of their significance.

4.4.1 Aspect 1: Improving Learning

Survey question: "*Using laptops in lectures assists students to learn the material in a better way*".

Students are asked here if the use of laptops in lectures could improve their learning potential. Figure 4.1 shows that 63% of the students either agreed or strongly agreed that laptops could assist them with various learning tasks in the lecture theatre. About 17% students do not fully agree with any significant benefit in this area and 23% are undecided.

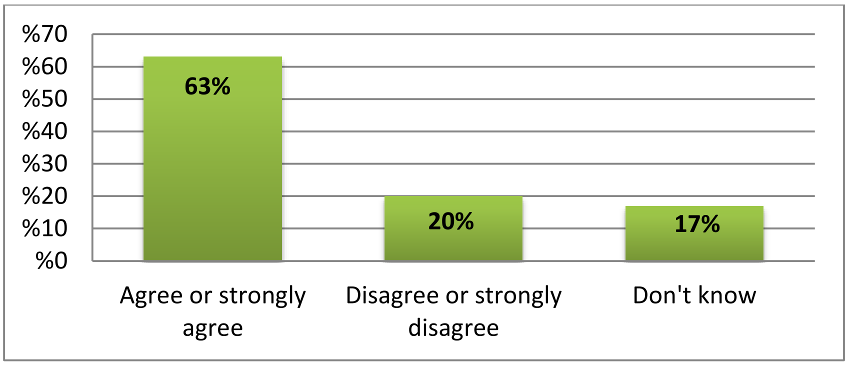


Figure 4.1: Improving Student Learning

4.4.2 Aspect 2: Encouraging Collaboration between Students

Survey question: "*Using laptops in lectures assists students to work together to learn the materials in a better way*".

Communication and collaboration between students on lecture topics is a significant issue in a learning environment. The respondents had somewhat mixed views on the usefulness of laptops in this regard. Figure 4.2 illustrates that over half the respondents (58%) prefer laptops for in-lecture communications on course material, whilst the remaining students were divided over the usefulness of laptop in enhancing group communication and collaboration. While 21% feel that laptops did not assist in communications, the remainder (21%) felt that they are uncertain about any impact.

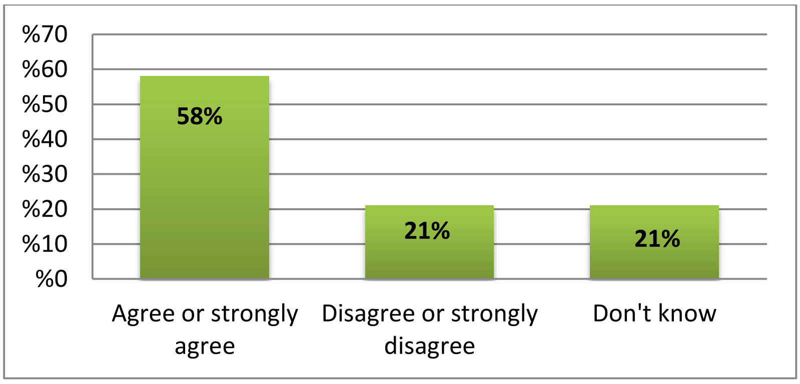


Figure 4.2: Encouraging Collaboration

4.4.3 Aspect 3: Increasing Student Engagement

Survey question: "*Using laptops in lectures assists in delivering more interesting materials*".

This item in the questionnaire asked students about the usefulness of laptops in increasing their engagement by delivering course material in a more effective and interesting manner during lectures. As shown in Figure 4.3, over two-thirds (68%) agree or strongly agree that laptops could enable better course delivery. Of the other one-third of respondents, 14% disagree with the statement while 18% are uncertain about any impact.

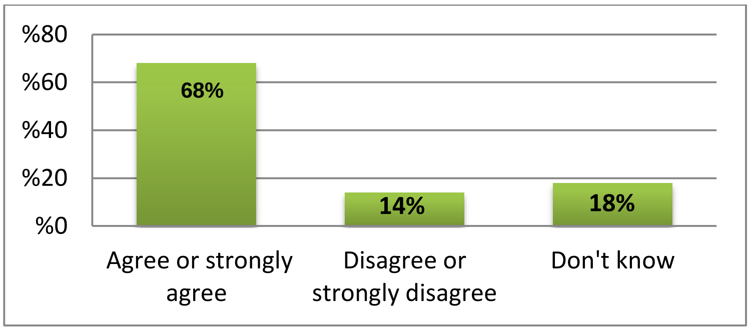


Figure 4.3: Increasing Student Engagement

4.4.4 Aspect 4: Distracting Students

Survey question: "*Using laptops in lectures distracts students from the topic being discussed*".

This aspect tackles the issue that has been cited the existing literature as the most significant disadvantage of laptop use in a learning environment. The question here asks students if they consider laptops to be a distraction in a lecture theatre. As shown in Figure 4.4, 60% agree that laptops could distract them during lectures while 21% of respondents reject this notion and 19% are undecided on the issue.

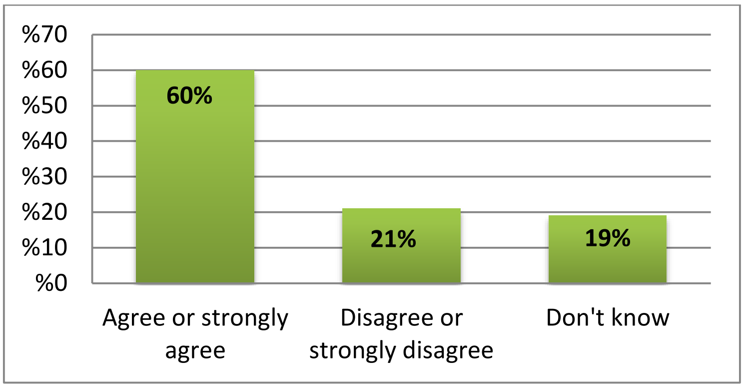


Figure 4.4: Distracting Students

4.4.5 Aspect 5 : Ubiquitous Technology

Survey question: "*Using laptops in lectures is just part of the modern-lifestyle and does not really help on the learning materials*".

This statement relates to a perception that laptop use in everyday life is not so much a matter of their targeted utility but their ubiquity as an ordinary work tool in the modern world. In this sense, the use of laptops as new technology with a role in improving learning efficiency and effectiveness may be exaggerated, as they are just mundane work tools with no significant advantage to add to a learning environment. But only a quarter of respondents (23%) agree with the statement while more than half of the respondents (57%) disagree. The rest (20%) are not sure of their opinion on the issue. Figure 4.5 demonstrates these results as follows.

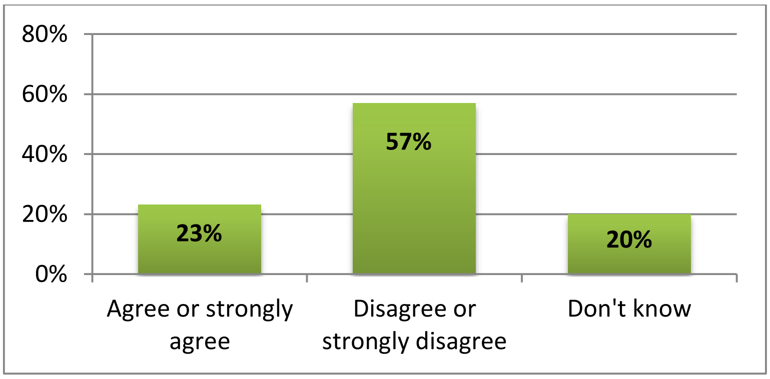


Figure 4.5: Ubiquitous Technology

4.4.6 Aspect 6 : Non-educational Usage

Survey question: "*Using laptops in lectures assists students to only organise non-educational tasks*".

Respondents are asked whether they use laptops for educational or non-educational purposes. This question is answering whether the laptop is merely an ordinary communication tool which is just sometimes used for educational purposes by students. This question would help to not only identify use patterns of laptops by students, but more importantly, to determine if laptops are actually used as a learning tool. As shown in Figure 4.6, over half of the respondents (55%) disagree or strongly disagree with this statement. However, one-third (34%) state that non-educational matters comprise the majority of their laptop usage, while 11% are unsure on this matter.

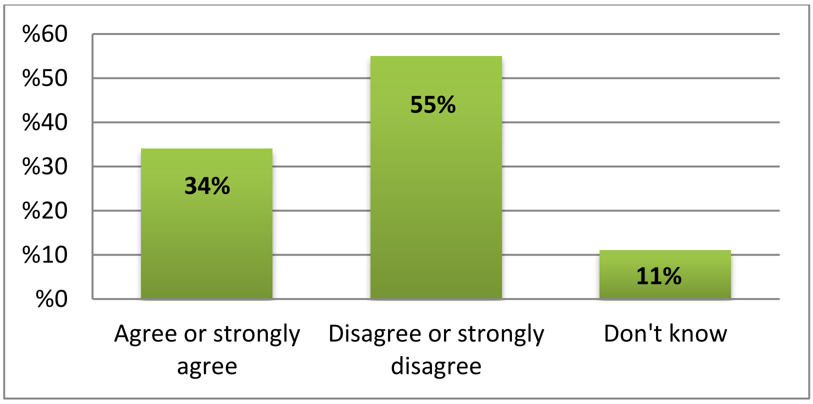


Figure 4.6: Non-Educational Usage

4.5 Correlation between Student Readiness Criteria and Their Demographic Characteristics

This section seeks to identify if differences in demographic profiles of the students could affect students' readiness criteria of ownership and preparedness. A Pearson Chi-squared test is conducted to identify how demographic characteristics such as attendance, gender, age, program, and purchase could affect the readiness criteria of ownership and preparedness among different students.

4.5.1 Ownership

Ownership is only related to the other readiness criterion of preparedness. Students who have a laptop are more highly prepared to bring their laptops to lectures, as shown by the results of the test which are as follows: x^2 (6, n=175) = 17.90, p = .006, r_s = .03. Other than that there is no relationship of significance between ownership of laptop and any demographic characteristics (see Table 4.2).

4.5.2 Preparedness

The students' preparedness to bring a laptop to lectures is also related to the demographic characteristics of age and willingness to purchase. Students who are younger are more prepared to bring their laptop to lectures, as shown by the results: x^2 (9, n=175) = 18.83, p = .027, r_s = .08. There is also a significant correlation between preparedness and willingness to purchase laptops through university discount: x^2 (3, n=175) = 14.76, p = .002, r_s = .27.

Table 4.2 below presents a summary of existing correlations of the two criteria of ownership and preparedness with the students' demographic characteristics discussed above.

Table 4.2: Summary of Existing Relationships between Student Readiness Criteria and Their Demographic Characteristics

Students' Readiness Criteria	**Demographic Characteristics**						
	Attendance	Gender	Age	Program	Purchase	Preparedness	Ownership
Ownership	×	×	×	×	×	✓	-
Preparedness	×	×	✓	×	✓	-	✓

×: No correlation

✓: Significant correlation, p<.05

4.6 Correlation between Student Perceptions and Their Demographic Characteristics

Pearson Chi-squared and Multiple Regression tests are used to identify any link between students' perceptions on laptop use and their demographic profile.

4.6.1 Pearson Chi-squared Test

The Chi-squared test of independence tests the association between two categorical variables. This test is conducted to examine if there are any relationships between attendance type, age, program type, gender, laptop ownership, preparedness to take laptop to lectures and willingness to purchase a laptop through the university at a discount with the six aspects pertaining to their perceptions of laptop use as listed in the following Table 4.3.

Table 4.3: The Six Aspect of Students' Perceptions of Laptop Use

Aspect No.	The Aspect
1	Improving Learning
2	Encouraging Collaboration between Students
3	Increasing Student Engagement
4	Distracting Students
5	Ubiquitous Technology
6	Non-educational Usage

Attendance Type

A Chi-squared test of independence reveals that there is a statistically significant positive association between student's attendance type and their perception of first aspect of improving learning, x^2 (4, n=175) = 13.84, p = .008 with strength of r_s = .21, p = .006 based on Spearman correlation. Moreover, a significant negative relationship is found with aspect 5, ubiquity of technology, x^2 (4, n=175) = 9.96, p = 0.041, r_s = -.22, p = .003. However, no statistically significant relationships are found with the four other aspects.

Age

The Chi-squared test on the age variable show that the relationship with all the six aspects are $p > .05$, meaning that age has no bearing on their perceptions.

Gender

Similarly, there is no gender difference in students' level of agreement on all of the six issues.

Program Type

The program type, whether undergraduate or postgraduate, has no bearing on students' perceptions on all six aspects.

Preparedness to Take Laptop to Lectures

There is a significant relationship between level of preparedness to take laptop to lectures and level of agreement on aspect 1 of improving learning, x^2 (12, n=175) = 82.54, p = .000. The Spearman correlation identifies strong and positive relationship, r_s = .48, p = .000. Likewise, aspect 2 of encouraging collaboration is significant at x^2 (12, n=175) = 52.33, p = .000, r_s = .35, p = .000. A statistically significant correlation is found with respect to aspect 5 at 90% of confidence interval, x^2 (12, n=175) = 29.24, p = .083. Students who are highly prepared to bring laptop to lectures disagreed to aspect 5 about ubiquity of technology (r_s = -.21, p = .005). However, students' perceptions on aspects 3, 4 and 6 do not differ in their level of preparedness.

Willingness to Purchase a Laptop Through the University at a Discount

There is a significant relationship between students' willingness to purchase a laptop through the university at a discount and their level of agreement on aspect 1 of improving learning, x^2 (4, n=175) = 20.13, p = .000. The two variables are positively correlated, r_s = .29, p = .000. Moreover, statistically negative correlation are found with aspects 4 and 5, x^2 (4, n=175) = 10.97, p = .027, r_s = -.23, p = .002 and x^2 (4, n=175) = 18.80, p = .001, r_s = -.19, p = .011 respectively.

Laptop Ownership

Statistically significant relationship are reported on only aspect 2, x^2 (8, n=175) = 19.23, p = .014, however, the two variables are weakly correlated, r_s = .06, p = .40.

Table 4.4 summarises the correlation between students' perceptions of laptop use during lectures and their demographic information in relation to all the six parameters used in this survey. It shows any significant relationship with (✓) under (Sig.) column and the strength of this relationship under (r_s) column based on the Pearson Chi-squared test.

Table 4.4: Summary of Relationships between Student Perceptions and Their Demographic

Aspects*	**Significance (Sig.) and Pearson Correlation (r_s)**													
	Attendance		Gender		Age		Program		Purchase		Preparedness		Ownership	
	Sig.	r_s	Sig.	r_s	Sig.	r_s	Sig.	r_s	Sig.	r_s	Sig.	r_s	Sig.	r_s
IL	✓	.21	×		×		×		✓	.29	✓	.48	×	
EC	×		×		×		×		×		✓	.35	✓	.06
IE	×		×		×		×		×		×		×	
D	×		×		×		×		✓	-.23	×		×	
U	✓	-.22	×		×		×		✓	-.19	✓	.21	×	
NEU	×		×		×		×		×		×		×	

* IL: Improving Learning, EC: Encouraging Collaboration, IE: Increasing Engagement, D: Distraction, U: Ubiquity, NEU: Non-Educational Usage (from question ten in the survey)

Cross tabulations using Chi-squared and Spearman correlation tests are used to choose the independent variables needed for running a multiple regression test (Landau & Everitt 2004). As Table 4.4 displays, attendance, purchase, preparedness and ownership have significant relationship with students' perceptions. However, as ownership has very week relationship, we do not consider it as one of the independent variables. Therefore, the independent variables are attendance type, preparedness to take laptop to lectures and willingness to purchase a laptop through the University at a discount.

4.6.2 Standard Multiple Regressions

The multiple regressions test helps to analyse relationships between metric or dichotomous independent variables and a metric dependent variable. Standard multiple regression is used here to evaluate relationships between a set of independent variables (attendance type, preparedness to take laptop to lectures, and willingness to purchase a laptop through the university at a discount), and the dependent variables of student perceptions of laptop use in lectures (Aspects 1 to 6). See Table 4.5.

Table 4.5: The Dependent and Independent Variables

Independent Variables	Attendance	Purchase	Preparedness

Dependent Variables	IL	EC	IE	D	U	NEU

* IL: Improving Learning, EC: Encouraging Collaboration, IE: Increasing Engagement, D: Distraction, U: Ubiquity, NEU: Non-Educational Usage (from question ten in the survey)

If a relationship exists between the two, using the information in the independent variables will improve the accuracy in predicting values for the dependent variable. Table 4.6 below presents a summary of all the relationships between the independent variables and the six aspects. It shows any significant relationship with (✓) under (Sig.) column and the strength of this relationship under (β) column based on the Multiple Regressions test.

Table 4.6: Summary of Relationships between Student Perceptions and the Independent variables

Aspects*	Significance (Sig.) and Beta Coefficients (β)					
	Attendance		Purchase		Preparedness	
	Sig.	β	Sig.	β	Sig.	β
1. IL	✓	.14	✓	.14	✓	.45
2. EC	✓	.14	×		✓	.36
3. IE	×		×		✓	.20
4. D	✓	-.15	✓	-.20	×	
5. U	✓	-.20	✓	-.13	✓	-.13
6. NEU	×		×		×	

* IL: Improving Learning, EC: Encouraging Collaboration, IE: Increasing Engagement, D: Distraction, U: Ubiquity, NEU: Non-Educational Usage.

Aspect 1 (improving learning)

The independent variables of attendance, preparedness and purchase account for R^2 = 29.1% of the variance in students' perceptions on aspect 1. The overall model is significant, F (3,171) = 23.38, p = .000. The standard multiple regression analysis indicates that attendance (β= .139, p< .05), purchase (β = .143, p< .05) and preparedness (β= .446, p = .000) predict students' perceptions on aspect 1. Preparedness has the highest impact on this aspect compared to the other aspects (see Table 4.5).

Aspect 2 (Encouraging Collaboration)

A significant model emerges at F (3,171) = 10.64, for p = .000. Adjusted R^2 = .16 where attendance (β = .140, p = .050) and preparedness (β = .360, p = .000) are identified as significant variables for aspect 2. However, purchase of a laptop is not found to be a significant predictor.

Aspect 3 (Increasing Engagement)

Only preparedness is found to be a significant predictor of students' perceptions on aspect 3, where β = .201, p = .01. This also explains a significant proportion of variance in this aspect, R^2 = .063, F (3,171) = 3.80, p = .01.

Aspect 4 (Distraction)

Attendance and purchase significantly predict students' perceptions on aspect 4, with $\beta = -.152$, $p < .05$ for attendance and $\beta = -.197$, $p < .05$ for purchase. The two variables also explain a significant proportion of variance in this aspect, $R^2 = .074$, F (3,171) = 4.53, $p = .004$.

Aspect 5 (Ubiquity)

A significant model emerges at F (3,171) = 6.27, $p = .000$. Adjusted $R^2 = .099$, where all independent variables are significant for aspect 5, with attendance ($\beta = -.200$, $p < .01$), purchase $\beta = -.133$ and preparedness $\beta = -.134$ at 90% confidence level.

Aspect 6 (Non-Educational Usage)

None of the independent variables are found to be significant predictors on this aspect.

4.7 Qualitative Analysis of the Open-Ended Survey Questions

The open-ended questions in the survey ask students about their views on the advantages, disadvantages, opportunities and challenges of using mobile technology in a formal learning situation, the lecture theatre. Surprisingly, 86% (n=150) of the students responded to these open-ended questions giving a high response rate. An interesting point is that there is a high level of similar responses from the students for issues not raised elsewhere in the questionnaire. SWOT and TOWS analyses will be used to identify relevant recommendations to facilitate a program for the structured introduction of laptops into the university environment. TOWS/SWOT analyses uses a cross-functional matrix comparing the data to develop appropriate strategies (Weihrich 1982).

4.7.1 SWOT Analysis

This phase of our study is intend for complementary analysis of some of the pedagogical and technological aspects of operational advantages and disadvantages. We gather data regarding the challenges and opportunities for the use of laptops in higher education and analyse the effect of a learning strategy using this technology. The open-ended questions are designed for the responses to act as inputs for a SWOT analysis (Dyson 2004). SWOT is the acronym of (Strengths, Weaknesses, Opportunities, and Threats) a strategic tool for analysing situations and has long been acknowledged in many industries and educational fields as a useful analytical tool for building strategies (Felton 2004). All open-ended questions are categorised on the basis of the four categories and the survey data are analysed to extract themes for each category. Then, the themes were subjected to SWOT analysis. First, the responses of the four categories will be described, then, relevant themes for each category are identified.

4.7.1.1 Advantages

Students cite many advantages of using laptops during lectures. About 28% of students explain that the main advantage of using laptops during lectures is the ability to follow up lecture presentations by accessing PowerPoint slides and other visual material delivered in the lecture. Elaborating this point further, another 5% mention that they could not read charts and other visual material from their position in the lecture hall and it is necessary to revisit this material to understand the point being made. Further, 18% of respondents state that use of laptops enables them to access references and supporting material online, while 19% say that laptops would make it easy for them to take notes during the lecture. About 10% of the students explain that laptops could enable them to access the course material during breaks. Moreover, as students could not use any programs that are not installed by university administration or they need permission to be installed, they appreciate that they would use non-university programs for their preferences which they need to use at university. Additionally, students note that the use of laptops in lectures could assist them to work in groups and share information. Likewise, students value the portability of laptops and the possibility of running programming codes on remote servers. Overall, students note the benefit of receiving on-time information, real-time feedback for their questions, and results of in-lecture testing. The following are some examples of students' quotes:

> "We can try out code given to us and see the results during the lecture."
>
> "Able to go through lecture' slide on laptop."
>
> "Using laptops would be easier to type rather than write note."
>
> "It is portable."
>
> "Students can search for the new materials."

4.7.1.2 Disadvantages

Distraction is the significant issue from our findings (60% in the quantitative section). This point is raised again in the open-ended section. Of the reduced sample, 57% again nominate distraction, and 16% of the respondents further note that distraction came from playing games, music and movies on laptops during the study periods. While there is possibility of being distracted by such activities during lectures the students say that they would observe more restraint in the environment of the lecture hall and abstain from playing games or music. It is especially during self-study periods that they are diverted to non-academic activities on their laptops. A further 17% of the respondents mention that while the use of laptops during a lecture may not only distract the student who is using it, there is a possibility that other students could be distracted by the constant typing sounds or flashing of the screen on laptops of the neighbouring students. Furthermore, students note that theft, loss or breakage could result with carrying laptops to lectures. Time is also a concern mentioned by the students. They note that they could lose time for example by fixing problems. The following are some examples of students' quotes:

> "Laptops can distract students from listening to the lecturer."
>
> "Bulky laptops are hard to carry."
>
> "It may distract both owner and other students."
>
> "I've seen people watching movies and playing games during lecture."

"It is not safe; I heard some students lost their laptops in class."

4.7.1.3 Opportunities

Affordability of purchasing laptops and simplicity of course materials are highlighted as important issues in the opportunities section of the questionnaire. Keyboard and program familiarity are also emphasised as a vital concern. Students say that they would feel more comfortable with using their own laptop, as they could organise their work more efficiently with individualised programs, operating systems, hardware and software. Other student respondents mention that they have data stored in a number of places, and with a laptop, they could consolidate university and personal data. Interestingly, 16% of the students mention that using laptops would be a more environment-friendly method that could help save paper used in making lecture notes. Accessing books, lecture notes, tutorials and other materials electronically instead of purchasing hard copies could also save them money. Furthermore, students note that their collaboration activities could be increased with the use of laptops. Wireless connectivity is also an opportunity of using laptops in order to get the advantages of accessing the Internet and its related actions. The following are some examples of students' quotes:

"It may assist students to understand what the lecturer is talking about."

"All of your files are in one easy spot/ better organization of materials."

"Carrying recourses such as book and lecture notes in electronic way is better, better for the environment."

4.7.1.4 Challenges

Students point out battery life on their laptops as the main challenge facing laptop use during classes. There is significant concern about network speed and availability of cable access points. Further, students express concern that the physical strain caused by using laptops in tightly packed halls with long lectures is far greater than using a PC on an ordinary table for that period of time. This also raises a challenge for disabled people attending university who may not be able to access and use a laptop. Students are concerned about the incompatibility of different operating systems, protocols and platforms, and safety and security of the network. Their software may be incompatible with the systems that the university supports or the university software may be available only on an expensive license. Access to laptops for all students is crucial and some respondents state the need for all university students to be so equipped for such a learning approach to be implemented. The following are some examples of students' comments:

> "The power points are not enough."
> "Sometimes the signal of the wireless connection is weak."
> "Battery life is an issue."
> "Can't assure that all students will have laptops."
> "Compatibility between different operating systems."
> "The tables are not strong enough to hold my laptops."

4.7.1.5 Extracted Themes

A SWOT analysis is selected for this study because it is a mapping technique which organises qualitative data in longer-term aspects that may be addressed by planning. This fits the data on laptop usage and offers a means forward towards a sustainable program. The following Table 4.7 allocates the answers from the open-ended questions into the SWOT analysis for laptop usage in lectures. After listing the main responses within the four categories of questions in the survey, all the themes are subjected to SWOT analysis and listed under the headings of "Strengths", "Weaknesses", "Opportunities" and "Threats".

Table 4.7: Student SWOT Analysis of the Use of Laptops in Lectures

Strengths	Weaknesses
• access non university's programs • search course information • follow up lecture presentations • use breaks and travelling time • assist in group work • share information • portability • instant feedback on queries and results • access internet and email • run code on remote servers for programming students • note taking	• distractions: entertainment • distractions: other • time consuming (math) • large heavy case • theft, lose and breakage • lose time fixing problems • cables are a nuisance
Opportunities	**Threats**
• affordability • simplifies course materials • eliminates wastage and PC availability • environmentally friendly • desktop familiarity • wireless • social	• insufficient power points • network speed and number of access points • lecture tables inadequate for typing • ergonomics • incompatibility of systems • security of the network • free software licenses • all students have to have one (affordability) • training students and teachers • handicapped students

4.7.2 TOWS Analysis

While SWOT analysis lists the content of the four dimensions Strengths, Weaknesses, Opportunities, and Threats. The TOWS analysis is conducted to perform a cross-matrix match considering the following combinations: Strengths/Opportunities (SO), Strengths and Threats (ST), Weaknesses and Opportunities (WO) and Weaknesses and Threats (WT). TOWS analysis is an effective way of combining a) internal strengths with external opportunities and threats, and b) internal weaknesses with external opportunities and threats to develop a strategy. Table 4.8 presents potential options based on TOWS analysis as follows.

Table 4.8: TOWS Analysis of the Use of Laptops in Lectures

	External Opportunities	**External Threats**
	1. Affordability 2. simplifies course materials 3. eliminates wastage and PC availability 4. environmental friendly 5. desktop familiarity 6. wireless 7. social	1. insufficient power points 2. network speed and number of access points 3. lecture tables inadequate for typing 4. incompatibility 5. security of the network 6. free software licenses 7. all students have to have one 8. training students and teachers 9. handicapped students
Internal Strengths	**SO – Options**	**ST - Options**
1. access non university's programs 2. searching course information 3. following up lecture presentations 4. use breaks time 5. assists in group work 6. sharing information 7. portability/mobility 8. instant feedback on queries and results 9. access internet 10. run codes on remote servers for programming students 11. note taking	A. transforming traditional lecture to active learning environment (S2S5S6S8S10O1O2O6) B. providing collaboration environment (S5S6O7) C. saving environment (S7O4O6).	A. provide online training sessions for users (S9T8). B. publicise software available for downloading and /or recommending web-based software (S1S9S10T4)
Internal Weaknesses	**WO – Options**	**WT - Options**
1. distractions: entertainment (e.g. playing games, watching movie) 2. distractions: other 3. time consuming (math) 4. large heavy case 5. theft, lose and breakage 6. lose time fixing problems 7. cables are a nuisance	A. reduce the time that students may waste by getting the advantage of their familiarity with their laptops (W3W6O5) B. laptop's affordability may minimise distracting other students in which all students have one and avoid heavy cases(W2W4O1) C. organisze interesting learning materials and use of web-based application or specific software to minimise the distraction (W1O2O6)	A. issues of distraction and damage to laptops to be addressed through security and training measures (W1W5W6T8) B. power outlets and wireless connectivity can be provided throughout logistic arrangement (W7T1T2)

Each quarter of options in the Table 4.8 above combines two of the four dimensions of SWOT analysis. For example, Quarter of (SO - Options) lists set of recommendations by combining (Internal Strength) with (External Opportunities) coding them as S (no. of a Strength) and O (no. of an Opportunity).

4.7.2.1 Strengths and Opportunities (SO)

This combination seeks to determine how internal strengths of laptop usage in lectures can help capitalise on external opportunities. Respondents note that there are benefits in undertaking group work and sharing information as collaborative learning could help students to gain greater understanding of the material under review. All the benefits relating to learning enhancement, such as easier access, follow-up of media presentations and the ability to search for information, assist in transforming the traditional lecture to an active learning environment. Accessing learning material and writing lecture notes on these portable devices is more environment-friendly as it would help save paper.

4.7.2.2 Strengths and Threats (ST)

The internal strengths identified in mobile learning can help avoid external threats. Incompatibility of software or hardware is cited as one of the main threats in using laptops in lectures. In this case, Internet access can help provide training sessions for student and faculty members to further improve their laptop use. Universities may also list all possible programs or applications that work with different operating systems and students can download the appropriate programs.

4.7.2.3 Weaknesses and Opportunities (WO)

This theme determines how the internal weakness of laptop usage in lecture can be eliminated by using external opportunities. Opportunities can frequently overcome weaknesses. For example, desktop familiarity can be exploited to minimise the time students may take to fix some problems. Also, since laptops are affordable, all students could easily purchase laptops. Therefore, if all students have laptops, this may decrease the possibility of being distracted by other students. Affordability may also enable students to buy an appropriate case to carry their laptops as this is mentioned as being cumbersome and problematic by few students. Simplifying and organizing the course material in an interesting way may reduce the distraction problem.

4.7.2.4 Weaknesses and Threats (WT)

Reducing weaknesses and avoiding threats can be achieved through the options outlined in this section. Training can be conducted to improve communication and computer skills and provide resources for appropriate pedagogic use of laptops in lectures. The analysis shows that availability of wireless connectivity and power supply outlets should also be addressed.

4.8 Summary

The purpose of Phase 1 is to examine students' perceptions of the mobile-based learning approach in traditional lecture environment and gauge students' readiness by investigating patterns of ownership and use of laptops among students. These aspects were then correlated with their demographic characteristics. Therefore, the two main areas explored in this phase (student perceptions and student readiness) help us understand the potential of mobile devices like laptops as a learning tool to enhance traditional lectures. Further, they assist us to recognise and identify factors that could motivate or hinder the implementation of such an intervention.

Our findings show a high level of student readiness as the majority of respondents are willing to take their laptops to lectures and a high percentage of students own laptops. All these factors validate the focus of this research on the possibility of capitalising on the widespread use of laptops by students to implement them as a learning tool. Results also show interesting correlations between students' perceptions of such learning environments and their demographics. Preparedness was found to have the highest impact. Therefore, students' level of agreement on the positive trends of such mobile-based learning approach could be predicted by their level of preparedness. In addition, age and willingness to purchase university-assisted laptops were found to affect students' preparedness to bring laptops to lectures.

The students' views on using a laptop in lectures are generally positive, with more than half of the respondents indicating a positive attitude to the trend. The exception is the distraction element, where the majority agreed on this negative aspect to laptop usage. Therefore, to identify potential issues regarding distraction, and the negative responses received, analysis of the qualitative aspects of this questionnaire, the open-ended questions, were discussed and analysed.

Investigating all four quadrants of the SWOT analysis (Advantages, Disadvantages, Opportunities and Challenges) not only provides rich and varied information but also enables a strong cross-matrix analysis for SWOT. The results show that the quantity of responses relating to strengths is the highest for all the other quadrants in the SWOT analysis. This not only holds importance as a research finding for the literature but indicates that the practical application of mobile devices in higher education has a vast array of strengths to draw on. Further the opportunities identified in this survey also shows great prospects for better utilization of mobile-based learning approaches. In turn, the strengths and opportunities identified here also guide this phase to develop some recommendations to overcome the weaknesses and threats.

Chapter 5 - Lecturer Perceptions

5.1 Introduction

This chapter reports the results from the analysis of the second phase of the study guided by the second research question: *How do existing perceptions of lecturers influence their attitude to a constructivist mobile-based teaching approach in lectures?* This chapter examines the context in which the intervention will be tested. It considers the attitudes and perceptions of Computer Science lecturers about the design and the use of a constructivist mobile-based teaching approach and how it is aligned with their needs, perceptions and concerns to increase the potential of success.

Phase 2 focuses on investigating Computer Science lecturers' perceptions on the use of mobile devices by their students in programming lecture theatres to practice the concept being taught. It also focuses on lecturers' teaching methods to deepen the understanding of the nature of programming lectures and problems in teaching programming. Qualitative data are collected through interviews with seven lecturers. The participating lecturers are first asked about current teaching methods and traditional course delivery, then, they are questioned about their perceptions of using mobile devices in lectures (see Appendix 6). The analysis aims to show how the use of mobile devices in lectures with their teaching methods would be possible with the following questions:

- *What are the lecturers' teaching methods for the delivery of programming lectures?*
- *How ready are the lecturers for a constructivist mobile-based teaching involving the use of laptop computers by their students during lectures?*
- *What advantages and disadvantages do lecturers perceive in the constructivist mobile-based teaching approach using laptops in lectures?*
- *How can lecturers' existing teaching methods affect their tendency to adapt the constructivist mobile-based teaching approach?*

5.2 Participant Profile

A rich amount of data were gathered and analysed from the seven interviews. The teaching experiences of the lecturers in programming ranged from six to thirty years. All the lecturers were male. The courses that they were teaching vary from introductory to advanced programming. The substantive differences in teaching experiences and type of programming courses enriches the diversity of the data. Table 5.1 lists the participating lecturers' years of experience in teaching programming and the programming course defined in terms of its objective.

Table 5.1: Characteristics of Interviewees

Participants	Years of experience	Courses' objectives
P1	8	"Introducing basic concepts, the basic features of Java and advanced in C programming"
P2	20	"In programming 1, the main objective is to develop problem solving skills so that students can write programs of reasonable size with up to 500 to 1000 lines."
P3	30	"The objectives are to cover the basics and some very simple Object Oriented concepts in Java"
P4	11	"The objectives are to teach things like data structures and C language. It is assumed that people have already done programming before they start this subject"
P5	6	"The objective in this program is not teaching programming as such rather the aim is to educate students from non-programming backgrounds how to think in a linear logical way as a programmer"
P6	13	"The course teaches programming in C to second year students, who have done Java or had some programming background"
P7	12	"This program teaches introductory Java and C programming languages"

Themes are then constructed from the patterns that emerged from the raw data. The data has been classified into two major themes, teaching methods and mobile device usage and several sub-themes for each.

5.3 Theme 1: Teaching Methods

The first theme, teaching methods refers to the lecturers' approach to teaching programming courses. The discussion focuses on how the lecturers teach their course, the technology they use, and their approach to motivate their students. The participating lecturers have a variety of teaching approaches which have been classified under the following sub-themes.

5.3.1 Discussion and Interaction

Participants refer to discussion and interaction as important components of their teaching style. In fact, lecturers often spoke simultaneously of discussion and interaction as they are related to each other in the sense that increasing interaction will increase discussion. The participating lecturers adopt different methods for encouraging discussions and interactions between students and instructor. However, some concerns are also raised.

One lecturer for example encourages interaction by actively inviting students to write some programs on paper. Then, he asks them to give him their feedback and develops the program in front of them to discuss solutions. Pointing out the importance of discussion and interaction, he notes:

> "It tends to be fairly interactive … so typically I would invite students to write some programs themselves and I would sort of develop it in front of them and getting their feedback, sometimes I even invite students to come and do it on the computer" [P2].

This is support the claim that Personal Response System "Clickers" increases interaction and activity by providing immediate feedback to the lecturers (Duncan 2006; Hall 2013; Lantz 2010; Morling et al. 2008).

Alternatively, another participating lecturer tries to elicit as many different answers as possible from students. He gives students small problems to work on then he asks two students to come up and write their solutions on the board after separating it into two sides. Rather than the lecturer demonstrating the solution, this method allows students to develop their own answers and identify the proper solution through comparison and discussion. He argues that this encourages students to be more proactive and imaginative in their approach to the problem and other students also become engaged in a discussion to suggest their answers.

Apart from these approaches, some lecturers use technological means to increase interaction and discussion among students. For example a lecturer who likes to draw and write during his lectures to demonstrate a problem or a concept used a document camera to encourage discussion; he says:

> “A typical lecture even though … will have a good mix of presentation, use of document camera for discussions” [P3].

However, concerns have been raised by the lecturers regarding lecture theatre’ size and time which affect discussions and interactions. It is hard for a lecturer to give feedback to individuals in a lecture with large number of students. Therefore, the interaction between students and lecturer could be affected. One participating lecturer notes the following:

> “The most difficult one would be the lecture format is not a 100 per cent great for doing an interactive style. I have got 298 students enrolled. It is very hard to make sure that I get round to all the questions the students might have because there are so many students” [P5].

Moreover, one participant raises his concern about the time consumed by increasing discussion between students and instructor instead of completing the topic at hand. This participant prefers to embed the discussion in his lecture by simply asking students if they understood the concept or had questions. He explains:

> “We do discussions but not a huge amount because we do have a large number of course materials to cover … so the opportunities for discussion only come when I ask questions on whether they actually understood the concept or whether they have some specific questions” [P1].

Lecturer P2 feels that in a large lecture theatre students may feel too self-conscious to contribute to a discussion, and this would reduce motivation and affect the learning process. Lecturer P2’s issues regarding size of lecture theatre are directed not only to the lecture format, but consider the students’ social environment:

> “Some students feel intimidated in the lecture environment because it is a big hall . . . So, motivating the students by reducing their fear of participation; they are the things that I actually find difficult from the teacher’s perspective . . . the lecture format and large class size has to be addressed” [P2].

In addition to the lecture time and size the course design is another concern reported by participating lecturers. Lectures, tutorials and laboratory work comprise the traditional approach to curriculum delivery in universities. Lecturers make presentations of concepts and information. Tutorials consist of discussion forums for the material learnt in the lecture and laboratory work provides the practical setting for testing that knowledge. Generally, the course design of programming courses consists of a weekly schedule of three hours of lecture, two hours of tutorials and two hours for laboratory work for 12 weeks. Although students seem to benefit from this format, the participating lecturer suggests the need for redesigning curriculum delivery to improve teaching strategies.

Some lecturers criticise the separation of lectures, tutorials and lab work in this traditional method as it hampers holistic learning and interactivity. One lecturer prefers an interactive workshop environment merging lecture and lab work at the same time. This lecturer prefers the workshop environment for its student-centred approach as it helped in increasing feedback, interaction and discussion.

> "Doing it as a workshop will be fantastic. I would like a two-hour block where you are in the room, they have got a computer in front of them and you are doing a combination of lecture tutorial and lab. In a workshop environment we can collaborate together. I think it will be very productive" [P5].

Another participant reinforces the same claim by saying that students contacting one person (lecturer or tutor) and getting familiar with him/her is better than dealing with two or three of them.

> "The problem is that often the lecturer, tutor and lab assistant are all different persons, so the students do not really get to know you well and the lecturer does not know the students well" [P2].

The participating lecturers have various ways of encouraging interactions and discussions between students and instructor either by questioning and answering, presenting concepts or actively asking students to practice something on paper. However, they are all concerned about the traditional course delivery.

5.3.2 Practical Exercises and Examples

The analysis of this section will be discussed from two different angles, focussing on the practical examples demonstrated by lecturers and practical exercises that the students are asked to do during lectures. Generally, all the lecturers mention the use of program code examples for explaining new concepts in addition to the power point slides. However, some lecturers also have some concerns about students practising exercises in lectures.

Practical Examples by Lecturers: The participating lecturers agree on the importance of demonstrating practical examples during lectures. It is acknowledged as a critical method for adapting situated learning for students in lecture. Lecturer P6 notes the advantages:

> “Well, try to give them examples so they can see, understand and relate better to the concepts rather than just giving them abstract definitions” [P6].

Moreover, P2 mention ‘thinking aloud’ as a strategy for promoting better understanding and engagement. He illustrates this:

> “I do write the code but by thinking aloud, I talk through the rationale of each step of the process. The students really like that because when they see a program being written they do not know what went through person’s mind. But when you are explaining to them and writing it at the same time, they grasp it better” [P2].

Furthermore, lecturer P3 points out that the use of practical examples not only facilitates better lecture delivery it also increases discussion and engagement. He says:

> “You know seeing is believing so when you do something in the lecture and run a program they see that it produces the results you expected to … so they can ask questions about the behaviour of the program … it creates discussions which I think is good not just for the individuals who are asking the questions but for others as well” [P3].

Likewise, one participating lecturer adds that teaching programming must be a ‘hands-on’ process where students do not merely learn the abstract concept but understand how it is applied. He relates the importance of practical examples for allowing such a ‘hands-on’ approach in lectures. This lecturer appreciates hands-on practice because he is concerned about the actual ability of students in practicing or doing programming on their own later. He explains:

> “I think the more hands-on I am during my lecture, the more chance there is of the students getting in to the process as well. In many classes,

> students do not get hands-on the subject, a lot of them study in theory until the assignment comes up. But the first two weeks I do not think anyone touches the computer … I mean they do not do any programming" [P4].

Lecturer P6 reinforces that claim and notes that:

> "The most frequent problem is students do not spend enough time practicing so they assume that they understood the concepts. But they actually do not, so I always tell them to practice more" [P6].

Lecturers P5 and P6 describe two common methods for using practical examples. The first method is presenting power point slides and demonstrating small coding examples to explain new concepts by switching between them. This shows students how to compile and run a program code. The lecturer also makes some changes, and then recompiles it to make the students see the changes. The second method is producing a problem to the students and asking them to think, solve and suggest solutions. The exercises range from filling the blanks to writing lines of codes. The answers from the students are compiled, debugged and tested. The results and outputs are to be discussed with the students. Examples of both methods were illustrated by lecturers P6 and P5.

> "We switch between the two, the slides and small coding examples … actually we demonstrate how to compile and run and make some changes and then recompile to see the changes" [P6].

> "We do a lot of experimental building asking feedback from students through the process. We say ok let's take that and try to build it and see if it works. Quite often what the students suggest have a logical error, but I try their solution and show them the error" [P5].

Although the participating lecturers highlight the strengths of this approach, a few others are not as enthusiastic about doing practical examples. For example lecturer P3 notes that:

> "I'll use my access to the Unix machine for the students to compile, run and debug these programs. But that only happens three or four times during the semester" [P3].

Moreover, one lecturer prefers the way of presenting the lecture materials with power point slides. He explains:

> "In lectures I use slides and also give them small coding examples but still mainly I talk" [P6].

Practical Exercises for Students: Lecturers vary in their opinion on the efficacy of allocating practical exercises to students during the lecture. P1 raised a concern about lecture time:

> "It is hard to ask students to do practical exercises; we do not have time to do that" [P1].

Another participant supports the traditional method of separate lecture/lab work module and argues that these practical exercises do not need to be done in lecture.

> "No, not really, I do not ask my students to do practical exercises. The practical exercises are to be done in the lab. In the lecture, I am trying to show and run the code but they do not have to do that" [P6].

However, there are lecturers who appreciate the fact that the students would be actively engaged during lecture if they are asked to do practical exercises. Two examples were:

> "The traditional lecture model is too time consuming, but if the students could try the program that we are discussing in class . . . then that would be good thing" [P3].

> "Typically in my lecture I will have after two or three slides for exercises, either filling the blanks or multiple choice questions … or possibly writing a few lines of code. So every 15 minutes, the students are made to do some exercises. It does slow down the lecture because obviously we need to stop every fifteen or twenty minutes but I think that the price will be (worth it in the) end" [P2].

The discussion above shows that there is greater support for practical examples by lecturers than practical exercises for students. This can also be seen as reflecting the dominance of lecturer-centred approach in current practices of teaching programming.

5.3.3 Engagement

Engagement is a very important aspect for teaching and learning, particularly, for a subject like programming. All lecturers report many interesting techniques of engagement based on their beliefs about good teaching. Each lecturer considers a specific way to engage students, either focusing on the type of examples they use or the way they presented the lecture materials. There are some examples of lecturers and their methods of engagement.

> "I found that using analogies from daily life was extremely useful in engaging students … so when you describe new concepts, if you can connect it to news or new movies or something in the media, they find that very interesting" [P1].

This lecturer P1 is attentive to the type of examples he used when describing new concepts to attract students attention. In addition to engaging students, interesting examples also enable students to remember the hard concepts. He notes:

> “And if you give vivid examples, this would make it easier for them to remember difficult concepts” [P1].

Visual presentation of concepts and animation are pointed out as another factor to encourage student motivation. Lecturer P2 mentions that:

> “I play snakes and ladder game where the snakes are actually moving around on the board. When they see an animation with a game, they get a lot more motivated” [P2].

This lecturer believes in the importance of a “seeing is believing” approach, so he makes sure that the students can see the program working in real time as it is being taught.

> “The factors that makes teaching programming enjoyable is developing the programs with them and showing them the way it works … when they see something working in action, something they can relate to, obviously they will be really motivated” [P2].

Scholars argue that students’ engagement and motivation are achieved when the learning environment embraces an active learning process using technology as an aid for instruction (Biggs & Tang 2011).

Furthermore, one participating lecturer P4 feels that articulating a clear agenda about the lecture is important.

> “The way I motivate students is to tell them why this is useful, why they are learning this, at the start of every lecture” [P4].

Some of the participants, however, note that putting together students with different knowledge levels and needs in the same course, often posed a challenge to the lecturer. The growing number of students increases the level of discrepancy in their background as they come from different sources; some would be postgraduate or undergraduate, some would have been in industry. Therefore, in a single class there could be students who have no or little programming experiences and very advanced programmers. Consequently, questions raised during lectures from more advanced learners may be difficult for the rest and those raised by the novices could be irrelevant or boring for the others. Some lecturers find it difficult to organise course content and assignments that are interesting and relevant for all students. Lecturers P2 and P5 note the problems in catering to the needs of diverse students:

> "Sometimes we're given assignment that is related to accounting and some students have replied that they are not interested in accounting" [P2].

> "I try and find concepts that are suitable for the degree they are doing. It is a bit difficult because we have got students from different degree courses taking the subject. But in the lecture I try and have something that really balanced with each particular group" [P5].

The large number of students in lectures causes difficulty in controlling diversity of students. One of the participants mentioned that:

> "The good students get the concepts very fast and become very excited about the subject, they respond to you almost all the time. [However,] there are 20 to 30 % of the students who are slow to get the concepts … they do not ask questions" [P1].

This argument is also made by two other lecturers. They suggest an approach to avoid such a problem by grouping students based on their ability and learning experiences:

> "Definitely one way you can improve programming is to have a small class size where you are able to stream them (students) according to their ability" [P5].

> “So if you really want to resource with no constrain you would have a classroom base teaching” [P2].

5.3.4 Feedback

The feedback which lecturers receive from students is a crucial indicator of the efficacy of their teaching methods and course materials. The participating lecturers mainly rely on the assessments to get feedback from students. The assessments are assignments, demonstrations and exams. In lectures, they depend on questions and answers raised by students or students’ facial expressions. As lecturers are not sure whether students understand the lesson, they employ a range of interrogative methods to get immediate feedback. For example, lecturers P1 and P2 specify the following methods for immediate feedback during the lecture.

> “I conduct two or three quizzes with small questions in every lecture, where the students just raise their hands and answer on spot. Also I look at the faces … if they look blank you know that they did not get the concept” [P1].

> “Typically what I do is put some multiple choice questions which gives them a code and asks them what the output is … and the students respond by putting up their hands” [P2].

Weekly meeting with tutors and lab assistants and assignments are another medium for lecturers to get feedback. Lecturer P1 describes this.

> “After the lecture you have a weekly meeting with tutors and lab assistants, they give us feedback.” [P1].

A quote from lecturer P5 supports the usefulness of the assignments as a form of feedback.

> “I find that particularly the assignments motivate a lot of deep thinking about whether they really understand the concepts and provoke them to think about their problems and questions” [P5].

However, lecturer P3 argues that one needs to talk to individual students to get real feedback. He claims that students’ results might not be reflected with their assignments or even exams. He says:

> “I think we do not get a real idea of the situation until we actually talk to individual students because the results from an assignment are not always a good indicator. They could have got some help from others which is fine, they could have copied which is not fine, or they could have managed to do something because they’ve seen another example but they do not know why they’ve managed to do it” [P3].

Exams are another way to measure student understanding and competency in a course. But while one lecturer points out that exams could have some issues with accuracy, another pointed out that exams are too late for teachers to act on any feedback from the exams.

> “The other thing is exams but how do we know that exams are an accurate indicator … again you know many of the exams have multiple choice questions … have they just guessed the right answer?” [P3].

> “The only way you can know if they have learnt anything is by their performance in the exams. But then the final exam is too late … we want to find out what they did not understand earlier during the course” [P4].

Therefore, the lecturers are concerned about the lack of any tangible means for immediate feedback that could help them take immediate steps in the direction of remedying gaps in students understanding during the lecture itself.

5.3.5 Technology Used

The participating lecturers mention some of the technology devices they use for the delivery of the course contents during lecture. Lecturers use laptop computers to run power point slides, *Lectopia*[1] for recording the lecture, Eclipse for running program codes, Internet, projector, document camera and whiteboard. While the technologies used by the participants are the same, some lecturers rely on technology more than others. The lecturers also point out some of the devices their students use during the lecture. For example lecturers P3, P6 and P7 note that:

> "These days we use document camera or overhead projector because I like to write things and give examples and draw ... and the laptop computer to show the power point slides and programs to be run" [P3].

> "I use a laptop with power point and Eclipse, Java environment. I also use another interface called Alice that provides programming concepts in a very graphic way" [P7].

> "We use code examples and run them directly on the server which is connected back to Yallara. This shows them running examples under the server and we use *Lectopia* to record the lecture" [P6].

Another lecturer P5 relies a lot on an old technology, the whiteboard. He says:

> "I use the whiteboard a lot. This is very old technology but I like to write stuff. I take example from students and I work with them. I get them to come and write on the board. So I use it a lot" [P4].

On the other hand, all the participating lecturers notice that some of their students used laptops in the lecture hall. The lecturers vary in their opinion about the use

[1] Lectopia is a lecture capture and delivery system. It can record audio and visual presentations, e.g. accompanying Power Point presentations.

of laptops by students in lectures. Some of the lecturers are positive about this trend.

> "I think most of them rely on the laptop. I can see many compiling the sample program during the class and asking questions. Not everyone but there is quite a large number looking at the computer and comparing with the slides. I think that is a good thing, if they do that I think it is better" [P1].

Moreover, lecturer P2 even feels that it is often the good students who use laptops during the lectures as they are more earnest about practicing the code being taught in the lecture.

> "I have seen some good students who have their laptops" [P2].

However, there are lecturers who are not as positive about this trend as they are not sure if the students are using their laptops for learning.

> "There were few students who had laptops but I do not know whether they were using it to listen to me and take notes or they were doing other things" [P3].

> "Some students use their laptop, but I do not like it. I want them to focus their attention on what I am saying in the lecture rather than doing other things" [P6].

The responses show that all participating lecturers use laptops for their teaching either for presenting power point slides or running program codes. Moreover, some students also use their laptops in the lectures although there are no structured instructions for using them and the lecturers vary in their opinion about this trend.

5.4 Theme 2: Mobile Device Usage

This discussion deals with the participating lecturers' opinions on the use of mobile technology by students during the lecture. It explores the advantages and concerns noted by the lecturers. Furthermore, it relates the participants' opinions with their teaching methods and course objectives.

5.4.1 Lecturers' Readiness

From the data analysis, six of the seven instructors express positive opinions about the use of mobile devices by students in lectures. The majority state that it would be a good practice to have such technology in the programming lecture environment, and to allow their students to use it for learning purposes. The grounds for their views are as follows:

> "Definitely, yes. I am happy if students bring their laptops ... and they are doing this anyway. If we implement this in a structured way then, yes, I think it will be beneficial as a useful tool for programming. That's for sure" [P1].

Other lecturers P4 and P2 feel that the use of laptop during lectures is suited to the nature of learning programming as it is a practical skill that needs to be applied as it is learnt.

> "I think in programming, 'hands on' is the best way (towards) learning. So I have no objection if they all have a laptop in front of them. They could type activities and I could tell them, let's do this or that activity. It would definitely be helpful" [P4].

> "I think what you are doing on mobile devices can enhance learning programming because programming is very much a practical skill. Therefore getting them to write programs in the lecture makes the whole learning process more interesting for them" [P2].

As these responses show the participating lecturers appreciate the use of mobile technology in lecture. There is one exception to this. Lecturer P6 prefers the current approach of teaching programming. He believes in the traditional lecture delivery and could not see any benefit from using mobile devices during lecture. He notes:

> "My personal thought is that using laptops in lecture can be very distracting, so I am very worried whether to adopt it or not" [P6].

Overall, most lecturers are positive about the use of laptops as long as it is implemented in a structured way for the purpose of learning, but one participant feels that the distraction from the use of mobile device in lectures makes it less preferable to traditional lecture delivery.

5.4.2 Advantages

Instructors who agree on the use of mobile technology in their lectures are asked to list some potential advantages. One lecturer thinks that introducing devices such as tablets and laptops could make the lecture more interesting and enjoyable to engage and motivate students.

> "When the students are all well-motivated they are going to learn better, because it's going to make the lecture a lot more enjoyable rather than just listening to the lecturer. Using laptops would also be more interactive than just writing on a piece of paper" [P2].

Another lecturer appreciates the immediacy of testing a program. He mentions that it may encourage active learning by helping students to write, compile, and run code instantly during lecture.

> "I would not mind if they use their laptop when you give them activities to do. They can use it to code, compile, and run a program. It is perfectly

> expected for people to use the compiler as a means of correcting themselves” [P4].

Lecturer P4 also feels that doing exercises in lecture on laptops may increase students’ understanding, however, he feels that there needs to be a specified time for such activities during the class.

> “That’s useful because I think programming is about hands on learning, about doing exercises. So for me, it is about getting students to understand what they learnt, but I would only use it 15% of the lecture time” [P4].

In addition to students’ understanding, P2 mentions that using laptops for actual exercises has the potential of improving students’ skills as they could see the results of their efforts instantaneously.

> “Good students obviously are very motivated students. Using laptops can improve their skills further. If you ask them to write an algorithm they can write it and see how it is working, how many steps they are writing and so on” [P2].

Furthermore, the use of mobile technology in lectures could help students to take notes. P7 notes this advantage:

> “They could have the slides on the laptop so they could take notes straight away. Normally we have printed lecture notes and some people bring them and some people forget to bring them in the class, and then if they want to make notes, the notes and the slides are in different places. So I guess if they all brought laptops to access the slides, they could add notes straight away” [P7].

Lecturer P5 see the advantage of having everything stored together in the laptop. He notes:

> "Students can have their lecture notes, assignments and everything in one device so they do not have to carry all of those notes or books separately" [P5].

Moreover, lecturer P7 points out that laptops act as a communication device for some students who could be shy to orally ask questions in lecture. He says:

> "I think a shy person, who does not want to verbally ask the question, could email the question" [P7].

In summary, the advantages of laptop use by students during the lecture reported by the participating lecturers touches on many aspects of learning improvement. Laptops could be used for increasing students' engagement, improving student's skills, and increasing students' understanding. In particular, laptops could be used as a device for taking notes, storing everything together, facilitating communication, practising exercises immediately in the lecture.

5.4.3 Disadvantages

Apart from the advantages, lecturers also mention possible drawbacks of using mobile technology. The analysis extracts three problems from the responses given by the participants. The participating lecturers agree that the main problem of using laptops in lectures is the potential for distraction. As an example lecturer P7 notes:

> "The negative aspect is that in a lecture theatre with two to three hundred students, if some students are playing games or playing some movies or something else they are not only distracting themselves but also distracting others" [P7].

Furthermore, lecturers note that there are a whole host of logistical issues relating to the use of mobile devices, including, battery life, power points, wireless connection, lectures theatre seats, lights and tables. All these issues are out of lecturers' or students' control. For example, lecturer P5 worries about the usefulness of using power points at the school.

> "As far as I know, the proper protocol for students bringing their laptops and plugging them in to the labs has not been resolved by the school" [P5].

Participating lecturer P2 notes that a minor issue like lighting could easily disrupt students if they mistype something because of the light. He says:

> "Because the lecture environment is not suitable for serious programming, if the lighting is not good they might actually mistype some characters and some typos are quite difficult to check" [P1].

While the use of laptops for practicing exercises is generally appreciated, this also poses some potential problems during the lecture. Lecturer P3 explains:

> "If 300 of them had laptops and I said try this program see what it does, I think there would be a lot of problems. Some students being able to do it or some people not even starting because they cannot find Eclipse or something like that or their laptops are not working or they cannot get internet" [P3].

Despite this, students who may be able to try the program might also experience problems too. Participant P1 notes:

> "Most likely students will have some problems and some questions while practicing exercises. It would be very difficult in the lecture to give individual help for the people sitting in the lecture" [P1].

To sum up, the three key disadvantages reported by the participating lecturers are:

1 loss of control in the difficulty of knowing whether the students are working on the course materials or have been distracted with something else;
2 loss of control on providing the proper environment that covers all the logistical problems;
3 loss of control on providing individual help for students either because they are facing problems on the tested program or they have not started the program at all.

Although some of the disadvantages noted above can be mitigated by using SRS system with BYOD's described in the literature review chapter, for programming, the problem with SRS is the lack of suitable software applications such as ones that allow small pieces of code to be written and run. Thus, the use of software that allows students to try their code would help cover such a problem.

5.4.4 Challenges

This sub-theme of challenges deals with issues that can obstruct the encouragement of mobile devices use in lecture to achieving learning outcomes. Course delivery, lecture' time and size are all issues that the lecturers feel pose challenges to a proper implementation of a learning approach based on laptop use by students in the lecture. Some lecturers argue that before having a mobile-based teaching approach it is critical to implement a policy of small class size.

> "In a small classroom, this can be very effective. But I am not sure about a big lecture theatre where you have no control on what the students are doing. I have noticed in the past that some students disturb others and are unable to focus on the task" [P2].

Moreover, two other lecturers are concerned about compatibility of the traditional lecture model with this new method. P3 feels that the design of the course delivery in lecture, tutorial and lab are not suited to laptop use.

> "I think the use of laptops is certainly something that could work but not necessarily in the traditional lecture model. I think what would work better with laptops is a different kind of space not traditional lecture but a setting with a group of students with laptops around the table so that they can communicate with each other engage with each other" [P3].

On the same note, P5 advocates the workshop approach over the traditional method. Giving an analogy of piano lessons, he claims that just as no one would be able to play a piano from a lecture, he argues that the workshop approach is more suited to programming as well.

> "I think it is a lot more convenient to learn a practical skill like programming in the workshop model. From an old model of broadcasting info which only goes from the lecturer to the students, technology permits feedback and interaction in the class. In a way, it is almost trying to fix a model that really is not that good anymore" [P5].

Furthermore, the duration of the lecture format is of concern to lecturer P6 who is worried that the use of mobile devices for exercises and discussions by the students may be time-consuming. There could pose serious problems in curriculum delivery if there are delays during the lecture for exercises.

> "The main challenge is that we have to cover all the course material in the lectures and we want them to pay attention to the concepts being taught. If they use up the time to practice in lecture, this can hinder the completion of the course" [P6].

However, lecturer P7 does not have a concern about time as he feels that such learning modules could be run if it is organized properly.

> "If the lecture time was organized properly, there would be no problem" [P7].

Finally, affordability of the mobile devices is a matter of concern for lecturer P7. He is worried about students who have no laptops and suggests a way for solving such kind of issue. He notes that:

> "I get concerned about students who do not have the financial resources to have a laptop because you know there are students who do not have that sort of money. I think there should be some equity system where students could borrow a laptop or have a laptop loaned to them by the school or something so that nobody is disadvantaged. I think this sort of stuff is good as long as no one is left behind" [P7].

5.4.5 Preparation

Preparation include the things that the lecturers have to do before commencing on such changes in their teaching methods. They point out the need to rewrite the lecture notes and reorganise the structure of the lecture to best fit the new environment. For example, lecturer P5 and P3 note that:

> "I think it can be very productive of course … but the lecture would need to be rewritten to facilitate that sort of thing" [P5].

> "It would mean changes in the way we introduce some materials" [P3].

P7 raises some further preparatory activities that need to be undertaken by lecturers when they use mobile devices in lectures. This includes preparing a backup of the electronic exercises and of taking care of structure of the lecture in case of distortion by unforeseeable reasons. He says:

> "Changing the presentation of the lecture materials and preparing the new environment will take time but it will be worth it. There is a need to back up everything to avoid losing lecture time, fixing things in case the software is down or something" [P7].

5.4.6 Influences

This sub-theme focuses on the relationship between lecturers' pedagogical beliefs and their use of technology. Instructors' pedagogical beliefs have been identified as significant motivators for such change (Tondeur et al. 2008; Ertmer 2005). The analysis shows that there are relationships between lecturers' perceptions with their course objectives and their teaching methods. The following two sections discuss them separately.

Course Objectives: Lecturers note that the type and level of any programming course affects the use of mobile devices in lectures. The curriculum includes various types of programming and this is delivered at different levels of complexity ranging from basic introduction to highly advanced programming. The use of mobile technology in the lecture theatre may depend on the course itself, where it could be applicable in some curriculum delivery while redundant in others.

> "I think in terms of teaching a programming language, it really depends on the language itself, so different languages I think should be taught slightly differently" [P1].

The interviewee describes the difference that might occur between two programming courses, for example, Java and a scripting programming language such as PHP, Python or Perl.

> "For Java, probably there is not a huge benefit, but for a script language using laptops would be good, because the programs are so small they are very easy to try, and there are some strange concepts that they can immediately try" [P1].

Another lecturer undertaking advanced course content explained that mobile technology may be more appropriate for introductory programming courses for novice programmers rather than more advanced programming courses.

> "I do not think there is a way to make it beneficial to my course, maybe for some projects, some courses, but not for programming technique. It may be useful for someone learning programming for the first time" [P6].

Teaching methods: It is important to consider the current delivery method used by lecturers to evaluate their willingness to use technology in their classroom [37]. This question considers the alignment between the instructors' teaching practices and their acceptance of the integration of mobile technology in the lecture. We find that lecturers who rely on interactive discussion and practical exercises are more willing to adopt such technology.

> "Yes, of course, I ask my students to do practical exercises, typically in my lecture notes. I structure them in a way that every 15 minutes the students will do something themselves. I think what you are doing on mobile devices can enhance learning programming. Yes, I do believe technology can be used to enhance learning, but as I said, you still need a lot of control" [P2].

However, the lecturer who held negative beliefs on the adaptation did not use any practical exercises and his lecture style was mainly passive.

> "No, not really I do not ask my students to do practical exercises, the practical exercises are meant for the lab. So I talk in my lectures mainly, but I give lots of practical examples" [P6].

This analysis shows that the type and complexity of a programming course may affect mobile technology use in programming lectures and lecturers' teaching methods can influence their willingness to encourage the use of mobile devices by students.

5.5 Summary

The purpose of Phase 2 was to investigate lecturers' perceptions on the mobile-based teaching approach in programming lectures. The analysis here identifies the advantages, disadvantages, challenges, preparations and influences that would entail a shift from traditional lectures to lectures with students using mobile devices.

The first theme discussed the participating lecturers' teaching methods and their concerns about the traditional course delivery. While the lecturers vary in their ways of teaching, the main themes pointed out by the lecturers are: discussions and interactions, practical examples and exercises, engagement, feedback and technology used.

The second theme discussed the lecturers' perceptions of the use of laptops by their students during lectures. It reports that with one exception, the lecturers support mobile technology as a delivery medium during programming lectures. The lecturers report the potential advantages, disadvantages and challenges of such mobile learning environments. Programming course objectives and lecturers' willingness to adopt mobile technologies in the classroom are affected.

Although the traditional lecture has been the major form of course delivery in tertiary institutions and will remain so for the foreseeable future, participating lecturers voiced some concerns about its efficacy and benefits especially for teaching programming. Overall, the participating lecturers perceive the traditional method of course delivery by lecture to be a hurdle for implementing a mobile-based teaching approach, with many interviewees reporting a preference for a workshop format with fewer numbers of students. Although they did not formally use this medium in lectures, they consider a mobile-based teaching programming approach could lead to a more productive and interesting learning environment that is better able to motivate and engage students. The next chapter will explain the process of designing and implementation of the intervention lecture in light of the factors highlighted here in Phases 1 and 2.

Chapter 6 - The Intervention

6.1 Introduction

Following Phases 1 and 2, the next step in the research is to design the tasks and surveys to be used during the intervention. The results of the first two phases will be used to refine the plan for the Phase 3 of the study. This chapter discusses the development of the intervention and its surveys. The chapter begins with a summary of the key arguments from Phases 1 and 2 which provide the relevant considerations that need to be incorporated in the development of the intervention. Then, the steps taken to prepare the intervention environment and the tasks designed for the intervention will be described. Finally, the chapter will explain the survey development and content of the surveys for measuring the effectiveness of the proposed approach after the intervention.

6.2 Findings: Study Phases 1 and 2

The TOWS analysis in the Phase 1 identified the advantages, disadvantages, challenges, and influences that would entail a shift from traditional lectures to lectures with students using their mobile devices. Further, this phase helps us recognise and identify factors that could motivate, moderate or hinder the implementation of the intervention. The intervention is developed on the basis of the information gathered in the literature review, but it also needs to be refined by considering the findings from Phases 1 and 2 on the specific research context of our study. The following section will consider these findings in relation to how the intervention and the survey need to be developed. The responses from participants on the strengths and barriers reported in Phases 1 and 2 are explained with the subsequent actions to address these issues.

Phases 1 and 2 produced some positive findings about the context that validated the focus of this study and motivated us to conduct the intervention. They show that there is a high percentage of students who own laptops and are prepared to take them to lectures, thus, displaying a high level of student readiness. The students' views on using a laptop in lectures are generally positive with more than half of the respondents indicating a positive attitude to using a laptop in lectures. Likewise, lecturers' perceptions about mobile-based learning show positive support for the argument that this approach may enhance their existing teaching methods. Phase 2 reported that with one exception, the lecturers supported mobile technology as a delivery medium during lectures. All participating lecturers already used laptops while teaching either for presenting power point slides or running program codes. Although they did not formally allow students to use laptops as learning aids in lectures, they believed that a mobile technology approach could lead to a more productive and interesting learning environment to engage students. All these factors validate the focus of this study on the possibility of capitalising on the widespread use of laptops by students to implement them as a learning tool.

Phases 1 and 2 highlighted some important contextual factors about the population sample that the researcher could utilise to develop a more effective intervention. Phase 1 of this study shows that younger students and students who were willing to receive university support for purchasing a laptop were more prepared to bring their laptops to lectures. On the other hand, students who were enrolled as part-time students were not as enthusiastic about this type of mobile-based learning as they considered laptops in lectures to be a potential distraction. This supports the focus of this intervention on undergraduate students who were generally younger than postgraduate students.

Phase 2 findings show that lecturers believe mobile technology to be an effective tool to assist course delivery in certain programming languages but not others. Lecturers suggest that the mobile learning environment would work for novice students who are learning programming for the first time, but not with advanced courses that had complicated concepts and coding assignments. Therefore, this supports the choice of this study to focus on novices in introductory programming courses. Further, the interviews with instructors show that those who use practical exercises and interactive discussions were willing to adopt mobile devices during their lectures. So, the choice of lecturer for the intervention had to be made carefully to identify lecturers who were keen on mobile-based learning and eager to volunteer for the intervention. The lecturers also reported that there would be a greater need to provide individual assistance to students in running such classes involving live practical tasks on laptops as this could distract the lecturer. Therefore, a teaching assistant was engaged for the intervention lecture. A teaching assistant could move around the lecture hall and assist students in logistical issues like downloading the program and running the software.

There were also some issues that could pose some hurdles to the application of mobile-based learning and need to be considered before initiating the intervention. The major exception to the positive aspects of laptop-use reported by the students and lecturers was the perception that laptops could be a possible distraction in the lecture theatre environment where students are expected to focus on the instructor and the lesson. This means that the learning material should be organised more effectively, teaching strategy and software applications must be tailored to best fit the mobile learning environment in order to decrease distraction and increase engagement among students. This reinforced the use of ViLLE as software for the intervention with a focus on designing interesting learning materials to motivate and engage students to the task given at hand, so that any possibility of distraction is reduced. As the Internet could not be used in the intervention, measures have been taken to develop an off-line application of the software and a backup copy. Exercises on ViLLE also need to accommodate different groups of students with and without mobile devices.

6.3 Intervention Development

After considering the contextual factors and the challenges reported by lecturers and students, the intervention is carefully developed to refine its focus, minimise the potential obstacles and capitalise on the strengths. After the analysis of Phases 1 and 2 discussed above, the sub-sections below describe the procedure of conducting the intervention, how the lecture theatre is organised, how the students are informed and how the intervention is conducted.

6.3.1 Intervention Objective

The surveys of the intervention are aimed at answering the third research question: *How can the constructivist mobile-based learning and teaching approach to programming influence students' learning experience during lectures?* In addition, the following questions guide the surveys:

- *How is the current traditional programming lecture approach aligned with the seven principles of good practice in tertiary education?*
- *How effectively is the constructivist mobile-based learning approach to programming aligned with the seven principles of good practice in tertiary education?*
- *To what extent is the constructivist mobile-based learning approach to programming better aligned with the seven principles compared to the traditional lecture approach?*
- *How do students perceive the constructivist mobile-based learning approach to programming in terms of their satisfaction and motivation?*

The intervention is conducted with undergraduate students enrolled in an introductory programming subject. Moreover, an active lecturer teaching introductory programming courses is engaged to run the intervention. Furthermore, ViLLE is chosen as visualisation software with exercises developed for the learning materials. Once the students, the course, the lecturer and the software are chosen, the procedure for the intervention is mapped.

In traditional lectures, the lecturer uses power point slides for presentation and the document camera for discussion. He might stop using the document camera when talking to students or explaining a program output. He might give them paper-based quizzes. The lecturer sometimes uses practical examples, where he gives a program to the students to try to complete it by paper and actively shows them how to compile, run or debug it; but such active teaching with practical examples only happens three or four times during the whole semester. In most traditional lectures, students follow the lecturer's presentation as passive listeners and copy down the lesson in their lecture notes. They are given a set of exercises to practice after every lecture in the tutorials. Students write their answers to the assignment by referring to their lecture notes, then, have a discussion to verify and test their answers.

In contrast, the mobile-based lecture format used in this intervention is designed to fit the new learning environment. Different types of exercises are designed, such as tracing, coding and sorting questions. The main aim in designing the content for the intervention lecture is mixing theory and practice together so that students are not merely taking down notes during the lectures but also allowed to practice their lessons on actual programs. In this method, the lecturer explains a new concept and then asks the students to work on an exercise using that particular concept. Students using mobile devices are able to compile, run and debug programs and get immediate feedback about their performance from the software.

6.3.2 Before the Intervention

In week 1 semester 1 2011, the students are introduced to the intervention and its processes during the lecture and are sent an explanatory brief by email. In the steps to prepare the lecture theatre, Internet access was tested in week 2, students are asked to try and connect to the Internet with their mobile devices. It is found that the Internet access in the lecture hall only covered a few students in the class and the access was inadequate for everyone. Therefore, an off-line application of ViLLE needs to be developed by a ViLLE designer for students to use the interface without Internet access in the lecture theatre. Also, the learning tasks in the intervention need to be organised by the lecturer based on the learning materials of the week scheduled in week 4. The learning tasks will be described in Section 6.3.4.

After resolving the Internet access issue and organising appropriate learning tasks, we inform the students in week 2 about a pre-intervention evaluation to be done in week 3 on student perceptions of the traditional lecture model. Then, in week 4, the intervention will be carried out. In week 3, a paper-based survey is distributed to all students at the end of the lecture. Moreover, the students are informed in the same lecture and by email about the intervention in the following week. Students have a choice to participate in the intervention or not to participate and attend the lecture as normal. Students willing to participate in the intervention are asked to bring their mobile devices (laptops) and download the off-line application of ViLLE on their laptops. Detailed instructions about downloading the application are sent by email to all students. Furthermore, a backup of the off-line application is set up on some CDs and USBs in case students faced some downloading problems. Additionally, the tasks designed on ViLLE for the intervention participants are also designed on paper for students who do not want to participate in the intervention.

6.3.3 During the Intervention

The time for the intervention lecture is set for two hours like a normal lecture session and the tasks are divided in the following manner in Table 6.1.

Table 6.1: Lecture Time Slots for Two Hours Lecture

Preparation	Explanation	Task1	Explanation	Task2	Break	Explanation	Task 3	Surveys	ending
10min	20min	10min	20min	10min	5min	20min	10min	10min	5min

During the intervention lecture in week 4, the students with laptops are asked to sit together in one area of the lecture theatre and students who do not want to participate are asked to sit in another area. A teaching assistant is available during the lecture to assist students if they encounter any problems during the tasks. The researchers are also present in the lecture hall to take observational notes. Students are also asked to work in pairs on one mobile device. The pairs are arranged to ensure that all willing participants, especially those who want to participate but may not have a mobile device, have a partner with a laptop.

At the beginning of the lecture, the teaching assistant makes sure that all students participating in the intervention have downloaded the off-line application and launched it successfully. Students who could not download the application are helped by the teacher assistant to download the application by using the CDs and USBs with a backup file of the application. Paper versions of the learning tasks are distributed to students not participating in the intervention.

6.3.4 Tasks Development

The learning tasks for the intervention lecture are designed on ViLLE. As described in Chapter 2, ViLLE is a program which can be used as a visualization tool for teaching programming, and there have been many successful studies proving its effectiveness (Rajala et al. 2008). Teachers can use the tool in lectures to demonstrate the dynamic behaviour of program execution, and students can use it independently (Rajala et al. 2007a). ViLLE supports all the programming concepts generally featured in introductory programming courses. There are predefined sets of exercises in ViLLE and teachers can also add new examples. ViLLE's activities enable students to pay attention to the programming concepts and not to the programming language syntax. This encourages students to focus more on understanding the concept at hand instead of focusing on syntactic issues like spelling mistakes in their code. User interaction is a critical advantage in ViLLE as it has triggers which prompt students to respond at certain stages of the program execution. The automatic evaluation of answers accompanied with immediate feedback can substantially enhance the understanding of basic programming concepts (Laakso 2010). In addition, teachers and students can trace executions and compare editing of code between the original program and the edited program in ViLLE. Teachers can easily create a test with a set of exercises. Then, students can answer the questions in each exercise and receive immediate feedback on their answers. In ViLLE, teachers can also access the results of their students and interpret the strengths and weaknesses of their students' understanding (Rajala et al. 2008). Feedback includes correct answers and wrong answers with corrections as well as the final grade.

As the intervention lecture is conducted in week 4 of the semester, the syllabus objectives are about 'for loops' and 'while loops'. Therefore, three exercises involving ‘for and while loops’ are designed, such as tracing, coding and sorting questions. A screen shot of the ViLLE visualization tool in action is presented in Figure 6.1. Students select an exercise from the left-hand-side pane of the visualization window or screen, then, start the question and the program code with the Run button if any code has to be executed.

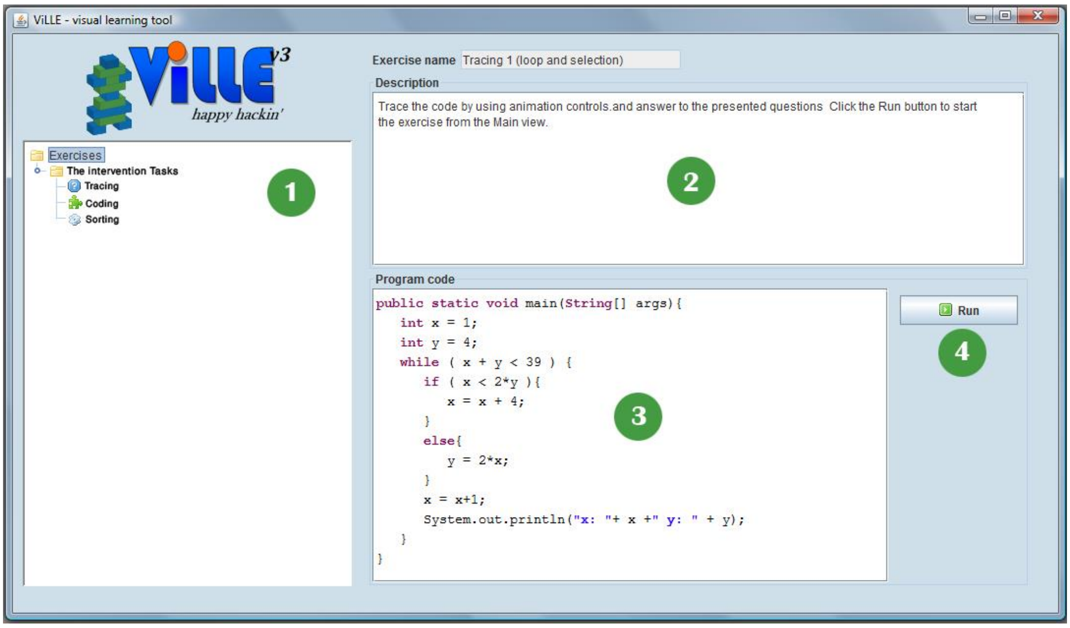


Figure 6.1: An Example Exercise Home Page

1: list of exercises, 2: the question, 3: the program code, 4: run button

Pressing the Run button will direct students to another page in which they can answer the questions. Figure 6.2 presents an example of a tracing exercise which when activated prompts questions to be answered during the trace. After completing all the ViLLE exercises, students can submit their answers to view their final scores for the exercises.

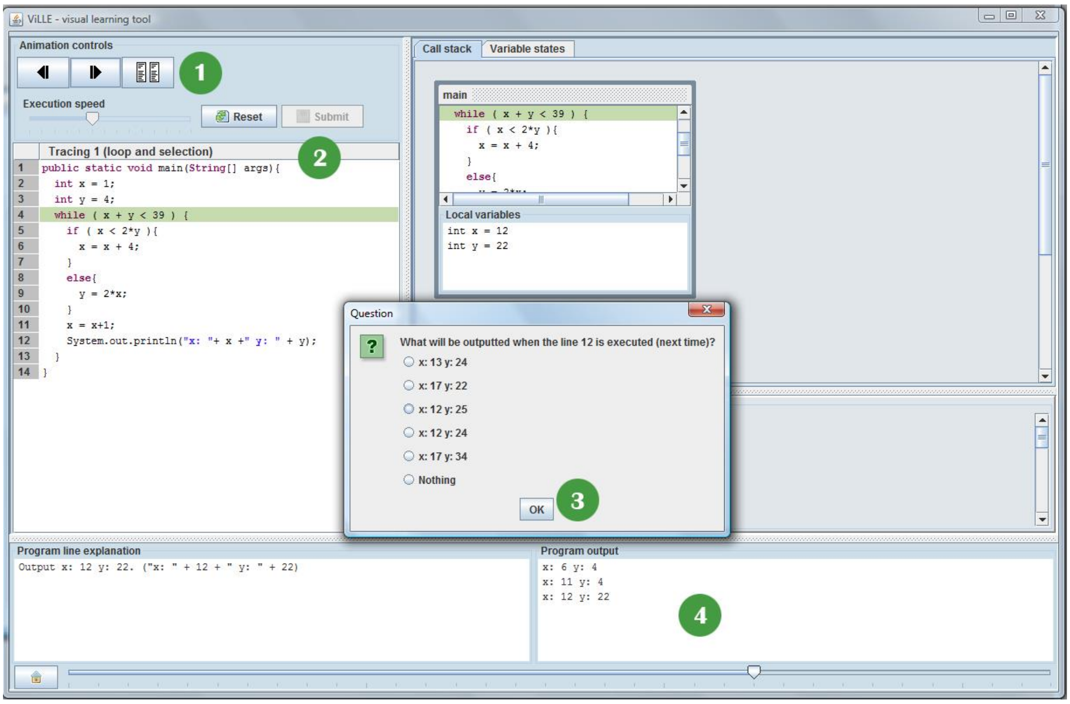


Figure 6.2: An Example of Running a Tracing Exercise

1: start tracing, 2: submit button, 3: The question arise, 4: Output and Score

The following Table 6.2 shows the task questions and the related program code. It includes tracing, coding and sorting questions.

Table 6.2: The Task Questions

Question	Program Code

<u>Exercise 1:</u> (tracing): What is the output from the following code?
Trace the code by using animation controls and answer to the presented questions Click the Run button to start the exercise from the Main view.
	public static void main(String[] args){
	  int x = 1;
	  int y = 4;
	  while (x + y < 39) {
	    if (x < 2*y){
	      x = x + 4;
	    }
	    else{
	      y = 2*x;
	    }
	    x = x+1;
	    System.out.println("x: "+ x +" y: " + y);
	  }
	}

<u>Exercise 2:</u> (coding): Write a program that outputs the first 20 numbers of the sequence 1,4,7,10,13…(each number in its own line)	public class Test{
	    public static void main(String[] args){
	…
	
	    }
	}

<u>Exercise 3:</u> (sorting): Sort the program code lines so that the program outputs numbers 5,6,7,8,9 (put the correct number in each line)	public static void main(String[] args){
	  int a = 3;
	  int b = 2;
	  System.out.println(++a + b++);
	  System.out.println(++a + b);
	  System.out.println(--a + ++b);
	  System.out.println(a + b++);
	  System.out.println(a + b);
	}

6.4 Survey Development

The intervention is conducted as an application of the constructivist mobile-based learning and teaching approach to programming to enhance students' learning experience in introductory programming lectures. To evaluate the effectiveness of the intervention, the participant students are surveyed after the completion of the intervention lecture. They are asked to rate the intervention on different parameters relating to the effectiveness of the constructivist mobile-based learning and teaching method employed in the intervention. These parameters in the survey are developed on the basis of the seven principles of good practice in undergraduate education developed by Chickering and Gamson (1987). The following two sub-sections explain the different surveys employed for participants and non-participants in the intervention lecture and the measurement framework built from the seven principles in the surveys.

6.4.1 Survey Types

As described earlier in the chapter, the intervention uses three surveys to understand students' perceptions about their learning experience during the lecture. Paper-and-pencil surveys are designed and distributed to students in all three stages. A pre-intervention survey is distributed to all students one week before the intervention. Subsequently, two versions of a post-survey are distributed, one to be completed by students who participated in the intervention (denoted PS1) and the other by students who do not participate in the intervention (denoted PS2) at the end of the intervention lecture session.

The pre-intervention survey and post-intervention survey (PS1) are designed on the basis of the seven principles. The pre-intervention survey aims to investigate the extent to which the traditional lecture approach is perceived to be an effective pedagogical model in alignment with the seven principles. The post-intervention survey 1 (PS1) aims to investigate the responses of students who participated in the intervention, while the post-survey 2 (PS2) aims to investigate opinions of students who are in the intervention lecture but did not participate in the intervention.

The three surveys (see Appendix 8, 9 and 10) contain some demographic questions at the beginning of each survey, relating to variables of study load, age, gender, and programming skill background. In addition to the demographic questions, the first post-intervention survey (PS1) has a question on whether the students worked alone or in pairs. The main part of the survey is designed on the basis of the seven principles and expanded into questions with 14 items. Moreover, it has another 14 items with questions relating to students' satisfactions and motivations. There are some open-ended questions at the end of the survey which ask students to note their personal opinions on any aspect of the intervention. The second post-intervention survey (PS2) for students who did not participate in the intervention has an open-ended question on the reason for their choice. Moreover, as these students attend the lecture without participating in the intervention, their observations and experiences may differ significantly from the rest of the class. So, the PS2 contains three question items examining their views on the constructivist mobile-based learning and teaching approach and their experiences in the intervention lecture.

For the 14 items designed in the pre and post-intervention surveys (PS1), the following paragraphs give a brief description of each principle and how they relate to expectations about the potential of constructivist-mobile-based learning and teaching programming approach in enhancing learning experiences during lectures. Furthermore, the post-intervention survey items correlated with each principle are also listed with their hypotheses. These hypotheses will be used to measure the effectiveness of the constructivist mobile-based learning and teaching programming approach in accordance with the seven principles.

6.4.2 Survey Content

As described in Chapter 2, the seven principles of good practice in undergraduate education have been developed by Chickering and Gamson on the basis of decades of research in undergraduate education (Chickering & Gamson 1987). They have been successfully used in many research papers to evaluate effective teaching in the traditional lecture setting (Chickering & Ehrmann 1996). Although these principles have been developed for education in traditional settings, they have recently been extended for technology-based models of lecturing and pedagogy (Cromack 2008; McCabe & Meuter 2011). This means that these principles can provide a strong evaluative framework for an approach that integrates the use of mobile devices with software such as ViLLE in the traditional lecture environment.

Principle 1: *Good practice encourages student and faculty contact*: Frequent contact between faculty and students amplifies student motivation and involvement (Astin 1996). With the application of the constructivist mobile-based learning approach during the lecture, the software used could give the students immediate feedback, which not only saves time but also helps the students become more confident about their work. Table 6.3 lists all the survey items and the hypotheses for measuring Principle 1 before and after the intervention.

Table 6.3: Principle 1 Survey Items

Principle 1: Good practice encourages student and faculty contact		
Pre-Intervention Survey Item	**Post-Intervention Survey Item**	**Post-Intervention Survey Hypothesis**
I communicate with my instructor in the lecture on asking and answering questions	I communicated more in the lecture with my instructor on asking and answering questions because of the application of the approach	$\mathbf{H_{01}}$: Applying the constructivist mobile-based learning approach does not support student and faculty contact
I communicate with my instructor in the lecture on sharing my ideas	I communicated more in the lecture with my instructor on sharing my ideas because of the application of the approach	$\mathbf{H_{02}}$: Applying the constructivist mobile-based learning approach supports student and faculty contact

Principle 2: *Good practice develops reciprocity and cooperation among students*: Cooperative work is proven to facilitate engagement and motivation among students (Hatfield & Hatfield 1995). During the intervention lecture, students were asked to work in pairs on their laptops as sharing ideas and solutions may increase their involvement (Tan, Wang & Xiao 2010). Table 6.4 lists all the survey items and the hypotheses for measuring Principle 2 before and after the intervention.

Table 6.4: Principle 2 Survey Items

Principle 2: Good practice encourages cooperation among students.		
Pre-Intervention Survey Item	**Post-Intervention Survey Item**	**Post-Intervention Survey Hypothesis**
I do cooperative work with my fellow students in the lecture	I did more cooperative work with my fellow students in the lecture because of the application of the approach	$\mathbf{H_{02}}$: Applying the constructivist mobile-based learning approach does not support cooperation among students.
I do share my ideas with my fellow students in the lecture	I did more on sharing my ideas with my fellow students in the lecture because of the application of the approach	$\mathbf{H_{a2}}$: Applying the constructivist mobile-based learning approach supports cooperation among students.

Principle 3: *Good practice encourages active learning*: Active learning engages students to not just passively receive information from the lecturer but participate in constructing knowledge and solving problems (Barak et al. 2006; Dyson et al. 2009). The application of the constructivist mobile-based learning and teaching approach during the lecture may help facilitate active learning as students immediately apply the knowledge imparted to them by the lecturer. This could support better understanding of abstract theoretical content. Table 6.5 lists all the survey items and the hypotheses for measuring Principle 3 before and after the intervention.

Table 6.5: Principle 3 Survey Items

Principle 3: Good practice encourages active learning.		
Pre-Intervention Survey Item	**Post-Intervention Survey Item**	**Post-Intervention Survey Hypothesis**
I actively participate in the lecture and practice what I have been taught	I participated and practiced - what I have been taught - more actively in the lecture because of the application of the approach	**H_{03}**: Applying the constructivist mobile-based learning approach does not support active learning.
I have the ability to relate the concepts and skills in the lecture to real life	My ability to relate the concepts and skills in the lecture to real life increased because of the application of the approach	**H_{a3}**: Applying the constructivist mobile-based learning approach supports active learning.

Principle 4: *Good practice gives prompt feedback*: Feedback improves students' learning as it gives them an idea of their achievements as well as the areas they are lacking in (Epstein et al. 2010). With the constructivist mobile-based learning and teaching approach, students can receive immediate feedback from the software on their laptop computers. Table 6.6 lists all the survey items and the hypotheses for measuring Principle 4 before and after the intervention.

Table 6.6: Principle 4 Survey Items

Principle 4: Good practice gives prompt feedback.		
Pre-Intervention Survey Item	**Post-Intervention Survey Item**	**Post-Intervention Survey Hypothesis**
I get enough feedback from my instructor during the lecture	I got more feedback from my instructor in the lecture because of the application of the approach	**H_{04}**: Applying the constructivist mobile-based learning approach does not support prompt feedback.
I get prompt feedback from my instructor during the lecture	I got prompt feedback from my instructor in the lecture because of the application of the approach	**H_{a4}**: Applying the constructivist mobile-based learning approach supports prompt feedback.

Principle 5: *Good practice emphasises time on task*: Students' time management skills and the organization of content are crucial for curriculum development (Vorkin 1995). ViLLE has a facility for measuring the amount of time spent on a task and ensure that curriculum content is completed within the allocated time. Programming activities in the intervention lecture environment were designed after considering the time expected for each activity. Although time-management mechanisms cannot guarantee that all students will finish their work on time, such a timed work environment imposes a mental constraint on students and they become trained to become conscious of time when working on activities. Table 6.7 lists all the survey items and the hypotheses for measuring Principle 5 before and after the intervention.

Table 6.7: Principle 5 Survey Items

Principle 5: Good practice emphasises time on task.		
Pre-Intervention Survey Item	**Post-Intervention Survey Item**	**Post-Intervention Survey Hypothesis**
I have the ability to complete tasks at times that are convenient for me in the lecture	My ability to complete tasks at times that were convenient for me in the lecture increased because of the application of the approach	$\mathbf{H_{05}}$: Applying the constructivist mobile-based learning approach does not support time on task.
I can manage and control my time efficiently in the lecture for my learning	Managing and controlling my time efficiently in the lecture for my learning increased because of the application of the approach	$\mathbf{H_{a5}}$: Applying the constructivist mobile-based learning approach supports time on task.

Principle 6: *Good practice communicates high expectations*: There is a proven relationship between student achievement expectancy and academic performance (Chickering & Gamson 1987). Although the lecturer may verbally communicate the expectations associated with a task, this may be easily forgotten by the students during the course of the lecture and the activity. In the intervention lecture environment, all activities are structured with specific objectives to achieve. Table 6.8 lists all the survey items and the hypotheses for measuring principle 6 before and after the intervention.

Table 6.8: Principle 6 Survey Items

Principle 6: Good practice communicates high expectations.		
Pre-Intervention Survey Item	**Post-Intervention Survey Item**	**Post-Intervention Survey Hypothesis**
The quality of my work in the lecture is very good	The application of the approach increased my quality of work in the lecture	$\mathbf{H_{06}}$: Applying the constructivist mobile-based learning approach does not support high expectations.
My understanding of the ideas taught in the lecture is very good	The application of the approach increased my understanding of the ideas taught in the lecture	$\mathbf{H_{a6}}$: Applying the constructivist mobile-based learning approach supports high expectations.

Principle 7: *Good practice respects diverse talents and ways of learning*: Different individuals are comfortable with different learning styles. According to Richardson (2011), the approach and style of learning among students can differ. Using diverse teaching and learning activities and techniques in the intervention lecture environment could help cater to a wider range of learning styles among students. Table 6.9 lists all the survey items and the hypotheses for measuring principle 7 before and after the intervention.

Table 6.9: Principle 7 Survey Items

Principle 7: Good practice respects diverse talents and ways of learning.		
Pre-Intervention Survey Item	**Post-Intervention Survey Item**	**Post-Intervention Survey Hypothesis**
I have a chance to get to know students who are different from me in their learning in the lecture	The application of the approach increased my chances to get to know students who are different from me in their learning in the lecture	$\mathbf{H_{07}}$: Applying the constructivist mobile-based learning approach does not support diverse talents and ways of learning.
I have the ability to use my preferred learning styles in the lecture	The application of the approach increased my ability to use my preferred learning styles in the lecture	$\mathbf{H_{a7}}$: Applying the constructivist mobile-based learning approach supports diverse talents and ways of learning.

6.5 Summary

This chapter has been concerned with the steps in the process of developing the intervention lecture and its surveys to evaluate the constructivist mobile-based learning and teaching approach in programming courses. It discusses how the findings from Phases 1 and 2 validate the focus of this research and highlight the contextual factors and obstacles to be considered before implementing any intervention.

The choice of students, the course, the task and the lecturer for the intervention are all explained. The surveys used to evaluate the students' perceptions after participating in the intervention lecture are also described in detail.

The next chapter will proceed to an analysis of the data gathered from these surveys to highlight how participating and non-participating students view the constructivist mobile-based learning and teaching approach to programming. Also, it will discuss the comparison between the traditional lecture approach and constructivist learning approach to programming.

Chapter 7 - Analysis of the Intervention

7.1 Introduction

This chapter reports the evaluation of the effectiveness of the approach delivering theoretical and practical components together in a lecture environment where students use their mobile devices to simultaneously practice the subject being taught in the lecture. Using the seven principles of pedagogy developed by Chickering and Gamson (1987) as a framework, it examines the effectiveness of this form of course delivery that combines lectures with mobile devices and ViLLE. The chapter begins with a reflection of the current traditional lecture model with regard to the seven principles. Then, the analysis of the intervention results is presented.

Phase 3 uses three surveys to gain an understanding about students' learning experience during lectures (see Appendix 8, 9 and 10). Paper-and-pencil surveys have be designed (explained in Chapter 6, Section 6.4) and distributed to students in three stages (explained in Chapter 6, Section 6.3.2 and Section 6.3.3). A pre-intervention survey is distributed to all students one week before the intervention, and students are informed about the process and objective of the intervention. Subsequently, two versions of a post-intervention survey are distributed, one to be completed by students who participated in the intervention (denoted PS1) and the other by students who did not participate in the intervention (denoted PS2). SPSS version 19 is used for quantitative data entry and analysis. Moreover, the qualitative data from the open-ended questions are analysed to extract themes relating to perceived benefits, challenges and satisfactions reported by the students.

7.2 Pre-Intervention Survey

The pre-intervention survey aims to investigate the extent to which the traditional lecture model is perceived to be an effective pedagogical model in alignment with the seven principles. 150 students complete the pre-intervention survey one week before the intervention. This survey targets all the students enrolled in the subject. The participants' profile will be presented first. Second, reliability testing and other procedures relating to data preparation will be explained. This is followed by the main section where students' perceptions based on their scores for the seven principles will be reported.

7.2.1 Participant Profile

The first part of the pre-intervention survey contains some questions relating to the demographic profile of students' study load, gender, age, laptop ownership, programming skill background and preparation to take laptops to university. We present the data relating to the background of the student cohort in Table 7.1.

Table 7.1: Student Demographics for Pre-intervention Survey, n= 150 Students (Percentage %)

Study Load	Full Time	98.7
	Part Time	1.3
Gender	Male	87.3
	Female	12.7
Age	Average	21 Years
Laptops Ownership	Yes	87.3
	No	8
	Willing to buy	4.7
Preparedness to take Laptops to University	Frequently	44.7
	Occasionally	45.3
	Never	5.3
Programming skills	Novice	45.3
	Intermediate	54.7
	Expert	0

In the cohort, 98.7% of the respondents are studying full-time and 1.3% part time, while 87.3% are male and 12.7% female. The average respondent is 21 years old. The majority of students, (87.3%) own Laptops and 8% do not have one, but of this latter group 4.7% would be willing to buy one if it becomes necessary for classes. Students are also asked if they are prepared to take their laptops to university, 143 students out of 150 answered this question. Our data shows that 90% of respondents frequently or occasionally bring their laptops to university or would be prepared to bring them. The targeted students are novice programmers enrolled in an introductory Java programming course. 54.7% students rate themselves as intermediate programmers who have developed some program software before and 45.3% students assess themselves as novices who do not have any programming knowledge.

7.2.2 Reliability Testing

A reliability analysis is run on the pre-intervention survey data to determine the internal consistency of the survey instrument. The initial reliability is calculated for each statement in the survey with Cronbach's Alpha. This helps to determine the internal consistency of the two statements within each principle and the reliability coefficient across all the statements within the principles. Cronbach's Alpha for internal consistency is acceptable when its value is greater than .60 (Nunnally 1967). However, the number of items within a category affects the value of Cronbach's Alpha, for example, in a minimal scale with less than ten items, Cronbach values can be commonly quite low. In this case, it may be more appropriate to report the mean inter-item correlation (I-iC) for the items (Pallant 2007) and an optimal range for the inter-item correlation recommended being between .2 and .4 (Briggs and Cheek 1986). The Cronbach's Alpha values (shown in Table 7.2 below) ranged from .68 to .92, which are in the acceptable range. However, Cronbach's Alpha value for Principles 3, 6 and 7 are less than .60, so the inter-item correlation is calculated for those principles, which are then shown to be within the recommended range, demonstrating good internal consistency.

Table 7.2: Reliability Analysis for Seven Principles (Pre-Intervention Survey)

Principles	Cronbach's Alpha (Before)	I-iC
1. Encourages student faculty contact	.79	-
2. Encourages cooperation among students	.82	-
3. Encourages active learning	.43	.27
4. Gives prompt feedback	.70	-
5. Emphasises time on task	.69	-
6. Communicates high expectations	.57	.40
7. Respects diverse talents and ways of learning	.54	.38
Total	.74	

7.2.3 Reflections of the Traditional Lecture Approach on the Seven Principles (Pre-Intervention Survey)

The second part of the survey is related to the seven principles for good practice in higher education. It aims to investigate the extent to which the traditional lecture model is aligned with the seven principles of good pedagogy to deepen our understanding of the effectiveness of the traditional lecture model and provide a framework to contrast it with the constructivist mobile-based model. This survey has 14 statements made up of 7 pairs of statements to represent each principle (see Appendix 8). For these statements, the students are asked to indicate their level of agreement on a Likert scale ranging from 1 “strongly disagree”, 2 “disagree”, 3 “neutral”, 4 “agree” to 5 “strongly agree”. At the end of the survey, the students are asked if they would be willing to participate in the intervention lecture with mobile device uses in the following week. They are also asked to give their thoughts on the use of laptops during programming lectures.

After combining each pair of statements on a principle by adding their mean values, the mean values of student responses ranged from 1 to 10 and are presented in Table 7.3. Mean values higher than 6 are considered relatively positive, mean values lower than 4 were considered relatively negative and mean values between 4 and 6 are considered relatively neutral.

Table 7.3: Mean Values for Each Principle (Pre-Intervention Survey)

	Principles	Mean	SD	T	Df	*P*
1	Encourages student faculty contact	5.68	1.90	-2.054	149	.042
2	Encourages cooperation among students	6.78	1.95	4.822	145	.000
3	Encourages active learning	6.88	1.52	7.054	149	.000
4	Gives prompt feedback	6.76	1.63	5.700	149	.000
5	Emphasises time on task	7.03	1.53	8.248	149	.000
6	Communicates high expectations	6.88	1.48	7.233	148	.000
7	Respects diverse talents and ways of learning	6.52	1.68	3.787	149	.000

As shown in the Table 7.3, except for Principle 1, the students' responses indicate a significantly positive view ($P < .05$) of the traditional lecture environment based on the seven principles. P1, which encourages student faculty contact, received the least positive perceptions (M = 5.68). This means that students feel there is inadequate contact with the lecturer in asking and answering questions and sharing ideas with their lecturer in the traditional lecture format. The respondents have the most positive perception for P5, which emphasises time on task (M = 7.03). This result indicates that students had the ability to complete tasks they were assigned to do within the expected time. Moreover, they can manage and control the time needed during the lecture.

Students' view of the traditional lecture model could be affected by many factors. For example, the materials used during lecture and the way of presenting them could be considered as one factor. Moreover, the lecturer's teaching style is another important point to consider. As described in Chapter 6, Section 6.2.3, the traditional lecture had some activities and the lecturer was an active presenter, meaning that the lecture format was not in a pure passive model. Furthermore, students' traits could affect their answers for the survey items. Thus, the following is a description of the possible correlations between students' traits and their answers to the seven principles.

A linear regression test is conducted to investigate possible relationships between students' traits and their responses to the seven principles. Only the students' programming skills are found to have significant relationships with some of the seven principles. The test finds that there are positive relationships between students' programming skills and Principles 3, 4, 5 and 6. Table 7.4 summarises the results.

Table 7.4: Correlations between Student Traits and the Seven Principles (Pre-Intervention Survey)

Students' Trait	Principle	Beta Coefficient β
Programming skills	P3: Active learning	.33
	P4: Prompt feedback	.28
	P5: Time on task	.39
	P6: High expectations	.38

Students' programming skills significantly predict students' view on active learning during lecture (Principle 3), β = .33, t (148) = 2.79, p < .05. The increase in students' programming skills level is associated with 33% greater agreement with Principle 3. Moreover, students' programming skills describe a significant proportion of variance in active learning, R^2 = .05, F (1, 148) = 7.77, p < .05. Therefore, students who have higher programming skills background tend to agree more with the statement about active participation. This is perhaps because students who are more advanced in their skills may be more confident about their learning making them more active in the lecture.

Moreover, Principle 4, "good practice gives prompt feedback", is significantly predicted by students' programming skills, β = .28, t (148) = 2.26, p < .05. Students' programming skills accounted for R^2 = .03 of the variance in students' perceptions on Principle 4, F (1, 148) = 5.09, p < .05. Thus, students who have higher programming skills background indicate that they receive both enough and prompt feedback during the lecture.

Furthermore, the students' programming skills account for R^2 = .07 of the variance in students' perceptions on Principle 5 (good practice emphasises time on task), F (1, 148) = 11.55, p < .05. The standard regression analysis indicates that students' programming skills (β = .39, t (148) = 3.39, p< .05) predict students' perceptions on Principle 5.

Finally, Principle 6 (good practice communicates high expectations) is significantly predicted by students' programming skills, $\beta = .38$, $t\ (147) = 3.34$, $p < .05$. The students' programming skills account for $R^2 = .07$ of the variance in students' perceptions on Principle 6 significantly, $F\ (1, 147) = 11.18$, $p < .05$. Thus, students who have higher programming skills tend to agree with the statement linking good practice with high expectations.

As reported in the descriptive data of students' demographics in Section 7.2.1, although many of the students are enrolled in an introductory programming course, many students do not rate themselves as novices in terms of their programming skill background. Further, the correlations between students' programming skills and Principles 3, 4, 5 and 6 support the conclusion that students are not all at the same level of programming knowledge. The students' programming skills significantly predict students' view on those four principles. Increases on students' programming skills level is correlated with increases in the students' agreement on those principles.

7.2.4 Student Willingness of Participation

The survey asks students if they were willing to participate in the intervention and more than half of the students (63.3%) reply in the affirmative. The students' willingness to participate may give an insight into students' motivation and acceptance of the idea of the intervention. Therefore, finding relationships between students' willingness and their traits may provide a deeper understanding of the factors that might influence students' responses to this question.

A linear regression test finds that the students' willingness to participate can be predicted by their mobile device ownership and preparedness to take them to University. Table 7.5 summarises the results showing that students who are more willing to participate in the intervention also tend to own laptops and are prepared to bring them to lectures.

Table 7.5: Correlations between Student Willingness of Participation and their Traits

	Students' Trait	Beta Coefficient β
Students' willingness of participation	Laptop ownership	.39
	Preparedness	-.83

Laptop ownership significantly predicts willingness of participation, $\beta = .39$, t (148) = 5.04, $p < .001$. It also explains a significant proportion of variance in willingness of participation, $R^2 = .15$, F (1, 148) = 25.44, $p < .001$. This evidence suggests that students who have laptops are more willing to participate in the intervention. Some of the students who are not willing to participate in the intervention gave many reasons, such as preference for traditional lectures, concern about the device's battery life, a preference for paper and pen, the distraction of laptops, lack of the Internet connection and the trouble of carrying about the mobile devices.

Moreover, the students' preparedness to bring mobile devices to lectures is negatively related to their willingness to participate, $\beta = -.83$, t (141) = -3.92, $p < .001$. The students' preparedness also explained a significant proportion of variance in willingness of participation, $R^2 = .10$, F (1, 141) = 15.39, $p < .001$. The students' responses indicate that the percentage of students' willingness to participate in the intervention increases as the preparedness moves from Never to Frequently. Students who are less prepared to bring their laptops to lecture are more likely to reject the offer of participation in the intervention.

7.2.5 Student Responses (Pre-Intervention Survey)

At the end of the survey, students are asked to give their thoughts on the use of their mobile devices during programming lectures. 78 students respond to the open-ended question with answers ranging from positive or negative evaluations of the intervention. From the analysis of those responses, themes identifying students' positive and negative responses about the intervention are detailed below.

7.2.5.1 Positive Responses

- ***Immediate Practice***: Interestingly, the most positive thought reported by the students is the immediacy of trying the program codes as they are being taught in the lectures. One student says, "If we are able to test out the examples that are being taught directly, then I believe this will benefit us". Another student echoes the same thought and emphasises that it "would only be useful if we could actively compile programs immediately as shown in the slides". Another student adds, "It would help students to understand the code better because there's barely any practical use of programming within lectures."

- ***Accessing PowerPoint slides and taking notes***: Students appreciate the possibility of having the PowerPoint slides up close on the screens of their personal devices as well as the ease in taking down notes. One student says, "Having PowerPoint readily available close to seats would be good" and another notes that "it is a lot more convenient than carrying notes". Another student thinks that carrying your own laptops to the lecture makes many classroom tasks more convenient and notes that "it is a great idea for research and note taking".

- ***Interaction***: Students appreciate the fact that a mobile-based learning session can involve active exercises and discussions, giving them an opportunity to interact with the lecturer. For example, one student notes that "it would be good to have a program to ask questions for the lecturer to answer".

7.2.5.2 Negative Responses

- ***Distraction:*** The most common problem reported by students is the potential for distraction posed by the use of laptops by all students in a classroom. Many students note, "Laptops are a distraction to the students using them and the people around them".

- ***Student learning styles:*** A few students also mention that they prefer to be passive in lectures listening and taking down notes rather than doing active exercises and engaging in discussions. Some of the responses in this category state, “I am listening type of learner and I need to listen to the lecturer at all times” and “I prefer pen and paper in lectures”.

- ***Logistical Issues:*** The logistical issues in carrying and using laptops in lectures are also perceived as a major hindrance by the students. While some students note that “battery life of mobile devices may be an issue if they in use for multiple subjects”, others said that they would “need stable network access”.

7.2.5.3 Suggestions

Apart from these negative and positive responses, some students make suggestions for introducing the use of mobile devices during lectures. Students say “it should be encouraged” and “it would be perfect if it was done in an organised way”. Some students suggest, “It would be good to make laptop use optional rather than mandatory to give students the freedom to choose”. On the other hand, others feel that if such a learning format is introduced then the use of mobile devices should be made compulsory for all students. They say “If the lecture is to be given with mobile devices everyone must be given access to a mobile device, otherwise it's unfair for those who don't have one”. Some others worry that, “those without mobile devices may be disadvantaged”.

7.3 Post-Intervention Survey (PS1)

The post-intervention survey (PS1) is distributed to the students who participate in the intervention. 54 students completed it at the end of the intervention lecture. The survey has three parts. The first part contains questions about demographic information. The second part contains 14 statements based on the seven principles and 14 statements regarding students’ satisfactions and motivations.

The last part of the survey was left for open-ended questions for students to offer their opinions or suggestions.

7.3.1 Participant Profile

The first part of the post-intervention survey (PS1) contains some questions relating to the demographic profile of students' study load, gender, age, group design and programming skill background. We present the data relating to the background of this student cohort in Table 7.6.

Table 7.6: Students Demographics for Post-Intervention Survey (PS1), n= 54 Students (Percentage %)

Study Load	Full Time	96.3
	Part Time	3.7
Gender	Male	92.6
	Female	7.4
Age	Average	21 Years
Group design	Alone	83.3
	In pair	16.7
Programming skills	Novice	40.8
	Intermediate	59.2
	Expert	0

In this cohort, 96.3% of the respondents were studying full time and 3.7% part time, while 92.6% were male and 7.4% female. The average respondent is 21 years old. Students are asked if they worked alone during the intervention or with their fellow students in pair. The majority of the students, almost 88.3%, work alone during the lecture and 16.7 % of the students worked in pairs. Similar percentages of programming skills are reported in the pre-intervention survey. Although the targeted students are enrolled in the introductory programming course, 40.8% students rate their programming background as low and very low, 44.4% students select medium and 14.8% students choose high and very high.

7.3.2 Reliability Testing

A reliability analysis is run on the post-intervention survey data to determine the internal consistency of the survey instrument. The initial reliability is calculated for each principle of the survey with Cronbach's Alpha to determine the internal consistency of the two statements within each principle and the reliability coefficient across all the statements representing the principles. Similar to the results for the reliability analysis for the pre-intervention survey, the Cronbach's Alpha values ranged from .68 to .92, which are in the acceptable range, but Principles 3 and 7 have values less than .60 (shown in Table 7.7 below). An inter-item correlation is calculated on Principles 3 and 7, and the values are found to be within the recommended range, demonstrating good reliability of internal consistency.

Table 7.7: Reliability Analysis for Seven Principles (Post-Intervention Survey)

Principles	Cronbach's Alpha (After)	I-iC
1. Encourages student faculty contact	.87	-
2. Encourages cooperation among students	.90	-
3. Encourages active learning	.57	.40
4. Gives prompt feedback	.92	-
5. Emphasises time on task	.68	-
6. Communicates high expectations	.75	-
7. Respects diverse talents and ways of learning	.47	.31
Total	.73	

7.3.3 Reflections of the Constructivist Mobile-Based Learning Approach on the Seven Principles (Post-Intervention Survey)

The second part of this survey contains the main portion evaluating the constructivist mobile-based learning approach on the basis of the seven principles for good practice in higher education. As in the pre-intervention survey, this post-intervention survey has 14 statements made up of 7 pairs of statements to represent each principle (see Appendix 9). For these statements, the students are asked to indicate their level of agreement on the constructivist mobile-based learning approach on a Likert scale ranging from 1 “strongly disagree”, 2 “disagree”, 3 “neutral” to 4 “agree” and 5 “strongly agree”. Moreover, each two statements are combined to represent one principle, so the mean values of student responses for each principle actually range from 1 to 10. A one-sample *t*-test is conducted on the seven principles scores to evaluate if their mean is significantly greater than 6, this would indicate positive support from students which implies that the intervention aligned effectively with the seven principles.

A set of hypotheses is developed with a null as well as an alternative hypothesis for each principle. Hypothesis testing is done using *P*-value by comparing it with an α set as .05 as level of significance. If $P \leq \alpha$, then H_0 is to be rejected, if $P > \alpha$, then H_0 failed rejection. Moreover, the mean value indicates whether the claim is supported positively (if M>6) or negatively (if M<6). Table 7.8 summarises the results for the seven principles followed by an explanation of the results for each principle.

Table 7.8: Mean Values for Each Principle (Post-Intervention Survey PS1)

	Principles	Mean	SD	t	Df	*P*
1	Encourages student faculty contact	5.29	1.87	-2.766	53	.008
2	Encourages cooperation among students	6.69	1.84	2.735	53	.008
3	Encourages active learning	7.37	1.34	7.538	53	.000
4	Gives prompt feedback	7.15	1.89	4.447	53	.000
5	Emphasises time on task	6.89	1.54	4.248	53	.000
6	Communicates high expectations	7.19	1.51	5.784	53	.000
7	Respects diverse talents and ways of learning	6.83	1.38	4.425	53	.000

Principle 1: *Good practice encourages student and faculty contact*.

H_{01}: Applying the constructivist mobile-based learning approach does not support student and faculty contact.

Based on the results, we reject the null hypothesis at *P* < .05. The sample mean of 5.29 (SD= 1.87) is significantly less than 6, *t* (53) = -2.766, *P* = .008. This indicates that the constructivist mobile-based learning approach negatively supports the principle of student and faculty contact.

Principle 2: *Good practice encourages cooperation among students*.

H_{02}: Applying the constructivist mobile-based learning approach does not support cooperation among students.

Based on the results, we reject the null hypothesis at *P* < .05. The sample mean of 6.69 (SD = 1.84) is significantly greater than 6, *t* (53) = 2.735, *P* = .008. This indicates that the constructivist mobile-based learning approach positively supports the principle of cooperation among students.

Principle 3: *Good practice encourages active learning*.

H_{03}: Applying the constructivist mobile-based learning approach does not support active learning.

Based on the results, we reject the null hypothesis at *P* < .05. The sample mean of 7.37 (SD = 1.34) is significantly greater than 6, *t* (53) = 7.538, *P* = .000. This indicates that constructivist mobile-based learning approach positively supports the principle of active learning.

Principle 4: *Good practice gives prompt feedback*.

H_{04}: Applying the constructivist mobile-based learning approach does not support prompt feedback.

Based on the results, we reject the null hypothesis at *P* < .05. The sample mean of 7.15 (SD = 1.89) is significantly greater than 6, *t* (53) = 4.447, *P* = .000. This indicates that the constructivist mobile-based learning approach supports prompt feedback positively.

Principle 5: *Good practice emphasises time on task*.

H_{05}: Applying the constructivist mobile-based learning approach does not support time on task.

Based on the results, we reject the null hypothesis at $P < .05$. The sample mean of 6.89 (SD = 1.54) is significantly greater than 6, t (53) = 4.248, P = .000. This indicates that the constructivist mobile-based learning approach positively supports the principle of time on task.

Principle 6: *Good practice communicates high expectations*.

H_{06}: Applying the constructivist mobile-based learning approach does not support high expectations.

Based on the results, we reject the null hypothesis at $P < .05$. The sample mean of 7.19 (SD = 1.87) is significantly greater than 6, t (53) = 5.784, P = .000. This indicates that the constructivist mobile-based learning approach positively supports the principle of high expectations.

Principle 7: *Good practice respects diverse talents and ways of learning*.

H_{07}: Applying the constructivist mobile-based learning approach does not support diverse talents and ways of learning.

Based on the results, we reject the null hypothesis at $P < .05$. The sample mean of 6.83 (SD = 1.38) is significantly greater than 6, t (53) = 4.425, P = .000. This indicates that the constructivist mobile-based learning approach positively supports the principle of diverse talents and ways of learning.

Based on hypothesis testing with the post-intervention survey data, except for Principle 1, all the null hypotheses have been rejected and the alternative hypotheses have been proved. This means that the constructivist mobile-based learning approach is aligned with all principles of good pedagogy except Principle 1. We can conclude from this result that this form of mobile-based learning is able to enhance learning experience on all the other six principles except for P1 which stipulates student-faculty contact.

As there are many factors that could affect the students' views of the seven principles, such as students' satisfaction and motivation, it is important to consider how their attitude to the intervention environment is related with the seven principles. This will be discussed in Section 7.3.4, along with correlations between students' traits and their responses to give a more detailed explanation of their responses. A linear regression test is conducted to investigate any possible relationships between the students' traits and their responses to the seven principles. This test shows that only students' study load and group design in the intervention influence the achievement of the seven principles in the mobile-based learning approach. The test finds that there are significant relationships between students' study load and Principles 5 and 6. Moreover, there are negative relationships between group design and Principles 1 and 5. Table 7.9 summarises the results.

Table 7.9: Correlations between Student Traits and the Seven Principles (Pre-Intervention Survey)

Students' Trait	Principle	Beta Coefficient β
Students' Study Load	P5: Time on task	-3.00
	P6: High expectations	-2.269
Group design	P1: Student faculty contact	-1.689
	P5: Time on task	-1.067

Students' study load significantly predict students' view on the principle of time on task (Principle 5) negatively, β = -3.00, t (52) = -2.889, p < .05. Students who are enrolled as part-time students are more likely to agree to this principle. This could be because part-time students generally are older students, who are perhaps more experienced in managing and controlling time (Trueman & Hartley 1996). Moreover, students' study load defines a significant proportion of variance on time on task, R^2 = .14, F (1, 52) = 8.346, p < .05. Students' study load is negatively related with high expectations (Principle 6), $\beta = -2.269$, t (52) = -2.163, $p < .05$. Students enrolled as part time students were more likely to communicate high expectations with a significant proportion of variance $R^2 = .08$, F (1, 52) = 4.678, $p < .05$.

Students' group design in the intervention has a negative impact on students' view on student and faculty contact (Principle 1), $\beta = -1.689$, t (52) = -2.605, $p < .05$. In contrast to students who work alone, students who work in pairs tended to disagree with this principle. This means that group work could hinder student and faculty contact. Moreover, students' group design describes a significant proportion of variance on student and faculty contact, $R^2 = .12$, F (1, 52) = 6.789, $p < .05$. Additionally, students' group design in the intervention also has a negative influence on Principle 5 of time on task, $\beta = -1.067$, t (52) = -1.949, $p < .05$ with a significant proportion of variance on P5, $R^2 = .07$, F (1, 52) = 3.799, $p < .05$. This means that students who work in pairs during the intervention are more likely to disagree with the statement of time on task. Students working in pairs feel less able to manage and control their time or complete the assigned task within the specified time.

7.3.4 Student Satisfaction and Motivation

The second part of the post-intervention survey (PS1) contains another 14 statements reflecting on students' satisfaction and motivation towards the constructivist mobile-based learning approach to programming. Table 7.10 summarises the results.

Table 7.10: Reflections of Student Satisfaction and Motivation (Percentage %)

Statement	Agree	Neutral	Disagree
1. The application of the approach during a programming lecture is a good idea	75.0	13.0	12.0
2. The application of the approach worked well with the way I like to learn in the lecture	64.8	14.8	20.4
3. I believe application of the approach enhanced my learning of programming during the lecture	63.0	24.0	13.0
4. I prefer the application of the approach to traditional approach	57.4	20.4	22.2
5. I felt that the application of the approach was a distraction during the lecture	31.5	27.7	40.8
6. The application of the approach to practice programming concepts during the lecture motivated me	72.3	18.5	9.20
7. I got more feedback from my instructor in the lecture because of the application of the approach	29.6	38.9	31.5
8. I got prompt feedback from my instructor in the lecture because of the application of the approach	26.0	37.0	37.0
9. The application of the approach in the lecture helped me to understand the material in a more interesting way	75.9	22.2	1.90
10. The lecture style was well organised for the application of the approach	51.9	25.9	22.2
11. I was motivated because I worked with my fellow students on one laptop during the lecture	44.4	33.3	22.3
12. I prefer to work alone using my laptop during the lecture	40.8	35.2	21.4
13. I liked working on ViLLE during the lecture	66.7	24.1	9.3
14. I prefer using ViLLE in the lecture compared to Eclipse	35.2	35.2	27.8

As shown in Table 7.10, generally, students express a moderately high level of agreement about satisfaction and motivation. The highest level of agreement at 75% is for the statements “The application of the approach during a programming lecture is a good idea”, and “The application of the approach in the lecture helped me to understand the material in a more interesting way”. Statements that are given the least score are about receiving prompt and detailed feedback from the instructor statements 7and 8, at 29.6 % and 26 % respectively.

Respondents are satisfied with the constructivist mobile-based learning approach as it suits their learning style (64.8 %) and is well-organised (51.9 %), while 57.4% prefer the new approach to the traditional approach. Moreover, 72.3 % of the students are motivated in practicing the programming concepts during the intervention lecture. Further, 75.9% of the students feel that the approach helps them to understand the materials in a more interesting way. In addition, 63% of students support the approach not only because it motivates them during the lecture but also enhances their learning during the lecture. In the negative statement about potential distraction posed by use of mobile devices, 40.8% disagree that this could be a problem, while 31.5% agree and 27.7% are undecided. Students are divided equally on the question of working alone or collaboratively in pairs as 44.4% are motivated to work with their fellow student and 40.8% prefer to work alone. The visualization software ViLLE works well in the environment as 66.7 % of the students liked working on it during the lecture. However, when they are asked if they prefer using ViLLE in the lecture compared to Eclipse the results are indecisive as 35.2% agree, 35.2% are not sure and 27.8% disagree.

7.3.5 Student Responses (Post-Intervention Survey PS1)

Apart from responding to those statements, the third part of the survey asks the students to offer their opinion on the use of mobile devices during lectures to highlight the advantages and problems of this method. From the analysis of the open-ended questions, positive and negative perceptions of students and their suggestions are detailed below.

7.3.5.1 Affirmative perceptions

- ***Immediate Practice***: One of the key areas of improvement in learning brought about by the visualization software ViLLE is that it enables students to practice their knowledge immediately. Students really appreciate the opportunity for compiling, running, checking, tracing, demonstrating and testing the code being taught in the lecture. A comment from one student highlights that the main advantage of this learning method is "being able to see the program running as we were discussing it", while another adds that it allows her to "try and learn the best method for a certain code by myself."

- ***Better Understanding***: Another key intervention of this method of hybrid learning is that it helps in increasing the students' understanding of concepts being taught in the lecture. While one student finds that "this allowed me to see holes in my understanding", another states that "it allowed me to test my knowledge immediately".

- ***More Enjoyable***: The students also like working in such an environment using hands-on computer-based technology. Some students say that the incorporation of laptop computers with lectures "makes it more interesting and allows me to work at my own pace" and another finds that it "was more interactive and enabled faster learning".

7.3.5.2 Negative perceptions

- ***Software***: A few problems were raised by the students about the version of ViLLE used during the intervention as the actual web-based application cannot be used due to the lack of Internet access in the lecture hall. Some students encountered issues during the compilation of codes, "setting up the program was an issue as everyone had different computers and it was difficult to compile".

- ***Physical issues***: The students mention some common concerns about the physical equipment needed for such lecture environment, such as laptop battery life, lack of power points, internet connection and appropriate tables. One student says, "We need power points and wireless Internet for this method to be really effective".

- ***Distraction***: Distraction is often cited as a common concern in such learning environments as there is a possibility that the focus is not entirely upon the instructor when student are allowed to work with their devices. However, very few students mention this issue in their answers to the open-ended questions.

7.4 Comparison of the Analysis between the Pre and Post-Intervention Surveys regarding the Seven Principles

The students' responses express a significantly positive view of the constructivist mobile-based learning model based on the seven principles except for Principle 1. A comparison of pre- and post-intervention survey responses is needed to report how their view of the new constructivist mobile-based model changed after the intervention. Table 7.11 describes the mean and *P* values for each principle before and after the intervention.

Table 7.11: Comparison of the Seven Principles between the Pre and Post-Intervention Surveys

	Principles	**Pre-Intervention Survey**		**Post Intervention Survey**	
		Mean	***P***	**Mean**	***P***
1	Encourages student faculty contact	5.68	.042	5.29	.008
2	Encourages cooperation among students	6.78	.000	6.69	.008
3	Encourages active learning	6.88	.000	7.37	.000
4	Gives prompt feedback	6.76	.000	7.15	.000
5	Emphasises time on task	7.03	.000	6.89	.000
6	Communicates high expectations	6.88	.000	7.19	.000
7	Respects diverse talents and ways of learning	6.52	.000	6.83	.000

The constructivist mobile-based learning approach is shown to be in alignment with all the seven principles except Principle 1. Further, the results indicate a possible improvement in students' learning experiences on Principles 3, 4, 6 and 7, but Principles 1, 2 and 5 show some depreciation after the intervention. This means that students' learning experiences in the lecture show different patterns of change across the seven principles after the intervention. The following sections explain the result for each principle in detail to mark any significant changes within the principle before and after the intervention.

Principle 1: *Good practice encourages student and faculty contact.*

Principle 1 received the least positive perceptions before and after the intervention. It was expected that students' face-to-face contact with their lecturer on asking and answering questions and/or sharing ideas would improve, as they would be able to practice the concept being taught promoting them to initiate discussions with the lecturer. Students' thoughts in the pre-intervention survey show that they appreciated the possibility of increased interaction with the lecturer. However, the mean value of this principle after the intervention is less compared to the mean value before the intervention. Also, a significant negative correlation has been found between this principle and the way students work during the intervention. Students who work in pairs with their fellow students are more likely to disagree with this principle. Based on these results, it could be assumed that student-faculty contact is comparatively lesser for students working in groups. Moreover, the feedback from the instructor was given the least positive perception from the general statements about student satisfaction and motivation. Students tend to disagree with this statement, suggesting that they might not get adequate and immediate feedback from their lecturer, which in turn could affect the interaction between students and lecturer.

Principle 2: *Good practice encourages cooperation among students*.

Theoretically, the constructivist mobile-based learning approach is about promoting active interaction and cooperation between students, so it is assumed to be significantly aligned with this principle (Jenkins et al. 2012b). In the intervention, students are given the option to work in pairs with two students sharing one laptop, especially students who do not have laptops and want to participate in the intervention. However, the mean value for this principle decreased after the intervention. The majority of the students prefer to work alone (83.3%) and only a few (16.7%) choose to work in pairs. Moreover, students who like to work in groups and students who prefer to work alone have convergent percentages as reported in their responses to the general questions. This means that students' perceptions on the effectiveness of this learning approach for promoting cooperation showed a slight depreciation after the intervention. Some responses in the open-ended questions indicate that the arrangement and layout of tables in the lecture hall could affect cooperation in such an environment. In conclusion, the students' experience from participating in the intervention showed a slight decrease in their perception about its benefit for the principle of co-operation among students.

Principle 3: *Good practice encourages active learning*.

Active learning received the most positive responses from the students after the intervention. As the constructivist mobile-based learning approach is designed to incorporate different kinds of activities ranging from active discussion to practising the concept as it is taught in the lecture, this would have a positive repercussion on efforts to foster students' understanding and motivation. The mean value (M = 7.37) for this principle showed the most significant jump after the intervention compared to the scores in the pre-survey. Thus, the students not only believe in the possibility of an improvement in active learning but testify to having experienced this positive effect after participating in the study as their scores on this principle increased in the post-intervention survey.

Principle 4: *Good practice gives prompt feedback*.

The constructivist mobile-based learning approach is designed to not only prompt students to practice the concepts immediately in the lecture but it also aims to give them immediate feedback. One of the main advantages of the ViLLE system used as part of the approach is the immediate feedback that students receive from the system as they put in their answers. This mechanism of prompt feedback is appreciated by the students and some students in the open-ended question also remark that they like working on the ViLLE software particularly due to this feature. This leads us to conclude that this new learning approach is aligned with the principle of prompt feedback as the mean value for this principle was not only positive but showed an increase after the intervention.

Principle 5: *Good practice emphasiszes time on task*.

The mean value for this principle showed a slight decline after the intervention (M = 6.89) compared to the scores for the pre-intervention survey (M = 7.03). Practicing the activities in the class may have taken more than usual time for normal lectures, thus reducing students' perception about the time on task capacity of this mobile-based learning approach. Moreover, significant negative correlation has been reported between this principle and students' study load as part-time students, who are generally older, are more likely to manage their time compared to full-time students. Furthermore, significant negative correlation has been found between this principle and the way students work during the intervention. Students who worked in pairs tended to spend more time in discussion compared to students who work alone, thus, increasing the probability of disagreement on this principle among the former group.

Principle 6: *Good practice communicates high expectations*.

Students appreciate the increment in their quality of work and their understanding during the intervention lecture. Consequently, the mean value for the principle is higher after the intervention compared to the pre-intervention survey. The results also indicate that students' study load is a significant predictor of students' view on this principle $\beta = -2.269$, t (52) = -2.163, $p < .05$. Students who enrol as part-time students (generally older than their cohorts) are more likely to agree with the ability of this form of mobile-based learning to communicate high expectations.

Principle 7: *Good practice respects diverse talents and ways of learning*.

The constructivist mobile-based learning approach is designed to meet a diversity of learning ability and styles displayed by different students in a class. A comparison of the pre- and post-intervention surveys support this contention that mobile-based learning approach is effectively aligned with this principle. While the students agreed to the positive effect of this learning approach on this principle in the pre-intervention survey, they gave even higher scores on this principle after participating in the intervention. This evidence proves that students valued the approach as it works well with their individual learning styles and preferred the new approach to the traditional lectures.

7.5 Post-Intervention Survey (PS2)

The post-intervention survey (PS2) aims to investigate opinions of the students who are in the intervention lecture but did not participate in it. Fifty students completed this survey at the end of the intervention lecture. The survey has four parts. The first part contains questions on the demographic information of these students. The second part contains a question about their reasons for refusal of participation. The third part contains a set of statements about the intervention. The last is an open-ended question asking for any opinions or suggestions on this form of lecture.

7.5.1 Participant Profile

The first part of the post-intervention survey (PS2) contains some questions relating to the demographic profile of students' study load, gender, age, and programming skill background. We present the data relating to the background of this student cohort in Table 7.12.

Table 7.12: Students Demographics for Post-Survey (PS2), n= 50 Students (Percentage %)

Study Load	Full Time	100
	Part Time	0.0
Gender	Male	88
	Female	12
Age	Average	21 Years
Programming skills	Novice	52
	Intermediate	48
	Expert	0

In this cohort, 100% of the respondents are studying full time; 88% are male and 12% female. The average respondent is 21 years old. 52% of students rated themselves as novices and 48% students are at intermediate level in programming skills.

7.5.2 Reasons for Refusal of Participation

In the second part of the survey, students are asked about the reasons behind their refusal to participate in the intervention. 45 students answered this question. They gave a lot of different answers, for example:

- they do not have a mobile device,
- they did not bring their laptop to university or forgot to bring it,
- they prefer paper and pencil,
- they feel that it would be a distraction,
- their laptop or tablet was broken or too heavy and
- battery was too low.

7.5.3 Reflections on the Constructivist Mobile-Based Learning Approach by Non-Participating Students

The third part of the survey has three statements about the experience of these students attending the intervention lecture without participating in it. Students are asked if they are distracted by their fellow students using laptops or feel that they have missed out any information given during the intervention lecture. They are asked if they would have preferred to participate in the intervention. The following Table 7.13 summarises the results.

Table 7.13: Reflections of the Constructivist Mobile-Based Approach on Non-Participation Students (Percentage %)

Statement	Agree	Neutral	Disagree
I felt that the application of the proposed approach was distracting me during the lecture	30	16	52
I felt that I missed some of the information given during the lecture because I did not have a mobile device	32	18	48
I would preferred to have had a mobile device	58	20	20

Overall, students do not have any objection to attending a lecture that implements the constructivist mobile-based learning approach as they felt the intervention to be just like any ordinary lecture. As shown in Table 7.13, more than half of the students (52%) do not feel that other students using laptops distracted them from the lecture, while 30% are distracted and 16% are undecided.

Not having access to the greater functionality and information available on the mobile devices, these students may have felt left out of the loop in the intervention lecture. So the second statement raises this question to the non-participating students. Here, 48% feel that they did not miss out on information due to the lack of a mobile device, while 32% did that they would have greater access to information if they had a mobile device. Notably, 58% of them would have preferred to have a mobile device during the lecture.

7.5.4 Student Responses (Post-Intervention Survey PS2)

The last part of this survey contained an open-ended question. Few students answered this question. Students who did not have a laptop voiced some concerns about device ownership. One student notes, “Bringing a laptop would give some benefits for learning, but think about people who do not have a laptop”. Another student raises a comment which indicates the inevitability of including mobile devices in lectures by only concerning about possible effect on lecture time, “I figure it's a matter of time but I am not sure”. Distraction is also a problem for some students, “Laptops or tablets can be very distracting when misused”. However, students who would prefer to participate in the intervention appreciated the possible benefit of this type of lecture, “It helps because we could immediately practice the concepts to check if we understood them”.

7.6 Summary

This chapter has evaluated the effectiveness of the constructivist mobile-based learning approach in a programming course from the perspective of students in an intervention lecture. The seven principles of good practice in undergraduate education have been used as a framework for evaluating the delivery of theoretical and practical components in the intervention lecture based on this approach. The pre and post-intervention evaluations also provided a comparison of traditional lecture model and constructivist mobile-based learning approach on the seven principles. Significant correlations predicting the values of students' responses on the seven principles before and after the intervention have been reported. A comparison between the pre and post-intervention results has been discussed to examine if there are any possible improvement or deterioration in students' perceptions on any of the seven principles. The results indicate a possible improvement in students' learning experiences in the lecture on Principles 3, 4, 6 and 7 and a possible deterioration or drop on Principles 1, 2 and 5 based on the comparison between the pre and post-intervention results. Potential reasons of such changes have been described. Students who are not involved in the intervention were also interrogated to investigate the effectiveness of the approach from different angles. Students' reflections on the approach, reasons for non-participation and thoughts have been reported. More than half of the non-participating students would have preferred to have a mobile device during the lecture.

At the completion of this phase, the third research question of our research has been answered with findings that support the main contention of this thesis that the constructivist mobile-based learning approach is able to improve students' learning experiences measured by the seven principles. However, the findings reveal the need for greater clarification and critical reflection on the results. For example, how could the application of the constructivist mobile-based learning approach be incompatible with Principle 1 and more effectively with the other principles and the possible reasons behind our findings? The next chapter, Chapter 8, therefore, discusses and reflects on the results from this phase of the study as well as Phases 1 and 2 by drawing on in-depth focus group interviews conducted with a group of lecturers.

Chapter 8 - Reflections of Lecturers in a Focus Group

8.1 Introduction

This chapter discusses the last phase of the study conducted with lecturers for the purpose of addressing the third research question: *How can the constructivist mobile-based learning and teaching approach to programming influence students' learning experience during lectures?* By confirming, expanding and reflecting on the results of previous phases of the study. Qualitative data are collected through a focus group with five lecturers and an interview with a lecturer who could not join the focus group meeting. The participant lecturers teach programming courses from different universities and this diversity of sample could help the study collect different views from different contexts. While one of the participants has actually conducted the intervention in his lecture, the other participants are briefed on the constructivist mobile-based teaching approach in the focus group before we ask them questions. The participants are asked to reflect on the general efficacy of such an approach, the results of the study gathered so far, and how such results could be confirmed and/or expanded. The results from the qualitative analysis of the responses from the participating lecturers yield seven main themes which are explained below after an overview of the demographic profile of the participants.

8.2 Participant Profile

The teaching experiences of the lecturers in programming range from eight to thirty years. The courses that they are teaching vary from introductory to advanced programming. The substantive differences in work experiences, type of programming courses and teaching contexts enriched the diversity of the collected data. Table 8.1 lists information on the lecturers in relation to their years of experience in teaching programming and the programming courses they are currently teaching.

Table 8.1: Characteristics of Interviewees

Participants	Years of experience	Programming Courses
P1	12	First, second and third year students from structure to object oriented programming
P2	20	Fortran, Pascal, c, c++, windows programming and Java
P3	13	Prolog, Java, Pascal and Mercury
P4	12	C++ and Java
P5	30	First year students Java
P6	8	C, C++ and Java

Themes are then constructed from the patterns that emerged from the raw data, including, interaction and feedback, collaboration, expectations, novices vs. non-novices, software features, preparation time, resources and active learning. These eight major themes also contain sub-themes which are detailed below with individual responses to prove or clarify the significance of each theme.

8.3 Theme 1: Interaction and Feedback

From the analysis of the raw data, interaction between lecturer and students and feedback during programming lectures are found to be highly correlated. The lecturers express different kinds of opinions on the kind of feedback that is able to increase interaction in the class. Lecturer P6, for instance, state that immediate feedback from the software to the students during the lecture on the work they have done would give them a clear idea of whether they have correctly understood and applied the underlying concept. When they have such tangible feedback on their performance, they could ask the lecturer if they had not properly understood the idea or application of the concept. This type of feedback is an unambiguous way of testing their level of understanding and is reflected with the definition of Principle 4 (good practice prompts feedback). She says:

> “I think it will help the lecturer actually if students get some feedback from the software. Then the students can say, ‘oh I am getting this as a feedback, which clearly means that I did get this concept right or did not get the concept right. The feedback would also give me an idea to make a judgment on why these students did not get it and then I will be able to provide some more support for them” [P6].

This assumption also guides the intervention lecture on the basis of the belief that immediate feedback during the intervention would boost interaction. However, the result from the quantitative analysis of student responses show that while the intervention lecture ensured that students could get immediate feedback from the software, the interaction between the students and teacher actually decreases. Other participating lecturers conclude that the immediate feedback students receive in lectures should be accompanied with feedback to the lecturer as well as other students. Lecturer P1, for example, points out that if the feedback channel was restricted to the individual student, this would just close in the communication. It would be more effective if feedback was opened to the whole class so that students knew what other people in the lecture are doing, and discussed what was right and wrong. He argues:

> “I am not sure if this approach could provide a social aspect to see what other people are doing in the class … you could pick a general answer from the class and say oh this is the problem so they learn from mistakes … and seeing the big picture and what the results should be and should not be is a learning activity in itself” [P1].

Lecturer P2 agrees with this and continues P1’s argument. He stresses the role of the tool to be used during lectures as a means for enabling such feedback. He explains that the tool must have the facility for students to upload the codes they write, he said:

> “One of the advantage that you could have with mobile devices, you can say (to students) once you finish your code upload this code to show it to

everyone else and then we can discuss … oh this is better … so we need to come up with a tool that allows students to upload codes easily because it prompts interaction and every student will see how others have done the job" [P2].

On the other hand, lecturer P4 emphasises the relationship between how students' feedback is made available to the lecturer and its ability to foster interaction in the class. He mentions:

"You are sitting there doing your exercises on your computer … if they just focus directly on their stuff they won't talk to anyone else. So a feedback tool allows a lecturer to see what people are doing, for example in a mass audience it gives you a graph like 75% did this and 25% did that. Then you could talk about the feedback … I think the ViLLE software as a tool lets you constrain the interaction according to the feedback on the performance of the students" [P4].

Actually, such forms of feedback and interaction are also available with other technology like Personal Response System "Clickers"[2] (Duncan 2006; Hall 2013; Lantz 2010; Morling et al. 2008). But it must be noted that it has had varying degrees of success as a method of engaging students in a lecture environment and providing the lecturer with some feedback from the students. Lecturer P3 picks up on this topic and says:

"What I did is use Clickers … I gave them all the Clickers and a code … Then I let them discuss with one another" [P3].

This method is, however, opposed by P1:

"but clickers does not help to boost programming skills … lecture participation sheet might help with disc checking, but doing something like

[2] Clickers are an interactive technology that enables instructors to pose questions to students and immediately collect and view the responses of the entire class.

> actual programming … no … we need to engage them with more programming … that is the most important thing” [P1].

The results, therefore, add to Principle 4 the importance of a two-way process of feedback between students and lecturer to enhance learning experience during programming lectures. In order to engage a digital platform that is best able to promote feedback and interaction, this study moves beyond the popular Clickers software to the ViLLE program that could provide students with a wider variety of activities that encourage actual programming. Although ViLLE provides lecturers with later feedback from students on how they answer the questions and how many times students try to answer them right, some features could be added to ViLLE for providing immediate feedback to the lecturer to increase its effectiveness during lectures.

8.4 Theme 2: Collaboration

The constructivist mobile-based teaching approach is designed to encourage students’ collaboration by working in pairs during the intervention lecture. A review of the literature suggests that cooperative learning should be integrated into all the curricula of higher education (Foss, Oftedal & Løkken 2013; Pinho, Bowman & Freitas 2008). Empirical evidence relates the intellectual and social benefits with the students in cooperative learning can achieve (Johnson, Johnson & Stanne 2000; Magnesio & Davis 2010; Sorcinelli 1991). However, lecturer P4 has a concern about such collaboration once students are focusing on doing the exercises:

> “As they are doing the exercises, you are not getting any discussion between the students about their solutions” [P4].

Going back to the results reported on this principle (Good practice encourages cooperation among students) in Chapter 7, the constructivist mobile-based teaching approach was found to be significantly aligned with this principle, although the mean value of the positive relationship decreased after the intervention. Lecturer P3 says that students might need explicit directions from the lecturer to start working in pairs as they would naturally be inclined to work on their individual devices:

> "If all of them bring their mobile devices, then they might start a discussion ... you could even encourage cooperation in pairs by asking half of them to shut their laptop and begin discussions with the person next to them" [P3].

Moreover, lecturer P6 notes task type as another factor that could affect students' collaboration. She says:

> "It depends on how you setup the task … if I decided to have a group task and said I want you three to start on that particular problem, then that work would definitely create collaboration" [P6].

Furthermore, she raises a point about students' characteristics which cannot be ignored in such situations where they have to negotiate and talk to their counterparts. She continues:

> "Also some people by their nature like to work on their own and do not like to work in groups" [P6].

In addition, lecturer P5 argues that oftentimes the lecture's content and objective were not suited to collaborative tasks. He notes that:

> "The venue is surprisingly a key factor in such decisions because you need a space where that kind of collaborative learning works … so I think that it also depends on the setup of the lecture too" [P5].

However, lecturer P4 disagrees with this statement and argues that the lecture theatre setup does not really affect the potential for collaboration between students engaged in pair programming. He says:

> "But not necessarily in terms of mobile devices such as laptops … you are talking about programming and pair programming that works, but triple does not really add anything … you can do pair programming in any sort of lecture theatre" [P4].

A review of the literature recommends that pair programming can offer alternative programming designs that are simpler and more maintainable than those of a single programmer who may not be able to see predictable problems in future use of the program (Salleh, Mendes & Grundy 2011; Williams & Kessler 2003). However, this research suggest not to make a blind assumption about the usefulness of pair programming rather these responses indicate that the constructivist mobile-based teaching approach should consider the diversity of students' characteristics, the task type, the equity of mobile device ownership and the lecture theatre's setup to effectively boost and control collaboration between students during lectures.

8.5 Theme 3: Expectations

What might a lecturer expect from students with the application of the constructivist mobile-based teaching approach during programming lectures and to what extent can such expectations be fulfilled? The participating lecturers list some improvement that could be expected from the students with the application of such an approach. They are engagement, better understanding, help with reducing attrition and better learning outcomes.

8.5.1 Engagement

Expectation of better engagement from the students with the content of the lecture was valued by the lecturer participants. All lecturers voice this same opinion, for example, they say:

> “I think using a device is quite engaging in itself … in a class lecturers can run some little quizzes with a device … and just that distraction wakes them up and keeps them engaged” [P1].

> “It is certainly critical to engage students and the use of laptops or any other technologies is a first step in that direction, a big step” [P5].

Lecturer P4 emphasises the importance of engagement for first year students who need that sort of motivation to be involved in the lecture, he says:

> “I think the fact that people do not find programming interesting is a big issue … so I think engagement is more important especially in the first year” [P4].

Researchers and advocates of constructive learning argue that the active engagement of the learner in practical learning tasks in laboratory classes is a more influential and effective form of knowledge transfer (Laurillard 2006; Low 2008). Lecturers P1 and P4 support the value of the engagement that might occur in regard to active learning, they say:

> “I think engagement is the primary thing because you might have exactly the same exercise, but they will be doing it and focusing on it if it engages their interest and curiosity” [P4].

> “So the expectation is that you will focus on a programming code at least as a process that is running in front of your eyes on the machine, which means they would be more engaged” [P1].

8.5.2 Better Understanding

The participating lecturers valued the constructivist mobile-based teaching approach as a way of providing better understanding and learning outcomes for their students. Lecturers P6 and P1 state:

> “My expectation is that it would bring better learning outcomes if the integration of mobile devices into lectures are well planned” [P6].

> **“**The expectation would be the same type of learning curve, but it would hopefully improve the outcome … they may understand the concepts more deeply when they actually see something in action … also I think that this type of learning approach would add value to the experience they have in the class” [P1].

Lecturer P2 explains how students could get a grip on better understanding. He says:

> “I think it does help students understand the sequence of how a code works, but I think what they do not understand is which aspect they have to choose … this is something that can confuse them. I think that structure gives you an idea of the way it works but does not actually give you a feel of how to use it” [P2].

Lecturer P5 who expects students to be more engaged is, however, not sure if this approach would support better learning outcomes, he mentions:

> “I think beyond being more engaged in the classroom, I do not know if I expect a better curve in terms of the results” [P5].

8.5.3 Reduce Student Attrition

The theme of expectations that the lecturers hold with regard to this form of learning could be divided into three important aspects. Of these the first two themes of engagement and better understanding are derived from the literature and tested in the initial survey with students in Chapter 7. But the focus group with the lecturers generated a new sub-theme for this issue relating to the potential of this teaching approach in reducing attrition rates in programming courses. The participating lecturer P5 was the first to talk about the potential of the constructivist mobile-based learning in reducing student attrition. He mentions that:

> "I think the expectation is that I would see more students stay in the course, it would help with the attrition … so my expectation is, it would reduce attrition through better engagement" [P5].

8.6 Theme 4: Novices vs. Non-novices

Results from student and lecturer perceptions support the decision to choose first year programming students or novices (who have no formal certificate of taking any programming courses) as the target population for this study. The question here is whether the lecturers agree on the application of constructivist mobile-based teaching approach with novices and reasons for that choice. The participating lecturers agree with this arrangement and explain the reasons behind their opinions.

Lecturer P4 agrees that the approach is more applicable to first year students as they need a teaching approach which is able to keep them engaged while they are being introduced programming as a subject, he says:

> "For second or third year programming you do not need to do this type of exercises. But for first year students, anything that can improve engagement would be important" [P4].

This argument supports the notion that practice increases a novice programmer's effectiveness, correctness, and efficiency (Andre & Russell 2002).

Lecturer P3 raises another reason. Second or third year programming students are more knowledgeable in the sense that they know the basic concepts, so they do not require practical exercises that encourage them to consider the basic structure and effects of a particular programming statement. He explains:

> "I think the more advanced students already know the answers. I do not think that there is much to learn from a practical demonstration of what the statement is going to do" [P3].

The complexity and length of second and third year students' program are also cited as reasons for their unsuitability to the more simplistic structure of mobile-based learning format. Participating lecturers P2 and P4 say:

> "Second or third year students' program tends to be very large with thousands of lines of codes. So which aspect can you focus on especially when you are talking about patterns, threads and so on" [P2].

> "The complexity of the program that you expect a third year programmer to solve is going to be hard to fit in this sort of structure" [P4].

However, lecturer P6 has a different opinion on this argument, she says:

> "It depends on the problem actually … may be it would be better for a novice … but an experienced programmer would be happy to work on these questions anyway … so I think I do not have a preference here … I think it works for both groups" [P6].

Therefore, factors of students' engagement, students' knowledge and computer program type support the argument that first year programming students are the proper cohort for implementing the constructivist mobile-based teaching approach.

8.7 Theme 5: Software Features

The software to be used is one of the key components of the constructivist mobile-based teaching approach. Research supports the contentions of programming educators concerning the use of visualization tool in demonstrating programming algorithms (Hundhausen, Douglas & Stasko 2002). There is no means of applying the approach without software which can support the activities to be done during lectures. Lecturer P6 emphasises the importance of the combination between the mobile device and the software in the following words:

> "I feel that the combination of using the laptops or iPads and some applications and doing some activities works better rather than completely focusing on mobile learning using the laptop" [P6].

The participating lecturers points out some vital features that need to be in the software used in such an environment for better application of the constructivist-mobile-based approach. First, the software that students use during lecture should be the same software that they use when doing their actual programming tasks such as lab exercises and/or assignments. Lecturer P1 explains:

> "They (students) need to get familiar with the environment that they are going to use … the transferability of skills is a difficult thing … even doing something on ViLLE in a structured way then going to Eclipse where they actually write code. As the two are completely different environments, learning to use the actual software after the class exercise is a waste of time and effort. So I think there is a possible negative in using different learning software in the classroom from the one they actually work on for their assignment. A small change in context with these different environments can make it difficult to transfer their skills or knowledge" [P1].

Second, the software should support the two-way process of immediate feedback discussed previously in Theme 1 (Section 8.3). Therefore, the software must be able to provide a combination of three types of feedback, lecturer to students, students to lecturer and students to students. As mentioned above, lecturers P2 and P4 say:

> "We need to come up with a tool that allows students to upload codes so easily" [P2].

> “Does the tool allow a lecturer to see what other people are doing… is there any channel of feedback for the lecturer from the device” [P4].

Third, the usability of the software should meet students’ needs and comfort. The lecturer who uses ViLLE in his course reports that:

> “I think ViLLE itself, I mean the user interface, has some issues … if you ask students they had mixed feelings about it … there were those who said it was great and were comfortable doing the exercises, but some said no” [P5].

Fourth, lecturer P4 appreciates the visual form of the software, he states:

> “Computer Science students like to solve challenging technical problems and a visual software can make it interesting for them” [P4].

Finally, lecturer P5 concludes that although there is no perfect tool that has all the features lecturers and students need in such an environment, the application of the constructivist mobile-based teaching approach is better than the traditional learning delivery. He says:

> “There is no universal tool that can make everyone happy … that does not mean you dismiss a tool because of the problem it might have … we have to adapt the tool with our teaching requirements … it certainly is better than presenting a hard copy or just static PowerPoint slides for a programming course” [P5].

Hence, the responses indicate that there is a need for customised software that supports familiarity, usability, visual presentation and immediacy of feedback for better application of the constructivist mobile-based teaching approach.

8.8 Theme 6: Preparation Time

Time constraints dominate the lecturers' preparations for applying the constructivist mobile-based teaching approach during programming lectures. The participating lecturers highlighted the value of the preparation in order to have a successful constructivist mobile-based teaching approach. Lecturer P2 says:

> "I think using laptops as an engagement tool or a mechanism like that in lecture does not mean there is not a great deal of preparation involved … You cannot just throw a piece of code and say try this … no" [P2].

These include time to prepare suitable questions or tasks during lectures, time to prepare the course content, time to use a tool that supports the application of the constructivist mobile-based teaching approach. Lecturers emphasise these issues in the following comments:

> "The time needed to set up the questions for discussion can be an obstacle in this type of lecture … and ideally I also need time to prepare my own content before I can even think of the questions" [P5].

> "In my case it is a matter of the time needed to start using the tool. I do believe it is an issue of being time poor … and of course you have to have time to pick up the basics of how to use a new tool" [P5].

Given all these concerns on time, lecturer P4 suggests a way that could help save some time for content preparation by ensuring that the materials for each course are present so that every lecturer only has to teach the content without having to complete it from scratch.

> "The course material does not belong to the lecturer it belongs to the course" [P4].

The time that students spend on each task should also be considered when designing the tasks. Students should be given a fixed slot of time in a lecture to finish the task, so that the rest of the time can be devoted without distraction to the lecture. Bruhn & Burton (2003) created studio teaching to help students better understand Java programming concepts during classroom presentations. They report concerns about the time needed in the classroom for active learning. Lecturer P3 and P6 say:

> "If you are doing long exercises, yes time is a problem" [P3].
>
> "I can only do very quick small problems. There is no way I get them to program some big code in the lecture time" [P6].

As in Phase 2, lecturers in this phase of the study are concerned with lecture time and suggest that lectures must cover less material but with a more intense focus so that students remember the concepts. This will help students develop a better understanding of the main concepts being taught rather than a shallow grasp of all the required materials. For example lecturer P4 and P6 notice that:

> **"**The fundamental problem is that lectures are not all good. In the traditional lecture format, memory retention is a problem and it really does not matter how good a lecturer you are. If you get them to do stuff you may cover less materials, but they will actually remember the materials you cover" [P4].
>
> "I think this is a good approach because there is no use in running through heaps and heaps of materials, if the students are actually not in to it and do not have a hands-on experience of practicing the concept" [P6].

Another lecturer P5 complains that the contraction of hours for delivering the same course is posing a serious time constraint on content delivery for first year programming students, he says:

> "I had my course for first year cut from seven hours of content to just four hours and I think for first year that is terrible I used to have three hours of lectures … the longer time you give, the more time you have to do what

> you want to do … you may have only one piece of code but you spend the whole hour talking about that piece of code and that was good" [P5].

Picking up on this issue, lecturer P6 supports P5 by saying that in such a scenario of shortened lecture times, it would be difficult to implement an interactive learning session with exercises and discussions:

> "If the time table of the lecture is set as a three-hour lecture, it will work perfectly. But if you had a one-hour lecture then it will be a bit tricky. It can still work but the lecturer has to plan it very well and have really short questions and focus on the main concepts otherwise they will run out of time" [P6].

Apart from these external time constraints, the lecturers concede that their own time management skill is also important. P6 mentions:

> "I believe this would work effectively only if the lecturer has full control of the lecture and plans it perfectly. Otherwise I do not think they will complete the syllabus because these things take a lot of time. I have to think it through clearly, I have to balance my time so my time management skill should be good, I should know exactly when I am going to do what" [P6].

8.9 Theme 7: Resources

In addition to the issue of time constraints, the participating lecturers raise the need for teaching assistants to support the lecturer in such an approach. The teaching assistants could walk around the class, monitor the students' exercises and answer their questions. Lecturers P5 and P4 say:

> "It might work in a workshop context where teaching assistants to walk around to help the students" [P5].

> “So in a class of 300 to 400 students you need at least 3 to 4 people doing that … students will be more focused if they know that someone will look at what they are doing … but I am not sure if that would be financially feasible for the university” [P4].

However, lecturer P3 raises a concern about the lecture venues currently in use as they are not suited for an interactive lecture format where teaching assistants can walk around, he says:

> “But the shape of the lecture hall is wrong … you won’t be able to walk around to check on students” [P3].

Although lecturer P4 worries about the ability of university to finance and support teaching assistants, lecturer P1 and P5 had a reply to his concerns. They note that the university provides a lot of support resources to the students, but they do not use them properly. According to him, a careful planning of financial resources could reduce expenditure on extraneous facilities and release funds to support teaching assistants.

> “But when you think about it the university has put a lot of infrastructure in to help programming students. For example, we have got a SLAM (students learning academic mentor) and we have helped a lot of students with that. And then we run our own little labs about 4 or 5 times a week, we book rooms and we have got 4 students looking after those. So when you think about it they have got the lectures, tutorials, labs, and facilities. They have got all these stuff that they can have access to face to face, but they do not utilise any of them” [P1].

Lecturer P5 concludes the discussion on this issue with this thought:

> “But I think all of that is saying to us is that we really need to start looking at different delivery models especially for programming. It is not just us needing to sort out that transition but also how the overall program works to promote an integrated learning delivery model … because as you said

> people do not turn up at such facilities and they do not use the resources provided" [P5].

In summary, the aspects under the theme of preparation time pointed out by the participating lecturers relate to the time needed to set up questions, time to prepare content, time to start using the tool, time for tasks to be done by students, lecture time and lecturers' time management skills. Moreover, the second type of preparation relates to ensuring the availability of teaching assistants during lectures. There is a need to better identify facilities that might motivate students to be more involved in their learning endeavours. This could assist the university to provide for much needed facilities and reduce unnecessary investment on less useful matters.

8.10 Theme 8: Active Learning

In order for computer programming students to acquire conceptual understanding as well as practical skills, it is important to follow a learning paradigm that includes a hands-on and practical approach (Carter et al. 2010; Eckerdal 2009; Hadjerrouit 1999). Active learning in the constructivist mobile-based teaching approach enables students to practise an exercise or a task on their mobile devices during lectures using visualization software. The participating lecturers appreciate such exercises that allow immediate implementation of a particular concept by students in lectures. Furthermore, they discuss the different values of such exercises in the lecture and the lab.

Programming courses consist of a set of practical and theoretical components. It is important for computer programming students to acquire conceptual understanding as well as practical skills, so the practice is critical to programming courses. Lecturer P4 notes:

> "So the thing you need to keep up to date with your course is practice … anything that boosts actual practice in programming is a good thing" [P4].

In addition, computer programming is a cumulative subject where concepts are built on top of each other. If students do not understand a particular concept in the beginning, it is hard to grasp the rest. Hence, lecturer P5 raises the importance of the immediate practice because of the cumulative issue.

> **“**The other advantage of getting them to do stuff is that fundamentally programming is a very cumulative topic … and you need to keep building your knowledge and understanding topic by topic through constant practice … really programming is one of the most cumulative subjects in my opinion” [P5].

Furthermore, lecturers feel that the students’ individual perception of their understanding of what is being taught in lectures does not really reflect on their ability to do it practically. Consequently, lecturer P6 believes that such an implementation of theory during lectures could help with that. She says:

> “I believe that they have to have that hands-on experience. It is easy for them to sit and listen to the lecturer and say oh yeah I understand all these things. But many times I have had students come back here for consultation saying that they understood the concept while I was explaining it, but they actually got stuck when they tried to do it on their own. This is clearly because there was a gap between what they thought they understood and what they actually understood by the time they got to doing it. So I believe that actually having it done in lectures as an exercise is a good thing” [P6].

Lecturer P4 emphasises the application of the constructivist-mobile-based approach in lectures as a way to enhance traditional delivery of lectures, he explains:

> **“**So I do not think that there is any particular reason why you cannot do this in lectures. I think anything that adds to interactivity and engagement

to the lecture is a good thing because the standard traditional model of the lecture is not very effective" [P4].

While practical exercises are undertaken simultaneously in the lecture in the constructivist mobile-based teaching approach, in traditional programming courses students are given practical exercises to do in the computer laboratory after the lecture. They often do such exercises on their own under the guidance of some lab instructors. While the participating lecturers see the advantage of doing the practice tasks in the lectures, they also see some benefit in allowing the students to practice the tasks in the labs. Here, the difference between lecture and lab tasks in terms of the time students can spend is a critical determinant of the benefit from each method. For example, lecturers P1 and P6 note that:

> "I think the lab sessions have their own meaning and having a small activity within the lecture has its own meaning. I think in the lab sessions they can try different problems for a longer time-duration and they have an assistant to help them. [In the lecture task] I think it should be focussed toward the learning outcomes for that particular lesson and the questions should be directed to those learning outcomes" [P6].

> **"**The time students can take to absorb the concepts is different in both contexts … the absorbing time is different in the lecture from the lab … the absorption in the lecture has to be quick" [P1].

Therefore, the time students spend on task during labs allows them to try different problems of different lengths on their own pace. However, lectures aims to encourage understanding of a specific concept. This requires that the lecture's tasks should be designed carefully to be focused on the immediate learning outcomes.

To sum up, programming courses are practical and cumulative subjects and the constructivist mobile-based teaching approach enables students to actively practice and apply their lessons during lectures. There is often a gap between the lecture where students think they understand the concept and the lab at the time of actual application. Practicing the concept in the lecture can help bridge that gap. Moreover, considering the cumulative manner in which programming courses work, the application of the constructivist mobile-based teaching approach may help students build a solid foundation before progressing on to the next level.

8.11 Summary

This last phase of the study conducted an interview and a focus group with five lecturers from different universities. The themes extracted from the analysis of the data are: interaction and feedback, collaboration, expectation, novices versus non-novices, software features, preparation and time and active learning.

Firstly, a two-way feedback process from students to lecturer and from lecturer to students is found to be important for fostering better interaction in the constructivist mobile-based teaching approach. Secondly, the approach should consider the diversity of students' characteristics, task type, equity of mobile device ownership and lecture theatre setup in order to effectively control collaboration between students during lectures. Thirdly, participating lecturers expect more engagement and better understanding from the students in such an environment as well as a reduction in attrition.

Lecturers believe that when students actively practice the concepts during lectures, it would support deeper understanding of the lesson and bridge the gap between the time that students thought they understood and the time of actual application. First year programming students are identified as the suitable cohort for the implementation of such a learning program due to factors of students' engagement, students' knowledge and computer program type. The software plays an important role for better application of the constructivist mobile-based teaching approach and it needs to support familiarity, usability, visual presentation and immediacy of feedback during lectures. The lecturers are concerned about the time taken to prepare for such lectures, including, time to setup questions, time to prepare content, time to start using the tool, time for the task to be done by students, lecture time and lecturers' time management skills.

This chapter has discussed the last phase of the study where the participating lecturers reflect on reasons, expand and/or confirm the results of the previous phases of the research. As the last chapter of this thesis, the following chapter will present a critical discussion and conclusion to this study.

Chapter 9 - Discussion and Conclusion

9.1 Introduction

A constructivist approach to learning is based on the ability of the learner to construct his or her own knowledge from the concepts provided by the instructor. In traditional lecture formats currently used in programming courses, it is hard for students to follow such a constructivist approach involving immediate application of the concepts being taught during lectures. The evolution of mobile devices, such as laptops, has led to growing interest in these tools to aid a constructivist learning and teaching approach in lecture theatres that can deliver theoretical understanding of concepts as well as practical application skills. In such a mobile-based learning and teaching paradigm, programming students can complete practice tasks on their mobile devices where they can immediately apply the concepts being taught during the lecture.

This research investigates the potential enhancement of the learning experience of novice programmers with a constructivist approach using their mobile devices and visualization software in programming lectures. The findings from this research are consistent with the view that traditional lectures are ineffective and not suited for practical forms of learning required in programming courses (Huet et al. 2004). Through this research we have shown that a constructivist approach can contribute to student learning as it can increase the competency of novice programmers in understanding the concepts being taught in lectures. Our research also shows that the high level of students' readiness and lecturers' approval of the use of mobile devices during programming lectures supports any consideration of the move to mobile-based learning and teaching environments.

This final chapter reviews the research conducted in this study and its implications for the practice of a constructivist mobile-based learning and teaching approach in introductory programming courses. The first section provides a recap of the research undertaken. The second section consists of a critical discussion of the overall findings in light of the research questions. This is followed by a discussion of the implications of the research along with some suggestions for universities and academics considering this approach. Finally, the chapter ends with some concluding notes and a discussion of possible future research directions.

9.2 Research Process Summary

This thesis investigates the effectiveness of a constructivist learning and teaching approach to programming courses utilising students' mobile devices in a traditional lecture hall environment and the capability of such an approach in enhancing students' learning experience. This form of learning in programming courses was tested with an intervention lecture delivering theoretical and practical components together using visualisation software on mobile devices. It uses seven principles of best practices in learning and teaching in higher education developed by Chickering and Gamson (1987) as a framework for evaluating the effectiveness of this mobile-based learning and teaching approach in programming lectures.

The thesis uses a mixed method approach integrating qualitative and quantitative methods. It has been organised into four phases of data collection and analysis. The following Table 9.1 summarises the four phases with their names and objectives.

Table 9.1: Summary of the Four Research Phases

Phase	Name	Objectives
Phase 1	Students' Perceptions	Investigates students' perceptions about a constructivist mobile-based learning approach using laptop in lectures.
Phase 2	Lecturers' Perceptions	Investigates lecturers' perceptions about a constructivist mobile-based teaching approach using laptops by their students in lectures. It also focuses on lecturers' teaching methods.
Phase 3	The Intervention	Designs, conducts and evaluates the effectiveness of the constructivist mobile-based learning and teaching approach to programming in a lecture environment. It uses the seven principles as the framework of evaluation.
	Pre-intervention survey	Investigates the extent to which the traditional lecture approach is perceived to be an effective pedagogical model. It targets all the students enrolled in the course.
	Post-intervention survey (PS1)	Investigates how effectively the constructivist mobile-based learning approach is aligned with the seven principles. It targets students who participated in the intervention.
	Post-intervention survey (PS2)	Investigates opinions of the students who were in the intervention lecture but did not participate in it.
Phase 4	Lecturers' Reflections	Discusses the last phase of the study conducted with lecturers for the purpose of confirming, expanding and reflecting on the results of previous phases of the study.

9.3 Discussion

The application of the constructivist mobile-based learning and teaching approach to programming courses requires technology integration which depends on many contextual factors such as the institute's resources, students' requirements and technology funding support. These factors vary from country to country, region to region, even institute to institute (Harris & Hofer 2011; Thompson & Mishra 2007-2008). Thus, it is vital that each school or organisation addresses their own context, needs and requirements to increase their potential for technology integration (Cox 2013). The first two phases were conducted with the purpose of examining the context in which this research is conducted. This would help us understand the constraints on technology integration and pedagogical practices at the institute, so that the intervention could be staged in a cohesive and strategic manner in line with the prevailing conditions. Phases 1 and 2 consider the perceptions of both Computer Science students and lecturers to design the learning and teaching approach so that the intervention lecture is suitably aligned with their needs, perceptions and concerns. Phases 1 and 2 also help us recognise and identify factors that could motivate, moderate or hinder the implementation of such an intervention. Then, the intervention is designed, conducted and evaluated based on the seven principles. Thus, the students' perceptions, lecturers' perceptions and the alignment of the constructivist mobile-based approach with the seven principles will be discussed in the following sections.

9.3.1 Student Perceptions

This section discusses the outcomes of research question 1:

> *How do existing perceptions of students influence their attitude to a constructivist mobile-based learning approach in lectures?*

This research examines Computer Science students' perceptions of laptop use in traditional lecture environment and students' readiness for such a move in terms of students' ownership and preparedness to take laptops to lectures. These aspects were then correlated with their demographic characteristics. The findings indicate that a high percentage of students own laptops, which shows a high level of students' readiness for a mobile-based learning approach. It supports the view that laptops have reached a price point where they are affordable for most higher education students (Wilen-Daugenti & McKee 2008). Moreover, the majority of respondents are willing to take their laptops to lectures showing that today's students are digital natives who expect to use technology everywhere (Tapscott 2010). Both these factors validate the focus of our research and point to the possibility of capitalising on the widespread use of laptops by students to incorporate them as a learning tool.

However, student responses to university-assisted purchase of laptops indicates that while most are appreciative of the financial help, some are also apprehensive that university-supplied laptops may be of a version or make that they dislike. Therefore, it is suggested that the university survey the stakeholders i.e. the faculty and students, to not only carefully consider wireless laptops suitable for lecture theatres and other learning situations, but also keep a track of student demands for the type of computer to be purchased.

Interestingly, students' preparedness to bring their laptops to lectures is found to have the highest impact on students' perceptions, which in turn is affected by age and willingness to purchase university-assisted laptops. Younger students and students who are willing to receive university support for purchasing a laptop are more prepared to bring their laptops to lectures. This supports the notion that the millennial generation of students born in or after 1982 is generally more positive about the use of information technology (Diana Oblinger et al. 2005; Howe & Strauss 2009). Also, students' level of agreement on the positive trends of such an environment can be predicted by their level of preparedness. Students who are highly prepared to bring their laptops to lectures also show greater agreement to the positive benefits of laptop use in lectures. Therefore, examining students' preparedness is considered as an important aspect for any institute wanting to adopt mobile devices in the learning process. Moreover, in order to ensure equity, universities need to provide and support ownership of devices for students who cannot afford them.

The students' views on using a laptop in lectures are generally positive, with more than half of the respondents (68%) indicating a positive attitude to the trend. The most significant aspect of the positive feedback relates to the increase in student engagement as the students believe that laptops could help deliver the course materials and lessons in an interesting way. The majority of students (63%) also seem to agree that using laptops may provide them with additional assistance in their learning tasks during the lecture. This confirms the findings of Campbell and Pargas (2003) who argue that the main advantage of laptop use during lectures is that they can assist students to better conduct their tasks. Moreover, the majority of the sample (58%) agree with the usefulness of laptop as a tool for facilitating group communication and collaboration as it has been acknowledged in the research by Olsen (2001).

The major exception to these positive aspects of laptop-use is the perception that laptops could be a possible distraction in the lecture theatre environment where students are expected to focus on the instructor and the lesson. The majority of students (60%) consider laptops to be a potential distraction and this result resonates with other studies that have identified distraction as a major disincentive to using laptops (Fried 2008; Hembrooke & Gay 2003; Wurst, Smarkola & Gaffney 2008). However, we find that contrary to the perception that laptops could be just mundane work tools in everyday life, about half of the students (57%) believe that they use laptops not because of its ubiquity but its utility for targeted tasks.

From our comprehensive analysis of student responses with regard to the four dimensions of advantages, disadvantages, opportunities and threats we extrapolate the responses to derive recommendations for higher education institutions about better integration of laptops in the learning environment. Respondents indicate many strengths and opportunities from the use of laptops in higher education listed in Table 4.4. Strengths include searching course information, following up lecture presentations, assistance in group-work, sharing information, portability, instant feedback on queries and results, note taking and internet access. These results are consistent with findings reported in previous studies (Dexter, Anderson & Becker 1999; Nilson & Weaver 2005). Furthermore, as our research focuses on Computer Science students, the significant benefit of this form of learning reported by them is the option of running program codes on remote servers. Students also report the potential for simplifying course materials by practising them on their laptops, a feature that has also been reported by Barak, Lipson and Lerman (2006). Other interesting aspects of opportunities recognised by this study are laptop affordability, environment friendly and keyboard familiarity. Our findings also show significant challenges that may impede the integration of laptops into the lecture format. Examples of challenges are network speed, few access power points, software incompatibility, security of the network, lack of free software licenses, lack of universal access to the technology, insufficient power points, lecture tables inadequate for typing, and training for users. The four dimensions in the TOWS analysis generate suggestions for approaches that could be adopted to best use laptops as a learning tool in lectures, by taking advantage of the strengths and opportunities to overcome and/or avoid weaknesses and/or threats. These recommendations are divided into two main types, technological and pedagogical.

Firstly, software licenses corresponding to the needs of the course curriculum should be provided and covered in the course fee. Measures must be taken to help students acquire laptops through assisted purchase from the university. Other technological aspects include issues, such as, access to wireless internet, security, suitable network speed, and power outlets. An important logistical issue relating to technology relates to designing the lecture theatre seating and layout to enable the use of technology in a comfortable and convenient environment by students. All these issues resulting from the threats that may impede the physical use of the laptops in lectures can be resolved with a strong university policy on technology compliance.

On the other hand, the pedagogical aspects relate to the issue of transforming the traditional lecture format into an active and collaborative learning environment applying mobile learning as an effective pedagogical method. Here, distraction is the most significant concern; this means that the learning material should be organised more effectively, teaching strategy and software applications must be tailored to best fit the mobile learning environment in order to decrease distraction and increase engagement among students.

The findings therefore provide an in-depth understanding of the motivations and barriers facing Computer Science students with regard to the possibility of adopting mobile technology in lectures. This is not only an important research finding for the literature but indicates that the practical application of mobile devices in higher education has a vast array of strengths to draw on. The opportunities identified also show great prospects for better utilization of mobile devices. The strengths and opportunities identified are further interpreted to develop some recommendations to overcome the weaknesses and threats.

9.3.2 Lecturer Perceptions

This section discusses the outcomes of the study for research question 2:

> *How do existing perceptions of lecturers influence their attitude to a constructivist mobile-based teaching approach in lectures?*

Our research examines Computer Science lecturers' perceptions on the use of mobile technology in programming lectures. The analysis identifies the advantages, disadvantages, challenges, preparations and influences that would entail a shift from traditional lectures to lectures with students using their mobile devices.

Instructors in a changing learning environment need to adapt their pedagogical practices to meet the expectations of students to maximise the potential benefits from current technology (Khaddage, Lattemann & Bray 2011; Uzunboylu & Ozdamli 2011). Our findings show that the majority of the lecturers support mobile technology as a delivery medium during programming lectures. Although they did not formally use this medium in lectures, they believe that a mobile technology approach could lead to a more productive and interesting learning environment to engage students. This validates the focus of this research on the possibility of implementing those tools as a learning aid to allow and encourage their students to use mobile devices during lectures. Exploring the relationship between lecturers' pedagogical beliefs and their use of technology, Ertmer (2006) found that instructors' pedagogical beliefs should be considered. Lecturers' perceptions and pedagogical beliefs are key issues to consider when moving to mobile-based approach in lectures. Our findings show that instructors who use practical exercises and interactive discussions are more willing to adopt mobile devices during their lectures.

Additionally, although the traditional lecture has been the major form of course delivery in tertiary institutions and will remain for the foreseeable future (McGarr 2009), participating lecturers voiced concerns about its efficacy and benefits especially for teaching programming. The lecture format does not support immediate feedback about students' learning processes and comprehension, it is not suited for higher order thinking, and students are often passive due to lack of interactivity and motivation (Baldwin 2009; Brophy 2010; Harris 2011; Hitchens & Lister 2009). The emerging dissatisfaction with traditional modes of course delivery validates this focus on mobile technology as a learning aid in the lecture theatre. Given improvements in technology, social acceptance of these devices and student access to appropriate mobile devices, all the lecturers, except one, were willing to change their curriculum delivery to incorporate mobile-based teaching approaches.

However, lecturers emphasised the concern that lecture time is limited, so incorporating a module of active learning may be difficult. Students need more time to undertake practical and interactive exercises which could pose some constraints in curriculum delivery if there were delays during the lecture in completing the exercises. However, some lecturers are supportive of active learning in lectures with no concern about time if the learning outcome was worth it. Time, therefore, is an important factor to be considered for successful use of mobile devices in lecture context. Moreover, the lecturers noted that mobile technology may assist course delivery in certain programming languages but not others, so the objectives and structure of the course must be considered in relation to the efficacy of using laptops in achieving those goals (ChanLin et al. 2006).

9.3.3 Alignment with the Seven Principles

This section discusses the outcomes of research question 3:

> *How can the application of the constructivist mobile-based learning and teaching approach in programming courses influence novice students' learning experience during lectures?*

After completing Phases 1 and 2, the intervention was initiated with the students using laptops and supportive visualization software called ViLLE in lectures. The constructivist mobile-based learning and teaching approach is evaluated on the basis of the seven principles for good practice in undergraduate education and students' satisfactions and motivations.

Generally, this new learning approach is perceived to have improved the quality of students' learning experience during the intervention lecture. Both groups of students, consisting of those who chose to participate as well as those who did not participate in the intervention, are satisfied with the intervention. Even before the intervention, the pre-intervention survey indicates that more than half of the students are willing to participate in the intervention and reported a higher level of students' readiness compared to Phase 1. Students expressed a moderately high level of agreement about satisfaction and motivation about this new learning approach in the intervention.

The seven principles are used as a framework to evaluate the effectiveness of the constructivist mobile-based learning and teaching approach in improving the quality of students' learning experience during programming lectures as well as questions reflecting students' satisfactions and motivations. This discussion reviews the results for each principle to examine how the constructivist mobile-based approach is aligned with each principle, the possible reasons for the result, any parallels with past literature and the implications of such an approach on learning experience. Although the questions in the survey are designed in a way that focus on the difference between traditional lectures and constructivist mobile-based learning and teaching approach, a comparative evaluation of traditional lecture versus the new learning approach is also examined. Based on the hypothesis testing, the approach is found to be effectively aligned with all the principles of good pedagogy except Principle 1 (student-faculty contact). The findings show that Principle 1 (student-faculty contact) has the lowest score, while Principle 3 (Active learning) has the highest in the post survey. Further a comparison of post and pre-intervention surveys show an improvement in score on Principles 3, 4, 6 and 7, implying that the students viewed the constructivist mobile-based learning and teaching approach more favourably on those principles after having experienced it in the intervention lecture. Thus, the use of the seven principles for evaluating the constructivist mobile-based learning and teaching approach and the comparisons of the pre and post-intervention surveys reveal many reasons and factors to be considered for the effective implementation of such an approach.

Active learning (Principle P3) is found to have the highest score and it receives the most positive responses from the students after the intervention. The constructivist mobile-based learning and teaching approach is basically designed to incorporate practical activities in ViLLE for students to complete on their laptops during the lecture. Testing of this principle involves an evaluation of how the strengths of laptop usage in lectures can help capitalise on these opportunities of active learning. Drawing from the literature on the advantages of active learning (Machemer & Crawford 2007; Prince 2004; Smith et al. 2005; Walker et al. 2008), active learning with mobile learning (Barak, Miri, Lipson, Alberta & Lerman, Steven 2006; Litchfield et al. 2007), active learning in computer programming (Barak et al. 2007; Hadjerrouit 1999; Whittington 2004) and the recommendation drawn from Phase 1 of this study, active learning is positioned as one of the main advantages of this form of mobile-based learning. It helps to boost students' motivation, enhance students' understanding and increase their involvement in the learning process. The mean value of this principle shows the most significant jump after the intervention compared to the scores in the pre-intervention survey. Students greatly appreciate the opportunity of practically and immediately implementing their knowledge by writing, compiling and running code on the software. Participants' replies to the general statements on the questionnaire show the highest level of agreement for questions regarding understanding the materials in a more interesting way. This is also supported by the lecturers in Phase 4 who value the increased engagement of students with the learning process in this type of lecture. The second highest-rated statement is about motivation in practicing the programming concepts during the lecture, which supports the importance of combining programming theory and practice at the same time in lectures (Barak et al. 2007; Bruhn & Burton 2003). Although some lecturers in Phase 2 are concerned about time taken by students to complete practice exercises in lectures and some preferred the traditional way of completing practice assignments in the labs, lecturers in Phase 4 recognised the importance of such active learning in programming lectures. They argued that programming courses are practical and cumulative subjects and the constructivist mobile-based learning and teaching approach enables students to immediately practice and apply their lessons during lectures. Moreover, there is often a gap between the lecture and the time of actual application, and students can feel that they have understood the concept, but they may face problems when they actually get their hands on a practical assignment later on. Many lecturers in Phase 2 noted this situation where students do not actively work on the concepts until the first assignment comes out and students do not spend enough time on practice. Thus, practicing the concept in the lecture can help bridge that gap. Moreover, considering the cumulative manner in which the programming courses work, the application of the constructivist mobile-based learning and teaching approach helps students build a solid foundation before progressing to the next level. The time spent on those activities during lectures would then certainly be worth it.

The constructivist mobile-based learning and teaching approach is found to be aligned with Principle P2 (cooperation among students). In the intervention, the students worked in pairs sharing one laptop. Working together in pairs has been shown in the literature to have many benefits in comparison to working solo in terms of improving retention rates, student confidence and enjoyment of task (Braught, Eby & Wahls 2008; Brereton, Turner & Kaur 2009; VanDeGrift 2004). However, from the comparison of the pre- and post-intervention surveys, Principle P2 did not improve after the intervention, indicating that students' perception on the effectiveness of this learning approach for promoting cooperation showed a slight depreciation after the intervention. This is perhaps because the majority of the students preferred to work alone. Moreover, when the scores of students who liked to work in groups and students who preferred to work alone during the lecture were analysed, they showed convergent percentages in their responses to the general questions. The lecturers' reflections explained that the decline in score for this principle was a result of students' personalities affecting the efficiency of collaboration between students. They explained that in such an environment students would be focusing on doing the exercises rather than discussing their solutions with their peers. This issue has been noted in a recent research by Rogalli who found that pair programming is not appropriate in lecture theatres using smartphones as a learning tool (Rogalli 2012). In addition, another study by Liu and Kao concluded that students with handheld devices did not demonstrate tendencies for face to face active incorporation with their peers (Liu, CC & Kao 2007). Lecturers in Phase 4 further explained some other issues that could affect the level of collaboration between students. Task type (Chaparro et al. 2005) and lecture theatre setup also affect such practice. Also, given that the student who owns the laptop could dominate the relationship in pair programming, it becomes complicated as to how and when the pair needs to change their roles between driver and navigator. Many researchers have reported greater success with pair programming in lab sessions and/or work spaces (Nagappan et al. 2003a), however, our findings are concerned with the application of the constructivist mobile-based learning and teaching approach in the context of lecture theatres. This means that collaboration between students in the context of our environment can be challenging. Therefore, one possibility for further work is to design collaborative exercises using tailored software that helps virtual collaboration between students in lectures which may assist in better fulfilment of this principle.

The findings show that Principle P1 regarding student and lecturer contact had the lowest mean when compared with the other principles before and after the intervention. In fact, the score for this principle actually decreased after the intervention showing that the students felt that student-faculty contact had diminished in the intervention lecture. Also, it is the only principle to be negatively supported in the results of the hypothesis testing. Yet, considering the context of the programming lecture and other additional features that were elaborated by lecturers in Phases 2 and 4, the negative result for this principle is quite understandable. Statistically it was found that students who worked in pairs had less interactivity with the lecturer. This issue has also been reported by Whittington (2004) who found that student-faculty interaction suffered the most in pair programming in the studio model. Although the constructivist mobile-based learning and teaching approach is not found to be aligned with this principle, lecturers' reflections on this issue show the value of this principle and suggested ways of improving the lecture delivery to improve its score on this principle. Lecturers in Phase 2 claimed that interaction with students during traditional lecture is difficult given the size of the class (Lazaros & Davidson 2013). This restricts the ability of lecturers to provide feedback to individual students and puts time constraints on efforts in increasing student-faculty interaction. In Phase 4, lecturers noted the correlation between interaction and feedback and stated that increasing feedback will increase interaction.

In the intervention, Principle P4 (prompt feedback) was enhanced through the use of mobile technology. Prompt feedback has been recognised as one of the strengths of computer-based learning (Kift & Moody 2009). The visualisation software ViLLE-based activities provided students with prompt feedback during their interaction with the system. The feedback gave the students a clear roadmap of what they were doing correctly and how they could improve their work. Although the intervention lecture scored well on its ability to promote prompt feedback, the specific statements pertaining to interaction between students and lecturer were not rated highly. Further, the item of 'feedback from lecturer' showed the least level of agreement compared to the other general statements. Reflecting on this situation, lecturers in Phase 4 argued that the feedback should be a two-way process to promote good interaction between students and lecturer. The focus should be on lecturers providing feedback to students and vice versa that draw the students into the discussion and encourage them to respond to the lecturer instead of relying on students to start the discussion. Feedback supported by the use of technologies such as Clickers does not support individual feedback for highly technical exercises (Hall 2013; Lantz 2010; Mayer et al. 2009). Examining the efficacy of Clickers in large introductory psychology classes, Morling et al. (2008) found that the use of Clickers should be combined with other pedagogical techniques. Although ViLLE provides lecturers with feedback from students on the exercises, this is not done explicitly during the lecture. Therefore, it is important to utilise software that provides a channel for two-way feedback enabling the lecturers to comment on students' work and encouraging students to be more responsive to the lecturers. In combination with the lecturer's actual interaction with students, this sort of feedback channel could enhance the quality of students' learning experience in alignment with Principle P4 as well as Principle P1.

The results of the survey show that the constructivist mobile-based learning and teaching approach is aligned with Principle P5 (time on task), however, the mean value for this principle showed a slight decline after the intervention compared to the scores for the pre-survey. The practice activities in the intervention lecture may have taken more time than expected, thus, reducing students' perception about the time on task capacity of this learning approach. In addition, the fact that students worked in pairs could have negatively affected the efficient use of time, thus, increasing the probability of disagreement on this principle. This means that collaboration between students should be carefully monitored to ensure that it does not unnecessarily use up time in the lecture environment. Moreover, there is a significant negative correlation between this principle and students' study load as part time students, who were generally older, were more likely to manage their time better compared to full-time students. This indicates that novice students may need some training in time management. On the other hand, lecturers in Phase 2 mentioned time constraint as a significant barrier to this form of learning as they saw problems in the preparation time for organising the exercises, preparing a backup of the electronic exercises and designing the structure of the lecture in case of distortion by unforeseeable reasons. In Phase 4, the lecturers further reflected on this issue and suggested that the time for each task to be completed by students and time for starting the use of the learning tool should be allocated in advance by the lecturer. Moreover, they proposed that lecturers should only cover material related to the main concepts and lecturers need to collaborate in designing the new materials for such a course. Therefore, time is a critical aspect of such an active learning environment and needs to be carefully planned to achieve effective application. Specifically, lecturers were anxious about time considerations in the lecture and preparation before the lecture. Lecture time considerations relate to task time, interaction time, collaboration time, and students' and lecturers' time management skill. Preparation time relates to time taken for preparing lecture materials, designing exercises and preparing the backup.

Principles P6 (communicates high expectations) and P7 (respects diverse talents and ways of learning) can be described as consequences of the application of the constructivist mobile-based learning and teaching approach as they describe students' satisfaction on the intervention. Both principles showed improvement as the respondents indicated that their quality of work and understanding of the topic had been enhanced. In addition, the application of the constructivist mobile-based learning and teaching approach produced diverse ways of learning and helped students learn in a style they were comfortable with. A considerable number of students noted that the lecture style was well-organised and the approach worked well with a learning style they liked. The lecturers' perceptions, on the other hand, show that engagement was the most valued outcome, especially for first year students, as this form of learning actively involves them in the learning process. This could help stem the high attrition rate in computer programming courses and indicates that engagement should be placed as a focal point when organising a constructivist mobile-based lecture. Furthermore, lecturers appreciated the delivery of improved learning and better outcomes for students with the constructivist mobile-based learning and teaching approach.

The discussion of the four phases mentioned above proposes a framework of effective constructivist mobile-based learning and teaching programing approach based on the seven principles. It also reveals some considerations for effective application of our approach during programming lectures. The considerations are students' and lecturers' readiness, programming language objectives, software features, tasks designs, teaching assistants' availability, logistical infrastructure and time. As the mobile-based approach is based on a constructivist approach to learning and teaching programming, active learning for students is considered as the main point of our approach. This means that active learning (P3) is to be placed on the top of the demonstration of the principles, where active learning is the main feature of this approach. Our discussion shows the direct relationship between the second and third principles, in the sense that cooperation is a result of the efforts of the instructors to implement an active learning environment. This means that collaboration between students (P2) is to be joined with active learning (P3). Then, once active involvement is ensured in the design of the lecture, the focus needs to shift to ensuring the flow of prompt feedback (P4) after active involvement. Moreover, as interaction is found to be correlated with feedback, this places an emphasis on interaction (P1) followed by feedback. Finally, the principles of communicating high expectations (P6) and respecting diverse talents and ways of learning (P7) are considered as outcomes that students will achieve once the above principles are accomplished in this order. The following Figure 9.1 presents our proposed framework.

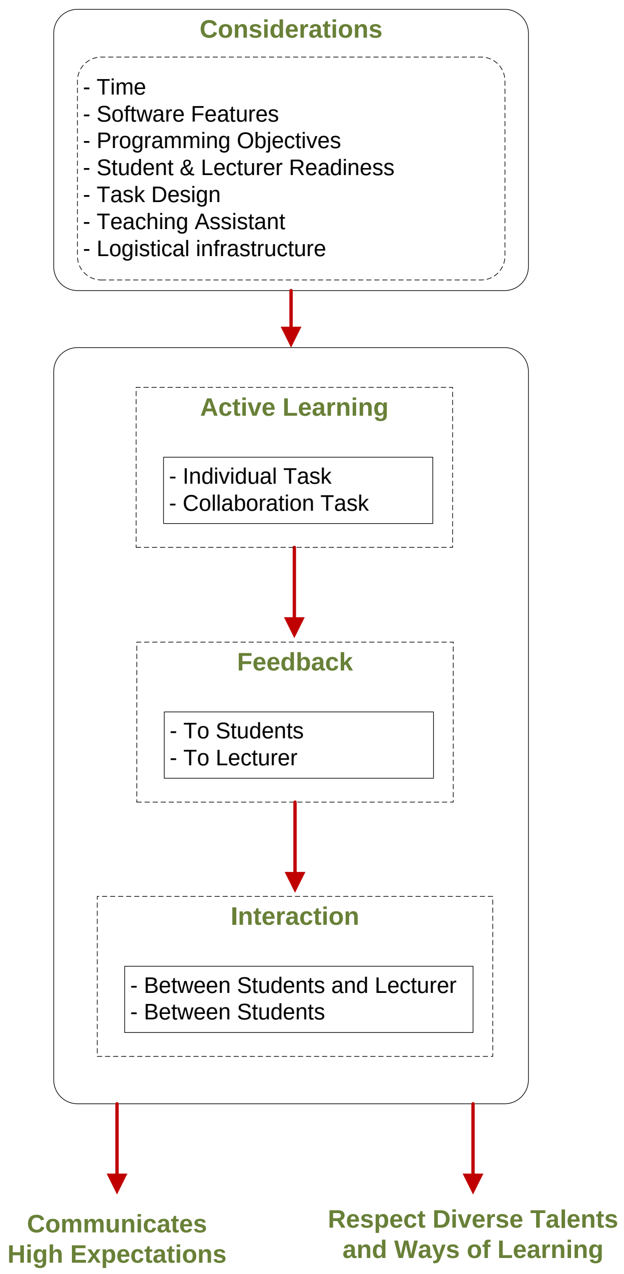


Figure 9.1: A Framework of Effective Constructivist Mobile-based Learning and Teaching Programming Approach

The framework developed and described in the above Figure 9.1 can be useful for designing and assessing effective implementation of constructivist mobile-based learning and teaching approach to introductory programming courses. Evidence gathered supports the hypothesis that, in our intervention, the instructor and the students perceived that the use of ViLLE in class increased active learning and thereby engagement.

The details of implementation strategy and tactics matter are listed as considerations need to be taken into account by the instructors. They have the making of a useful checklist for future innovators seeking to use mobile devices and application software in lecture halls. They illustrate how many factors instructors need to consider in order to successfully implement a mobile-based practice in a lecture theatre. Each factor of the considerations has been described and discussed in the previous discussion. For example, Computer-based tasks in class need to be more circumscribed while lab and homework tasks can be more ambitious and open-ended. Classroom exercise needs to be limited enough that it can be completed quickly. In contrast, lab and homework assignments can and often should be larger, more complex tasks.

While faculty-student contact was not advanced during the intervention, our proposed framework reveals one of the software features that should be available, in which the results of student programming be automatically summarised across students and made instantly available to the instructor. In addition, the software used to do in-class programming tasks is also used in other aspects of the course so that students have several reasons for acquiring and mastering the software.

Although the framework designed with considerations of all the issues raised by the students and instructors from the results, there are some areas of improvements. For instance, adding engagement as one of the outcomes of the framework in addition to communicate high expectations and respect diverse talents and ways of learning as there were specific questions for engagement in the survey. Furthermore, considering asking the students to rate time spent on the problem-solving during lecture on a scale from “good use of my time” to “bad use of my time” would be more appropriate rather than asking “managing and controlling my time efficiently in the lecture for my learning increased because of the application of the approach”.

The survey questions which designed based on the seven principles, can be used by instructors to evaluate effective use of mobile-based learning and teaching approach. However, questions regarding tasks design could be added to clarify which type of tasks will work more that others. In addition, the question asks students about 'cooperative work.' It might have been better to use a phrase more closely related to what students might do, such as 'talking with another student about how to solve a problem'.

9.4 Research Implications

The discussion in the sections above have provided a detailed explanation of how students and lecturers perceive the use of mobile devices in lectures and how such an approach can improve the quality of students' learning experience. This section discusses some implications for the practice of the constructivist mobile-based learning and teaching approach and makes some suggestions for academics and universities considering this approach in their programming courses.

As our study uses a well-known framework of best practices in undergraduate education for evaluating our mobile-based learning and teaching approach to programming, it contributes to the theoretical research on good pedagogy in computer education. The discussion of the four phases mentioned above reveal some considerations for effective application of the constructivist mobile-based learning and teaching approach during lectures, such as students' and lecturers' readiness, programming language objectives, software features, logistical infrastructure, effective use of time, tasks designs and teaching assistants' availability.

Lecturers' reflections in Phase 4 emphasise the need for software features supporting usability, visuality and feedback. They also argued for the need of consistency in the software being used during lecture and in the lab for assignments or exercises. This raises the need for customised software that is able to address these issues for a constructivist mobile-based learning and teaching approach in introductory programming lectures.

While distraction was listed as a potential hindrance to learning in such lectures from Phases 1 and 2, findings from the post-intervention survey PS1 in Phase 3 indicated that more students disagree with the presence of distraction. Also, a significant number of students who did not participate in the intervention did not feel that the laptops used by their counterparts were distracting them or causing them to miss out on any information given during the lecture. However, distraction is still an issue in a large lecture hall that needs to be highly considered (Fried 2008). A well-organised lecture environment is needed to minimise any possibility of distraction from unforeseen logistical issues and ensure a smooth integration of practical exercises. Interesting materials and customised software that maximise student engagement and involvement can also decrease distraction.

Phases 1 and 3 validate the focus of this study on the possibility of capitalising on the widespread use of laptops to implement them as a learning tool for students in programming lectures. It may be argued that while the price of laptops appears to have reached a point where almost any higher education student can afford to purchase one, there would be many higher education students for whom even a cheap laptop represents a significant financial hurdle. Therefore, instead of making a blind assumption that all students own or can afford to own a laptop, students' ownership of mobile devices should be carefully considered by any institute wanting to adapt mobile devices in the learning process.

The study also shows that most students were appreciative of the financial help in case of university-assisted purchase of laptops. However, some were also apprehensive that university-supplied laptops may be of a version or make that they disliked. Therefore, it is suggested that the university survey the stakeholders i.e. the faculty and students, to not only carefully consider wireless laptops suitable for lecture theatres and other learning situations, but also keep a track of student demands for the type of mobile device to purchase.

The importance of availability of teaching assistants and the cost for the university was also part of the discussion between lecturers in phase 4. Teaching assistants and resources for funding need to considered.

Phases 2 and 4 examine whether this form of learning was suited to programming courses for novice or non-novice learners. The majority of participants agree that in terms of students' engagement, students' knowledge and computer program type, first year programming students were the appropriate cohort for implementing this learning and teaching approach. This means that academics must pay attention to designing an interactive and engaging learning platform for novice learners that will retain their interest in programming and reduce the high attrition rate after the first year usually observed in programming courses.

Our findings indicate that the time for preparing lecture materials is a problematic issue for all lecturers. To counter this, efforts must be made to encourage collaboration between lecturers to reduce the stress and workload required from individual lecturers in designing lecture materials.

9.5 Concluding Remarks

This study investigates the possibilities of adapting mobile learning for traditional lectures in programming courses. The research contributes to the theory of the seven principles in computer education, the practice of learning and teaching in programming courses and knowledge about the influence of constructivist mobile-based programming approach on students' learning experience. It proposes a framework for an effective constructivist mobile-based learning and teaching approach in conjunction with the seven principles of good practice in undergraduate education in programming lectures. This could help educators in applying the constructivist mobile-based programming approach more effectively in alignment with the seven principles. The framework could be useful for designing and assessing constructivist mobile-based programming approach in introductory programming courses.

The principal investigation conducted in this thesis has led to five key messages relevant to teaching and learning about programming in a constructivist mobile-based environment at the introductory level.

Key Message 1: The current way of learning and teaching programming in lectures needs to be changed to a new constructivist format that supports immediate practice of the concepts being taught.

Key Message 2: Novice programmers need to be engaged in the learning process to enhance their learning experience and understanding of programming concepts. The constructivist mobile-based learning and teaching approach can engage students as it meets the expectations of a new generation of students.

Key Message 3: High levels of readiness among Computer Science students and lecturers in terms of their ownership and preparedness of the use of mobile devices during programming lectures both support this move to a constructivist mobile-based approach.

Key Message 4: The key factors that can act as a base for implementing and designing effective constructivist mobile-based learning and teaching approaches in introductory programming courses are: students' and lecturers' readiness, programming language objectives, software features, logistical infrastructure, tasks designs, effective use of time and availability of teaching assistants.

Key Message 5: The framework developed in this study can be used as a valuable framework for conducting future investigations into effective implementation of constructivist mobile-based learning and teaching approaches to programming.

The main outcome of this study is that a constructivist mobile-based learning and teaching approach in programming courses can enhance the learning experience of novice programmers in traditional learning environments by incorporating proactive and engaging learning exercises. The five key messages provide valuable information for university academics in Computer Science departments as they demonstrate the actual benefits of constructivist mobile-based learning and teaching approach and recommendations on how to develop such an approach that can be applied in other contexts.

9.6 Limitations and Future Research

This research was conducted to facilitate the application of mobile devices and visualisation software as innovative pedagogical tools in learning environments in higher education that currently do not support the use of mobile devices in lectures or only use it as an optional choice. While this concluding chapter has highlighted the strengths and achievements of the research, it is now time to end this discussion with a note on some limitations of the study, which may give raise avenues for future research in this area.

The data collection and analysis in our research design is based on students' perceptual attitudes to the constructivist mobile-based learning and teaching approach to programming. Future research could be undertaken on students' scores and assessment results for evaluation to make these results more robust by quantifying students' perceptions.

Also, this research is based on only one interventional study as we only implemented one lecture session at one locale. Conducting one intervention lecture is a challenging task in itself as it involves a lot of work, particularly in an environment that does not support the use of mobile devices in lectures. Future research would benefit from repetitive use of the intervention with different cohorts and/or more instructors. Implementing multiple intervention lectures could improve the reliability and generalisability of results.

Moreover, the impact of the intervention was only assessed in relation to its effect on the students' perceptions of their learning outcome in that lecture. Future research could investigate if this learning approach using mobile devices had any impact on students' work in the next laboratory session or in their preparedness to do the next homework assignment or their understanding in the next lecture.

This study focuses on novice programmers, but future work examining the application of the constructivist mobile-based approach for non-novice programmers could also be interesting. In fact, one lecturer in Phase 4 argues that such an environment should work for both novice and non-novice learners. So, future research could examine the application of constructivist mobile-based learning and teaching approaches in courses for non-novice programmers.

While this research has shown the effectiveness of constructivist mobile-based learning and teaching approach, future work needs to consider the design of activities and course material in such a learning approach. This would involve a systematic review of concepts in introductory programming courses and methods to best translate them into practical exercises of software. The design of an activity platform should keep the seven principles in mind and should be capable of being covered in the lecture time. Further, visualization software should be designed for specific use in programming lectures with features that support visual learning and interactive feedback. The results of student programming should be automatically summarised across students and made instantly available to the instructor.

This study found that collaboration between students in the classroom can often hinder their work. So, further research comparing effective application of the constructivist mobile-based learning and teaching approach in lectures with and without collaboration between students is needed. A comparative study could be done with lectures where students work alone, in pairs or groups, and the efficacy of each approach as well as specific types of programming modules must be evaluated. Diversity of personal and academic background among students is also another problem, and future research is needed to examine and resolve such issues.

Moreover, it remains to be seen how the involvement of lecturers, tutors and lab assistants in one program affects students' learning experiences. Given that the lecturer is responsible for both the theoretical and practical components of the course and students have contact with only one person, future research could examine how this might change the teaching of programming and influence learning experiences of students.

The importance of providing teaching assistants cannot be underestimated in such an approach. Further research is needed to examine the number of teaching assistants needed in a particular lecture and the ways in which universities can support such an initiative with provision of funding for teaching assistants.

There have been many changes in digital technology development, acceptance and use since 2011 when this intervention lecture was concluded. Future research could consider the implication of such changes for the constructivist learning approach to programming.

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Appendix 1: Ethics Approval for Phase 1

RMIT University

Science Engineering and Technology College

Human Research Ethics Sub-Committee

Plenty Road
Bundoora VIC 3083

PO Box 71
Bundoora VIC 3083
Australia

Tel. +61 3 9925 7096
Fax +61 3 9925 6506
• www.rmit.edu.au

4th May 2009

Wafaa Adnan O Alsaggaf
1/890 Pascoe Vale Road
Glenroy VIC 3046

Dear Wafaa

BSETAPP 09 – 09 ALSAGGAF An ICT Strategy for Learning Systems

Thank you for submitting your amended application for review.

I am pleased to inform you that the committee has approved your application for a period of **12 Months** to **May 2010** and your research may now proceed.

The committee would like to remind you that:

All data should be stored on University Network systems. These systems provide high levels of manageable security and data integrity, can provide secure remote access, are backed up on a regular basis and can provide Disaster Recover processes should a large scale incident occur. The use of portable devices such as CDs and memory sticks is valid for archiving; data transport where necessary and for some works in progress; The authoritative copy of all current data should reside on appropriate network systems; and the Principal Investigator is responsible for the retention and storage of the original data pertaining to the project for a minimum period of five years.

Annual reports are due during December for all research projects that have been approved by the Human Research Ethics Sub-Committee.

The necessary form can be found at: http://www.rmit.edu.au/governance/committees/hrec

Yours faithfully,

Associate Professor Barbara Polus
Chair, Science Engineering & Technology College
Human Research Ethics Sub-Committee 'B'

Cc	HRE-SC Member:	Zhen Zheng School of Health Sciences
	Supervisor/s:	Margaret Hamilton School of Computer Science and IT
		James Harland School of Computer Science and IT

Appendix 2: Ethics Approval for Phases 2 and 3

RMIT UNIVERSITY

RMIT University

Science Engineering and Health

College Human Ethics Advisory Network (CHEAN)

Plenty Road
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11th February 2011

Wafaa Alsaggaf
1/890 Pascoe Vale Road
Glenroy VIC 3046

Dear Wafaa

A&BSEHAPP 85 – 10 ALSAGGAF Applied technology and the learning experience: Enhancement of learning programming using mobile devices

Thank you for submitting your amended application for review.

I am pleased to inform you that the CHEAN has approved your application for a period of **2 Years** to **February 2013** and your research may now proceed.

The CHEAN would like to remind you that:

All data should be stored on University Network systems. These systems provide high levels of manageable security and data integrity, can provide secure remote access, are backed up on a regular basis and can provide Disaster Recover processes should a large scale incident occur. The use of portable devices such as CDs and memory sticks is valid for archiving; data transport where necessary and for some works in progress. The authoritative copy of all current data should reside on appropriate network systems; and the Principal Investigator is responsible for the retention and storage of the original data pertaining to the project for a minimum period of five years.

Annual reports are due during December for all research projects that have been approved by the College Human Ethics Advisory Network (CHEAN).

The necessary form can be found at: http://www.rmit.edu.au/governance/committees/hrec

Yours faithfully,

Diana Donohue
Chair, Science Engineering & Health
College Human Ethics Advisory Network 'A'

Cc	CHEAN Member:	Amanda Kimpton School of Health Sciences
	Other Investigator/s:	James Harland School of Computer Science & IT
	Supervisor/s:	Margaret Hamilton School of Computer Science & IT

Appendix 3: Ethics Approval for Phase 4

RMIT UNIVERSITY

RMIT University

Science Engineering and Health

College Human Ethics Advisory Network (CHEAN)

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1st May 2013

Wafaa Alsaggaf
1/890 Pascoe Vale Road
Glenroy VIC 3046

Dear Wafaa

A&BSEHAPP 85 – 10 ALSAGGAF Applied technology and the learning experience: Enhancement of learning programming using mobile devices

Thank you for requesting an amendment and extension to your Human Research Ethics project titled: ***Applied technology and the learning experience: Enhancement of learning programming using mobile devices*** which was originally approved by Science Engineering and Health CHEAN in February 2011.

I am pleased to inform you that the CHEAN has **approved** your extension and amendment as outlined in your request and your Human Research Ethics project is now approved until **December 2013**

The CHEAN notes and thanks you for providing all documentation that incorporates these amendments. This documentation will be appended to your file for future reference and your research may now continue.

The committee would like to remind you that:

All data should be stored on University Network systems. These systems provide high levels of manageable security and data integrity, can provide secure remote access, are backed up on a regular basis and can provide Disaster Recover processes should a large scale incident occur. The use of portable devices such as CDs and memory sticks is valid for archiving; data transport where necessary and for some works in progress; The authoritative copy of all current data should reside on appropriate network systems; and the Principal Investigator is responsible for the retention and storage of the original data pertaining to the project for a minimum period of five years.

Annual reports are due during December for all research projects that have been approved by the Human Research Ethics Sub-Committee.

The necessary form can be found at: www.rmit.edu.au/staff/research/human-research-ethics

Yours faithfully,

Linda Jones
Chair, Science Engineering & Health
College Human Ethics Advisory Network

Cc Other Investigator/s: James Harland School of Computer Science & IT
Supervisor/s: Margaret Hamilton School of Computer Science & IT

Appendix 4: Survey Questions (Student – Phase 1)

Survey Questions

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1. **Attendance type (Please circle one)**
    a. Full Time
    b. Part Time

2. **Age (Please circle one)**
    a. Under 20 years
    b. 20 – 24 years
    c. 25 – 29 years
    d. 30 years and over

3. **Program type (Please circle one)**
    a. Undergraduate
    b. Postgraduate
    c. Others

4. **Gender (Please circle one)**
    a. Female
    b. Male

5. **Do you own a laptop? (Please circle one)**
    a. Yes
    b. No
    c. Willing to buy one

6. **If you don't own a laptop, what is the reason for this? (Please circle one)**
    a. Not affordable (i.e. laptops are not reasonably priced)
    b. Use partner, roommate, friend or relative's laptop
    c. Prefer using a desktop computer
    d. Other

7. **Would being able to purchase a laptop through the University at a discount encourage you to buy a new one? (Please circle one)**
    a. Yes
    b. No
    Do you have any other suggestions or recommendations?

8. **Are you prepared to take your own laptop to University? (Please circle one)**
    a. Always
    b. Sometimes
    c. Rarely
    d. Not at all

9. **If not at all or rarely, why? (Please circle any applicable)**
    a. I do not see real benefits for using laptops the classroom
    b. I have a concern about loss, theft or breakage of the laptop
    c. I do not know how to connect to the University's wireless network
    d. Computer Labs are enough for me
    e. My smart or mobile phone does the job
    f. Too heavy to carry
    g. Other:

10. Generally, I believe that using the laptop in classrooms:

	Strongly Agree	Agree	Do not Know	Disagree	Strongly Disagree
Assists students to learn the material in a better way	A	B	C	D	E
Assists students to work together to learn the materials in a better way	A	B	C	D	E
distracts students from the topic being discussed	A	B	C	D	E
is just part of the modern-lifestyle and doesn't really help on the learning materials	A	B	C	D	E
Assists students to only organize non-educational tasks. For example, sending emails or checking the stock-market.	A	B	C	D	E
Assists the teacher to deliver more interesting material	A	B	C	D	E

11. Please list any critical <u>advantages</u> and other <u>disadvantages</u> you see for using laptops in classrooms

Advantages	Disadvantages
a. ____________ **b.** ____________ **c.** ____________	**A.** ____________ **B.** ____________ **C.** ____________

12. Please list any critical <u>opportunities</u> and other <u>challenges</u> you see for using laptops in classrooms

Opportunities	Challenges
a. ____________ **b.** ____________ **c.** ____________	**A.** ____________ **B.** ____________ **C.** ____________

13. Would you like to add any comments or suggestions for this research?

____

____

____

☺We really appreciate your cooperation

Appendix 5: Plain Language Statement (Student - Phase 1)

School of Computer Science & IT

RMIT UNIVERSITY

INVITATION TO PARTICIPATE IN A RESEARCH PROJECT
PROJECT INFORMATION STATEMENT

Project Title:
An ICT Strategy for learning Systems

Investigators:
Mrs Wafaa Alsaggaf (Computer Science and Information Technology, PhD student, s3175694@student.rmit.edu.au) ,
Dr Margaret Hamilton (Project Supervisor: Senior Lecturer, Computer Science and IT, RMIT University, margaret.hamilton@rmit.edu.au, +(61 3) 9925 2939) and
Associate Professor James Harland (Project Supervisor: Computer Science and IT, RMIT University, james.harland@rmit.edu.au, +(61 3) 9925 2045)

Dear Participant

You are invited to participate in a research project being conducted by RMIT University. This information sheet describes the project in straightforward language, or 'plain English'. Please read this sheet carefully and be confident that you understand its contents before deciding whether to participate. If you have any questions about the project, please ask one of the investigators.

Who is involved in this research project? Why is it being conducted?
The researchers are listed above: Wafaa Alsaggaf, *PhD* student at RMIT University who is doing the research project. Dr Margaret Hamilton as senior supervisor and Associate professor James Harland as second supervisor. The research is being conducted as part of my PhD degree.The project has been approved by the RMIT Human Research Ethics Committee.

Why have you been approached?
You have been approached randomly because you are enrolled in core courses offered by the School of Computer Science and Information Technology (IT).

What is the project about? What are the questions being addressed?
There is a diversity of opinion for use of laptops devices in learning situations. Some teachers argue that the use of mobile devices enhances the learning experience, but others suggest they can be a diversion if learners' attention wanders from the topic at hand. In this study, we would like to know your opinions about the use of laptops during lectures.
This study aims to investigate opportunities for students using laptops or similar devices in classrooms, and explore issues impacting their adoption within the School of Computer Science and IT. We will be approaching around 370 students.

If I agree to participate, what will I be required to do?
You are invited to participate in a focus group discussion that will take approximately 90 minutes to complete. Your contribution in this discussion is valuable because the findings from this project will assist in understanding ways to improve the use of mobile devices in lectures to enhance the learning of programming. The focus group discussion will be audio-taped with your permission.
Due to the nature of the data collection process, we are required to obtain written consent from you. Please read the consent form carefully and be confident that you understand its contents before signing the consent form. If you have any questions about the project please feel free to contact one of the investigators. Your participation is purely voluntary and you are free to withdraw from the project at any time.

What are the risks or disadvantages associated with participation?
There are no perceived risks outside the participant's normal day-to-day activities.

What are the benefits associated with participation?
The benefit of this research will include the production of model for improved programming course delivery and learning outcomes using mobile technologies

What will happen to the information I provide?
The focus group discussion report will be anonymous and de-identified. Data will be seen by myself and my supervisors, Dr Margaret Hamilton and Associate Professor James Harland. Any information that you provide can be disclosed only if (1) it is to protect you or others from harm, (2) a court order is produced, or (3) you provide the researchers with written permission. The results will be disseminated in a student report and that data will be aggregated and be kept securely at RMIT for a period of 5 years before being destroyed.

What are my rights as a participant?
You have the right to:

- ✓ withdraw your participation at any time, without prejudice.
- ✓ have any unprocessed data withdrawn and destroyed, provided it can be reliably identified, and provided that so doing does not increase the risk for the participant.
- ✓ have any questions answered at any time.

Whom should I contact if I have any questions?
Myself by email: (s3175694@student.rmit.edu.au) or any of the researchers listed at the top of the previous page.

Yours sincerely,

Wafaa Alsaggaf
PhD Student, CSIT, RMIT University

Dr Margaret Hamilton
Senior Lecturer, CSIT, RMIT University

Assoc Professor James Harland
Associate Professor, CSIT, RMIT University

Any complaints about your participation in this project may be directed to the Executive Officer, RMIT Human Research Ethics Committee, Research & Innovation, RMIT, GPO Box 2476V, Melbourne, 3001.
Details of the complaints procedure are available at: http://www.rmit.edu.au/research/hrec_complaints

Appendix 6: Interview Questions (Lecturer - Phase 2)

School of Computer Science & IT

Interview questions

Data Collection	
Place	Melbourne, Australia
Duration	30 Minutes
Date	Semester1/ 2011
Targeted sample	Computer Science lecturers teach programming courses at RMIT Universities, school of Computer Science and Information Technology.

Focus Group Questions	
The questions of this phase conducted with the purpose of investigating Computer Science lecturers' perceptions of mobile device use by their students in programming lecture theatres and their teaching methods to deepen the understanding of the nature of programming lectures and problems in teaching programming.	
The Questions:	1. Could you please identify yourself? a. Experience b. age 2. How many years you have been in teaching programming? 3. What courses you are teaching and what the objectives of these courses? 4. Could you give examples of lecture plan or teaching method you use to meet those objectives (in Q2)? 5. What kind of technology do you use in the teaching process? 6. What kind of technology do your students use in their learning process? 7. What is your typical lecture looks like eg. Do you talk for the whole lecture or do some discussion or …? 8. Do you write or try any piece of code during lecture? Why (in both cases) 9. What are the advantages to do this for students? 10. What are the disadvantages to do this for students? 11. How do you motivate your students when presenting new concepts? 12. Do you ask your students to do practical exercises during lecture? How? 13. What are the most frequent problems (matters) that you face in teaching programming? 14. What are the things that make it easier to teach programming? 15. How do you know that your student understood new concepts of programming? 16. Do you like the current methods of teaching programming? 17. How can we improve it? 18. What would make you to change your learning methods?

	19. How likely would you change your lecture plan or teaching method if someone suggested that to you? 20. What make you use new technology? (For example data projector) 21. What is your opinion on the concept of using laptop computer by students in lectures for learning programming purposes? 22. (-) How can we make this concept beneficial? 23. (+) Why we did not apply this concept until now? 24. How do you evaluate the teaching programming objectives (noted in Q2) with the use of laptops in lectures? 25. What challenges are they? 26. Do you think using programming learning's software (eg. Eclips) would help lecturers and students in teaching and learning and add to the idea of using laptops? 27. Did you expect a question but I did not ask? 28. Do you like to add any comments on the research

Appendix 7: Plain Language Statement and Consent Form (Lecturer - Phase 2)

School of Computer Science & IT

INVITATION TO PARTICIPATE IN A RESEARCH PROJECT
PROJECT INFORMATION STATEMENT

Project Title:
Applied technology and the learning experience: Enhancement of learning programming using mobile devices

Investigators:
Mrs Wafaa Alsaggaf (Computer Science and Information Technology, PhD student, s3175694@student.rmit.edu.au) ,
Dr Margaret Hamilton (Project Supervisor: Senior Lecturer, Computer Science and IT, RMIT University, margaret.hamilton@rmit.edu.au, +(61 3) 9925 2939) and
Associate Professor James Harland (Project Supervisor: Computer Science and IT, RMIT University, james.harland@rmit.edu.au, +(61 3) 9925 2045)

Dear Participant

You are invited to participate in a research project being conducted by RMIT University. This information sheet describes the project in straightforward language, or 'plain English'. Please read this sheet carefully and be confident that you understand its contents before deciding whether to participate. If you have any questions about the project, please ask one of the investigators.

Who is involved in this research project? Why is it being conducted?
The researchers are listed above: Wafaa Alsaggaf, *PhD* student at RMIT University who is doing the research project. Dr Margaret Hamilton as senior supervisor and Associate professor James Harland as second supervisor. The research is being conducted as part of my PhD degree.The project has been approved by the RMIT Human Research Ethics Committee.

Why have you been approached?
You have been approached randomly because you are teaching a programming course offered by the School of Computer Science and IT at RMIT University.

What is the project about? What are the questions being addressed?
There is a diversity of opinion about the use of laptops or other portable ICT devices in lectures for learning programming. Some teachers argue that they enhance the learning experience, but others suggest they can be a diversion if the learner's attention wanders from the topic at hand. For this study, we would like to know your opinions about the use of laptops during lectures for learning programming. This research aims to recommend a model and steps that can be taken to enhance the efficiency of learning programming by using portable laptop computers in the learning environment of computer science students and instructors in lectures. We will be approaching around twelve lecturers.

If I agree to participate, what will I be required to do?

You are invited to participate in a focus group discussion that will take approximately 90 minutes to complete. Your contribution in this discussion is valuable because the findings from this project will assist in understanding ways to improve the use of mobile devices in lectures to enhance the learning of programming. The focus group discussion will be audio-taped with your permission.
Due to the nature of the data collection process, we are required to obtain written consent from you. Please read the consent form carefully and be confident that you understand its contents before signing the consent form. If you have any questions about the project please feel free to contact one of the investigators. Your participation is purely voluntary and you are free to withdraw from the project at any time.

What are the risks or disadvantages associated with participation?

There are no perceived risks outside the participant's normal day-to-day activities.

What are the benefits associated with participation?

The benefit of this research will include the production of model for improved programming course delivery and learning outcomes using mobile technologies

What will happen to the information I provide?

The focus group discussion report will be anonymous and de-identified. Data will be seen by myself and my supervisors, Dr Margaret Hamilton and Associate Professor James Harland. Any information that you provide can be disclosed only if (1) it is to protect you or others from harm, (2) a court order is produced, or (3) you provide the researchers with written permission. The results will be disseminated in a student report and that data will be aggregated and be kept securely at RMIT for a period of 5 years before being destroyed.

What are my rights as a participant?

You have the right to:

- ✓ withdraw your participation at any time, without prejudice.
- ✓ have any unprocessed data withdrawn and destroyed, provided it can be reliably identified, and provided that so doing does not increase the risk for the participant.
- ✓ have any questions answered at any time.

Whom should I contact if I have any questions?

Myself by email: (s3175694@student.rmit.edu.au) or any of the researchers listed at the top of the previous page.

Yours sincerely,

Wafaa Alsaggaf
PhD Student, CSIT, RMIT University

Dr Margaret Hamilton
Senior Lecturer, CSIT, RMIT University

Assoc Professor James Harland
Associate Professor, CSIT, RMIT University

Any complaints about your participation in this project may be directed to the Executive Officer, RMIT Human Research Ethics Committee, Research & Innovation, RMIT, GPO Box 2476V, Melbourne, 3001.
Details of the complaints procedure are available at: http://www.rmit.edu.au/research/hrec_complaints

PRESCRIBED CONSENT FORM FOR PERSONS PARTICIPATING IN RESEARCH PROJECTS INVOLVING INTERVIEWS

College of	Science, Engineering & Health		
School of	Computer Science & IT		
Project Title:	Applied technology and the learning experience: Enhancement of learning programming using mobile devices		
Name(s) of Investigators:	Mrs Wafaa Alsaggaf	Phone:	+(613) 9306 2506
	Dr Margaret Hamilton	Phone:	+(61 3) 9925 2939
	Associate Professor James Harland	Phone:	+(61 3) 9925 2045

1. I have received a statement explaining the focus group discussion involved in this project.
2. I consent to participate in the above project, the particulars of which - including details of the interviews - have been explained to me.
3. I authorise the investigator or his or her assistant to interview me or administer a questionnaire.
4. I give my permission to be audio taped: ☐ Yes ☐ No

6. I acknowledge that:

   (a) Having read the Plain Language Statement, I agree to the general purpose, methods and demands of the study.
   (b) I have been informed that I am free to withdraw from the project at any time and to withdraw any unprocessed data previously supplied.
   (c) The project is for the purpose of research and/or teaching. It may not be of direct benefit to me.
   (d) The privacy of the information I provide will be safeguarded. However should information of a private nature need to be disclosed for moral, clinical or legal reasons, I will be given an opportunity to negotiate the terms of this disclosure.
   (e) The security of the research data is assured during and after completion of the study. The data collected during the study may be published, and a report of the project outcomes will be provided to RMIT University. Any information which may be used to identify me will not be used unless I have given my permission.

Participant's Consent

Name: ______________________________ Date: ________________
(Participant)

Participants should be given a photocopy of this consent form after it has been signed.

Any complaints about your participation in this project may be directed to the Executive Officer, RMIT Human Research Ethics Committee, Research & Innovation, RMIT, GPO Box 2476V, Melbourne, 3001.
Details of the complaints procedure are available at: http://www.rmit.edu.au/research/hrec_complaints

Appendix 8: Pre-Intervention Survey

Pre-Intervention survey

1. **Study load (Please circle one)**
    A. Full Time
    B. Part Time

2. **Please indicate your age __________ years**

3. **Gender (Please circle one)**
    A. Female
    B. Male

4. **Do you own a laptop? (Please circle one)**
    A. Yes
    B. No
    C. Willing to buy one

5. **If you owned a laptop how often would you be prepared to take your laptop to University? (Please circle one)**

1	2	3
Never	Occasionally	Frequently

6. **How do you rate your programming skill background as? (Please circle one)**

1	Novice:	This is the first language and/or programming course
2	Intermediate:	I have developed some software before
3	Expert:	I have developed many software before

7. **For each item please select the category that represents your perception of the traditional lectures with 1 being "strongly disagree" and 5 "strongly agree"**

	Strongly Disagree	Disagree	Do not Know	Agree	Strongly Agree
I communicate with my instructor in the lecture on asking and answering questions	1	2	3	4	5
I communicate with my instructor in the lecture on sharing my ideas	1	2	3	4	5
I do cooperative work with my fellow students in the lecture	1	2	3	4	5
I do share my ideas with my fellow students in the lecture	1	2	3	4	5

I actively participate in the lecture and practice what I have been taught	1	2	3	4	5
I have the ability to relate the concepts and skills in the lecture to real life	1	2	3	4	5
I get enough feedback from my instructor during the lecture	1	2	3	4	5
I get prompt feedback from my instructor during the lecture	1	2	3	4	5
I have the ability to complete tasks at times that are convenient for me in the lecture	1	2	3	4	5
I can manage and control my time efficiently in the lecture for my learning	1	2	3	4	5
The quality of my work in the lecture is very good	1	2	3	4	5
My understanding of the ideas taught in the lecture is very good	1	2	3	4	5
I have a chance to get to know students who are different from me in their learning in the lecture	1	2	3	4	5
I have the ability to use my preferred learning styles in the lecture	1	2	3	4	5

8. Are you willing to participate in the intervention next week?

A. Yes
B. No

____

9. Do you have any thoughts on the use of laptops during programming lectures?

____

____

____

☺We really appreciate your cooperation

Appendix 9: Post-Intervention Survey (PS1)

Post-Intervention survey (PS1)

1. **Study load (Please circle one)**
    a. Full Time
    b. Part Time

2. **Please indicate your age _________ years**

3. **Gender (Please circle one)**
    a. Female
    b. Male

4. **During the Intervention I worked(Please circle one)**
    a. Alone
    b. With my fellow student

5. **How do you rate your programming skill background as? (Please circle one)**

1	Novice:	This is the first language and/or programming course
2	Intermediate:	I have developed some software before
3	Expert:	I have developed many software before

6. **For each item please select the category that represents your perception on the constructivist mobile-based learning programing approach during the lecture with 1 being "strongly disagree" and 5 "strongly agree"**

	Strongly Disagree	Disagree	Do not Know	Agree	Strongly Agree
The application of the approach during a programming lecture is a good idea	1	2	3	4	5
The application of the approach worked well with the way I like to learn in the lecture	1	2	3	4	5
I believe using a laptop enhanced my learning of programming during the lecture	1	2	3	4	5
I prefer The application of the approach to traditional approach	1	2	3	4	5
I felt that The application of the approach was a distraction during the lecture	1	2	3	4	5

The application of the approach to practice programming concepts during the lecture motivated me	1	2	3	4	5
I was motivated because I worked with my fellow students on one laptop during the lecture	1	2	3	4	5
I prefer to work alone using my own laptop during the lecture	1	2	3	4	5
I like working on ViLLE during the lecture	1	2	3	4	5
I prefer using ViLLE in the lecture compared to Eclipse	1	2	3	4	5
I got more feedback for my learning during the lecture because of the application of the approach	1	2	3	4	5
I got prompt feedback for my learning during the lecture because of the application of the approach.	1	2	3	4	5
The application of the approach in the lecture helped me to understand the material in a more interesting way	1	2	3	4	5
I communicated more in the lecture with my instructor on asking and answering questions because of the application of the approach.	1	2	3	4	5
I communicated more in the lecture with my instructor on sharing my ideas because of the application of the approach.	1	2	3	4	5
I did more cooperative work with my fellow students in the lecture because of the application of the approach.	1	2	3	4	5
I did more on sharing my ideas with my fellow students in the lecture because of the application of the approach.	1	2	3	4	5
I participated and practiced - what I have been taught - more actively in the lecture because of the application of the approach.	1	2	3	4	5
My ability to relate the concepts and skills in the lecture to real life increased because of the application of the approach.	1	2	3	4	5

I got more feedback from my instructor in the lecture because of the application of the approach.	1	2	3	4	5
I got prompt feedback from my instructor in the lecture because of the application of the approach.	1	2	3	4	5
My ability to complete tasks at times that were convenient for me in the lecture increased because of the application of the approach.	1	2	3	4	5
Managing and controlling my time efficiently in the lecture for my learning increased because of the application of the approach.	1	2	3	4	5
The application of the approach increased my quality of work in the lecture.	1	2	3	4	5
The application of the approach increased my understanding of the ideas taught in the lecture.	1	2	3	4	5
The application of the approach increased my chances to get to know students who are different from me in their learning in the lecture.	1	2	3	4	5
The application of the approach increased my ability to use my preferred learning styles in the lecture.	1	2	3	4	5
The lecture style was well organized for the application of the approach.	1	2	3	4	5

7. **In what ways do you feel the application of the approach in the lecture has been of greatest benefit to your learning?**

8. **Were there any problems associated with using the application of the approach during the lecture?**

9. **Would you like to add any comments or suggestions for this research?**

☺We really appreciate your cooperation

Appendix 10: Post-Intervention Survey (PS2)

Post-Intervention survey (PS2)

1. **Study load (Please circle one)**
    a. Full Time
    b. Part Time

2. **Please indicate your age _________ years**

3. **Gender (Please circle one)**
    a. Female
    b. Male

4. **How do you rate your programming skill background as? (Please circle one)**

1	Novice:	This is the first language and/or programming course
2	Intermediate:	I have developed some software before
3	Expert:	I have developed many software before

5. **Why did you choose to not participate in the trial of laptop use?**

____

____

6. **For each item please select the category that represents your perception on the following statements with 1 being "strongly disagree" and 5 "strongly agree"**

	Strongly Disagree	**Disagree**	**Do not Know**	**Agree**	**Strongly Agree**
I felt that the laptops were distracting during the lecture	1	2	3	4	5
I felt that I missed some of the information given during the lecture because I did not have a laptop.	1	2	3	4	5
I would preferred to have had a laptop.	1	2	3	4	5

7. **Would you like to add any comments or suggestions for this research?**

____

____

☺We really appreciate your cooperation

Appendix 11: Plain Language Statement (Student–Phase 3)

School of Computer Science & IT

INVITATION TO PARTICIPATE IN A RESEARCH PROJECT
PROJECT INFORMATION STATEMENT

Project Title:
Applied technology and the learning experience: Enhancement of learning programming using mobile devices

Investigators:
Mrs Wafaa Alsaggaf (Computer Science and Information Technology, PhD student, s3175694@student.rmit.edu.au),
Dr Margaret Hamilton (Project Supervisor: Senior Lecturer, Computer Science and IT, RMIT University, margaret.hamilton@rmit.edu.au, +(61 3) 9925 2939),
Associate Professor James Harland (Project Supervisor: Computer Science and IT, RMIT University, james.harland@rmit.edu.au, +(61 3) 9925 2045)

Dear Participant

You are invited to participate in a research project being conducted by RMIT University. This information sheet describes the project in straightforward language, or 'plain English'. Please read this sheet carefully and be confident that you understand its contents before deciding whether to participate. If you have any questions about the project, please ask one of the investigators.

Who is involved in this research project? Why is it being conducted?
The researchers are listed above: Wafaa Alsaggaf, *PhD* student at RMIT University who is doing the research project. Dr Margaret Hamilton as senior supervisor and Associate Professor James Harland as second supervisor. The research is being conducted as part of my PhD degree.The project has been approved by the RMIT Human Research Ethics Committee.
The project has been approved by the RMIT Human Research Ethics Committee.

Why have you been approached?
You have been approached randomly because you are enrolled in an introductory programming course offered by the School of Computer Science and IT.

What is the project about? What are the questions being addressed?
There is a diversity of opinion for use of laptops or other portable ICT devices in lecture in learning programming. Some teachers argue that they enhance the learning experience, but others suggest they can be a diversion if learner attention wanders from the topic at hand. Different levels of accessibility for browsers and email on laptops are the ongoing subjects of much research, but for this study, we would like to know your opinions about the application of a constructivist mobile-based learning and teaching programming approach using laptops and visualisation software during lectures.

This research aims to recommend a framework and steps that can be taken to enhance the efficiency of learning programming by using portable computers in the learning environment of computer science students and instructors in lectures. We will be approaching around 250 students.

If I agree to participate, what will I be required to do?
We would like you to complete a survey which we anticipate will take approximately 15 minutes. Your participation is purely voluntary and anonymous and you are free to withdraw from the project at any time. Completion of this survey will be interpreted to mean that you have consented to participate in the project.

What are the risks or disadvantages associated with participation?
There are no perceived risks outside the participant's normal day-to-day activities.Your involvement or non-involvement in the project will not affect ongoing assessment or grades.

What are the benefits associated with participation?
The benefit of this research will include the production of a model for improved programming course delivery and learning outcomes using mobile technologies

What will happen to the information I provide?
Data will be seen by myself and my supervisors, Dr Margaret Hamilton and Associate Professor James Harland. Any information that you provide can be disclosed only if (1) it is to protect you or others from harm, (2) a court order is produced, or (3) you provide the researchers with written permission. The results will be disseminated in a student report and that data will be aggregated and be kept securely at RMIT for a period of 5 years before being destroyed.

Because of the nature of data collection, we are not obtaining written informed consent from you. Instead, we assume that you have given consent by your completion and return of the survey.

What are my rights as a participant?
You have the right to:

- ✓ withdraw your participation at any time, without prejudice.
- ✓ have any unprocessed data withdrawn and destroyed, provided it can be reliably identified, and provided that so doing does not increase the risk for the participant.
- ✓ have any questions answered at any time.

Whom should I contact if I have any questions?
Myself by email: s3175694@student.rmit.edu.au) or any of the researchers listed at the top of the previous page.

Yours sincerely,

Wafaa Alsaggaf
PhD Student, CSIT, RMIT University

Dr Margaret Hamilton
Senior Lecturer, CSIT, RMIT University

Assoc Professor James Harland
Associate Professor, CSIT, RMIT University

Any complaints about your participation in this project may be directed to the Executive Officer, RMIT Human Research Ethics Committee, Research & Innovation, RMIT, GPO Box 2476V, Melbourne, 3001.
Details of the complaints procedure are available at: http://www.rmit.edu.au/research/hrec_complaints

Appendix 12: Focus Group Questions (Lecturer - Phase 4)

School of Computer Science & IT

Focus Group interview questions

Data Collection	
Place	Melbourne, Australia
Duration	90 Minutes
Date	Semester1/ 2013
Targeted sample	Computer Science lecturers teach programming courses from different universities and school.

Focus Group Questions	
The questions of this phase conducted with the purpose of confirming, expanding and reflecting on the results of previous phases of this research	
Possible Questions	1. Could you please present yourself? a. Courses you teach b. Experience c. How many years you have been in teaching programming 2. To what extent do you think students' practicing what is being taught during lecture is important for their understanding, enjoyment? Explain the environment … 3. What is your opinion on students practicing programming tasks using their laptops with visualization software in a programming lecture? 4. How can such environment affect on students and lecturer interaction in lecture? 5. How can such environment affect on collaboration between students in lecture? 6. How can such environment affect on students' active learning in lecture? 7. Do you think active learning in lecture will help students for getting more hands on practice, better understanding, and more engagement? 8. How can such environment affect on provision feedback to students in lecture? 9. How important is it to cover the main points in lecture and get the students to fully understand them versus to cover the whole things you want to cover? 10. How can such environment affect your previous expectations of students' learning in a programming lecture? 11. What are your concerns regarding this environment? 12. What kind of preparations you need to adapt this innovation? TA 13. Do you think it is better for novices rather than advanced programmers? 14. What are advantages and disadvantages of exercises in a lab compared to the one in lecture?

Appendix 13: Plain Language Statement and Consent Form (Lecturer - Phase 4)

School of Computer Science & IT

INVITATION TO PARTICIPATE IN A RESEARCH PROJECT
PROJECT INFORMATION STATEMENT

Project Title:
Applied technology and the learning experience: Enhancement of learning programming using mobile devices

Investigators:
Mrs Wafaa Alsaggaf (Computer Science and Information Technology, PhD student, s3175694@student.rmit.edu.au) ,
Dr Margaret Hamilton (Project Supervisor: Senior Lecturer, Computer Science and IT, RMIT University, margaret.hamilton@rmit.edu.au, +(61 3) 9925 2939) and
Associate Professor James Harland (Project Supervisor: Computer Science and IT, RMIT University, james.harland@rmit.edu.au, +(61 3) 9925 2045)

Dear Participant

You are invited to participate in a research project being conducted by RMIT University. This information sheet describes the project in straightforward language, or 'plain English'. Please read this sheet carefully and be confident that you understand its contents before deciding whether to participate. If you have any questions about the project, please ask one of the investigators.

Who is involved in this research project? Why is it being conducted?
The researchers are listed above: Wafaa Alsaggaf, *PhD* student at RMIT University who is doing the research project. Dr Margaret Hamilton as senior supervisor and Associate professor James Harland as second supervisor. The research is being conducted as part of my PhD degree.The project has been approved by the RMIT Human Research Ethics Committee.

Why have you been approached?
You have been approached randomly because you are teaching a programming course.

What is the project about? What are the questions being addressed?
There is a diversity of opinion about the use of laptops or other portable ICT devices in lectures for learning programming. Some teachers argue that they enhance the learning experience, but others suggest they can be a diversion if the learner's attention wanders from the topic at hand. For this study, we would like to know your opinions about the use of laptops during lectures for learning programming. This research aims to recommend a model and steps that can be taken to enhance the efficiency of learning programming by using portable laptop computers in the learning environment of computer science students and instructors in lectures. We will be approaching around twelve lecturers.

If I agree to participate, what will I be required to do?
You are invited to participate in a focus group discussion that will take approximately 90 minutes to complete. Your contribution in this discussion is valuable because the findings from this project will assist in understanding ways to improve the use of mobile devices in lectures to enhance the learning of programming. The focus group discussion will be audio-taped with your permission.
Due to the nature of the data collection process, we are required to obtain written consent from you. Please read the consent form carefully and be confident that you understand its contents before signing the consent form. If you have any questions about the project please feel free to contact one of the investigators. Your participation is purely voluntary and you are free to withdraw from the project at any time.

What are the risks or disadvantages associated with participation?
There are no perceived risks outside the participant's normal day-to-day activities.

What are the benefits associated with participation?
The benefit of this research will include the production of model for improved programming course delivery and learning outcomes using mobile technologies

What will happen to the information I provide?
The focus group discussion report will be anonymous and de-identified. Data will be seen by myself and my supervisors, Dr Margaret Hamilton and Associate Professor James Harland. Any information that you provide can be disclosed only if (1) it is to protect you or others from harm, (2) a court order is produced, or (3) you provide the researchers with written permission. The results will be disseminated in a student report and that data will be aggregated and be kept securely at RMIT for a period of 5 years before being destroyed.

What are my rights as a participant?
You have the right to:

- ✓ withdraw your participation at any time, without prejudice.
- ✓ have any unprocessed data withdrawn and destroyed, provided it can be reliably identified, and provided that so doing does not increase the risk for the participant.
- ✓ have any questions answered at any time.

Whom should I contact if I have any questions?
Myself by email: (s3175694@student.rmit.edu.au) or any of the researchers listed at the top of the previous page.

Yours sincerely,

Wafaa Alsaggaf
PhD Student, CSIT, RMIT University

Dr Margaret Hamilton
Senior Lecturer, CSIT, RMIT University

Assoc Professor James Harland
Associate Professor, CSIT, RMIT University

Any complaints about your participation in this project may be directed to the Executive Officer, RMIT Human Research Ethics Committee, Research & Innovation, RMIT, GPO Box 2476V, Melbourne, 3001.
Details of the complaints procedure are available at: http://www.rmit.edu.au/research/hrec_complaints

PRESCRIBED CONSENT FORM FOR PERSONS PARTICIPATING IN RESEARCH PROJECTS INVOLVING INTERVIEWS

College of	Science, Engineering & Health		
School of	Computer Science & IT		
Project Title:	Applied technology and the learning experience: Enhancement of learning programming using mobile devices		
Name(s) of Investigators:	Mrs Wafaa Alsaggaf	Phone:	+(613) 9306 2506
	Dr Margaret Hamilton	Phone:	+(61 3) 9925 2939
	Associate Professor James Harland	Phone:	+(61 3) 9925 2045

1. I have received a statement explaining the focus group discussion involved in this project.
2. I consent to participate in the above project, the particulars of which - including details of the interviews - have been explained to me.
5. I authorise the investigator or his or her assistant to interview me or administer a questionnaire.
6. I give my permission to be audio taped: ☐ Yes ☐ No

6. I acknowledge that:

(f) Having read the Plain Language Statement, I agree to the general purpose, methods and demands of the study.
(g) I have been informed that I am free to withdraw from the project at any time and to withdraw any unprocessed data previously supplied.
(h) The project is for the purpose of research and/or teaching. It may not be of direct benefit to me.
(i) The privacy of the information I provide will be safeguarded. However should information of a private nature need to be disclosed for moral, clinical or legal reasons, I will be given an opportunity to negotiate the terms of this disclosure.
(j) The security of the research data is assured during and after completion of the study. The data collected during the study may be published, and a report of the project outcomes will be provided to RMIT University. Any information which may be used to identify me will not be used unless I have given my permission.

Participant's Consent

Name: ______________________________ Date: ________________
(Participant)

Participants should be given a photocopy of this consent form after it has been signed.

Any complaints about your participation in this project may be directed to the Executive Officer, RMIT Human Research Ethics Committee, Research & Innovation, RMIT, GPO Box 2476V, Melbourne, 3001.
Details of the complaints procedure are available at: http://www.rmit.edu.au/research/hrec_complaints