Profile Transformation in Mobile Technology Based Educational Systems

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Jueming Chen
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Abstract

In order to meet the learning needs from various types of students, computer aided education systems try to include new methods to provide personalized education to every student. From the early 1970s, a lot of adaptive educational systems have been created to provide training on a variety of subjects. Combined with the Internet, the adaptive educational systems have become web-based and even more popular. Recently, the development of mobile technology has made the web-based adaptive educational systems accessible through mobile phones. It is necessary that the students can also receive adaptive educational contents on mobile phones. This research project investigated the possible student's preference differences between Personal Computer (PC) and mobile phone, and then proposed a student profile transformation framework to address such differences.

This research project conducted two surveys on the student profile transformation between PC and mobile phone. A demo web-based educational system that could be accessed from both PC and mobile phone was also developed for participants of the surveys to give more real and precise responses. Based on Felder-Silverman Learning Style Theory (Felder, 1993; Felder & Silverman, 1988) and the results of the surveys, this thesis proposes a student profile template and a student profile transformation framework, which both fully considered the influences of device capabilities and locations on students' preferences on mobile phones. Furthermore, the proposed framework integrates a solution for unsupported preferences and preference conflicts.

By implementing the proposed template and framework, the students' preference changes between PC and mobile phone are automatically updated according to various device capabilities and locations, and then the students can receive adaptive educational contents that meet their updated preferences.

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Jueming Chen

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Chapter 1 : Introduction

1.1 Introduction

Computers and Internet technologies have become more and more essential for educational purposes. A lot of computer and Internet based education systems have been developed today. The convenience and efficiency of such systems successfully extend the education from the traditional classroom to everywhere in people's daily life. To suit various types of students, the educational systems begin to include adaptive features. Since the mobile phone technology is now available for education, it is also becoming essential for the educational systems to provide adaptive education to the students on mobile phones as well as on Personal Computers (PC).

This chapter briefly introduces the history of Adaptive Educational Systems and mobile learning. Then the research objectives and approaches are described. At the end of the chapter, the complete structure of this thesis is presented.

1.2 History of Adaptive Educational Systems

With the invention of computers, people tend to include computer assistance into a variety of areas for better performance and higher efficiency. Research in Computer-Aided Instruction began in 1950s. A lot of terms had emerged. Computer-Based Instruction (CBI), Computer-Based Training (CBT), Computer Aided Learning (CAL), Computer Mediated Education (CME), and Computer Assisted Instruction (CAI) were all typical examples of Computer-aided Educational Systems. However, those systems did little in providing personalized instruction for different users. Each system set up exactly same learning environment for all its users. The same educational contents were delivered to all users regardless of each user's

preferences and differences in cognitive processes.

In the early 1970s, Intelligent Tutoring Systems (ITS) came into existence, capable of providing students with individualized instruction. They were the combination of Computer-Aided Instruction with Artificial Intelligence technology ("An overview of intelligent tutoring systems", 1996). The individualization of delivered tutoring contents was achieved through the system's adaptivity, i.e. the system adapted its output using some data or knowledge about the learner in a system controlled way (Papanikolaou, Grigoriadou, Ornilakis, & Dagoulas, 2003). Together with a number of ITSs, e.g. SOPHIE (Brown, Burton, & de Kleer, 1982), Geometry Tutor (Anderson, Boyle, & Yot, 1985) and the LISP Tutor (Anderson, Conrad, & Corbett, 1989) being developed, four major components were identified within an ITS: the student model, the pedagogical module, the domain knowledge module, and the communication module (Woolf, 1992). The student module stores specific information of each student; the pedagogical module is the information about teaching process; domain knowledge module contains the information that is going to be taught to the student; and the communication module controls the interactions with the student. The fifth component, expert model, was separated from the domain knowledge module several years later, which contains the expert's perception of the domain knowledge. (Beck, Stern, & Haugsjaa, 1996). An illustrative figure was also included in their work to explain the interactions among those components (Figure 1-1).

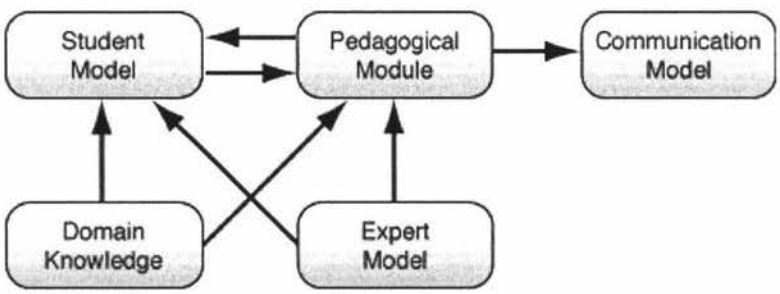


Figure 1-1: Interactions of components in an intelligent tutoring system (Beck et al., 1996)

As in the figure 1-1, the Expert Model in an ITS has knowledge about a particular domain and the Student Model contains measurements of the student's knowledge of the problem area ("An overview of intelligent tutoring systems", 1996). These two models interact to ensure that the educational contents being presented to the students are well individualized.

In the early 1990's, another great invention, the Internet began to allow limited commercial traffic ("Internet facts and statistics", 1999). With the advent of the World Wide Web (WWW) and the graphical web browser, the Internet expanded very quickly throughout the world. By using Hypertext Markup Language (HTML), browser software and WWW systems, various Internet protocols could then be accessed on a single interface (Berners-Lee, Cailliau, Luotonen, Nielsen, & Secret, 1994; Cohen, 2003; Musciano & Kennedy, 1998). As the result of the popularity of the Internet, Adaptive Hypermedia Systems (AHS) emerged to attract research efforts. Generally, AHSs were hypertext and hypermedia systems that stored some personal features about the user in a user model and applied this model in order to adapt several visible aspects of the system to the user (Brusilovsky, 1996). The Adaptive Hypermedia technology was believed to be helpful in providing personalized educational contents and navigation supports for different users. Web-based Adaptive Educational System (Web-based AES) or Adaptive Educational Hypermedia (AEH) was an inheritance form of the earlier ITS and AES. It was developed and became a hot research area (Khan, 1997) after 1996. These systems could be simply regarded as ITSs with WWW accesses (Brusilovsky, 1996). Since Web-based AESs were independent of classroom and platform (Brusilovsky, 1998), learners could enjoy more computer assisted education on their own. However, the educational systems seemed to ask for more adaptivity features. This was because these systems aimed at not only students but also life-long learners, whose knowledge levels and learning environments were even more diversified. A lot of such systems have also been developed quite successfully, such as ELM-ART (Brusilovsky, Schwarz, & Weber,

1996), AST (Specht, Weber, Heitmeyer, & Schoch, 1997), AHM (Pilar da Silva, Durm, Duval, & Olivie, 1998), AHA! (De Bra & Calvi, 1998), Arthur (Gilbert & Han, 1999), InterBook (Brusilovsky, Edlund, & Schwarz, 1998), ACE (Specht & Oppermann, 1998), and TANGOW (Carro, Pulido, & Rodriguez, 1999). A reference model called Adaptive Hypermedia Application Model (AHAM) was also defined to provide a sound basis for AHS development in 1999 (De Bra, Houben, & Wu, 1999). This reference model clearly distinguished four easily confused items in the AHS: domain model, user model, teaching model and adaptive engine. The information structure stored in Domain Model and the user information stored in User Model were combined together by the pedagogical rules set by Teaching Model, and then the adaptation would be performed accordingly (De Bra & Calvi, 1998; De Bra et al., 1999).

1.3 The Emergence of Mobile Learning

However, this is not the end of adaptive learning systems. New technologies keep emerging all the time. Availability of high bandwidth infrastructure, such as GPRS, 3G and UMTS networks, and the increasing number of mobile subscribers ("Mobile subscriber numbers exceed 1.5 billion", 2004) make mobile internet applications more and more common into our daily life. One important emerging mobile internet application is mobile learning (Sharples, 2000). With the help of wireless network adaptors, it is possible for the handheld mobile devices, such as Personal Digital Assistants (PDAs) and mobile phones, to enjoy the exciting world of the internet anytime and anywhere wirelessly. The researchers of adaptive learning systems will certainly not miss this technological revolution. Empowered by wireless communications, e-business can become m-business (Mobile Business), which will reach the users more effectively and enable instant access to business-critical information and communications (Deitel, Deitel, Nieto, & Steinbuhler, 2002). Similarly, e-learning can be extended to m-learning with the help of wireless

technologies. Quite a lot of attempts have already been made on mobile learning systems. Among them, the two famous examples are m-learning project (http://www.m-learning.org) and MOBIlearn project (http://www.mobilearn.org).

It is quite natural to think that the mobile learning is another form of web-based learning, except that the connection is wireless. But, will a mobile learner have same preferences for the adaptive contents on both mobile devices and on PC? According to (Vavoula & Sharples, 2002), learning can be considered as mobile only if it is mobile in terms of space, time and different areas of life. A similar definition for mobile education can also be found in (Lehner & Nosekabel, 2002, p. 103) as "any service or facility that supplies a learner with general electronic information and educational content that aids in the acquisition of knowledge regardless of location and time". These two definitions indicate that mobile learning will offer learners even more freedom in carrying out learning activities than PC based web learning systems. Learners can access learning systems from any location. Further, their access devices for mobile learning are quite different from PCs. Because of the limitation of mobile devices' capabilities, some functions will be not available on some mobile devices, e.g. the capability to display a video file on webpage. Such differences between PC and mobile learning are likely to make the same learner behave differently under PC and mobile learning environment.

1.4 The Need for Modeling Students under Various Environments

From the development of Adaptive Educational Systems, we can find that it is not incidental for the Adaptive Hypermedia technology to attract so much attention in the design of educational systems. The development of computer technology and the World-Wide Web made web-based educational systems much easier to access than ever before. Easy and convenient access directly resulted in the increase of users.

More and more people accepted such a revolutionary way of learning, but the one-size-for-all systems would certainly not be enough to meet the needs of a number of students with totally different background, knowledge level and learning habits. The definition of students here was greatly extended and the classroom was not the only place where learning could take place. Besides those on-campus students, actually anyone could be a student with the help of web-based educational systems. Use of Adaptive Hypermedia technology in web-based educational systems is indispensable because the users of those systems are so diversified.

The adaptation process can be generalized into three steps, i.e. (1) get the information about the student; (2) process the information to initialize and update a student model; and (3) use the student model to provide the adaptation. The student model plays an important role in the adaptation process. The adaptive educational system will provide the student with most suitable contents according to his/her student model. The information included in the student model is the key component for content selection and presentation.

In order to implement adaptivity on mobile educational systems, we should be fully aware of the student's behavior changes under PC and mobile learning environments. The student model under a PC environment will not always be applicable under a mobile environment. Even if we only consider the mobile environment, there are still various mobile devices with completely different capabilities, which will probably influence a student's learning behavior. Thus, there are situations that the information in the student model needs modifying under different learning environments even if for the same student.

1.5 Research Objectives

Our aim in this thesis is focused on the student profile transformation between PC and

mobile phone. Based on a student's preference settings in that student's profile, we need to provide students with adaptive learning contents in various learning devices including PC and mobile phones. We can conclude that our research objectives are as follows:

- ✧ To identify the main attributes of device sensitive preferences in student profiles when switching between a PC and mobile phone. In adaptive learning systems, the learning contents are customized for an individual student according to that student's preference settings. When learning with a mobile phone, the student is very likely to have different preference settings because the device capability and environment are so different from PC learning. By identifying the possible device sensitive preferences in the student's profile, the student's preference changes between PC and mobile phone can be understood and updated, so that the educational system is still able to provide adaptive learning to the student.

- ✧ To develop a framework that dynamically and transparently transforms student preferences between PC and mobile phone learning environments. Each student has his/her own view towards learning. Students' preferences for learning contents are very different from each other. Therefore the possible student preference changes on various devices or platforms should also be diversified. The framework we are going to develop should be able to capture and update the preference changes for each student according to various device capabilities and locations. In addition, the synchronization of student profiles on various devices should also be achieved.

1.6 Research Procedure and Organization

To fulfill the above research objectives, the research is planned in the following steps:

- ✧ Step 1: A literature review is conducted on student modeling technologies, especially on the application of learning styles theory in adaptive learning systems. This step includes the introduction (Chapter 1), the literature review on student modeling technologies for adaptive learning systems (Chapter 2) and the literature review on application of learning styles theories in adaptive learning systems (Chapter 3).

- ✧ Step 2: A questionnaire based survey is designed and carried out to get useful feedback from the students. Through the survey, we identify the attributes to be included in student profiles and understand how the mobile learning environment influences student's preferences for learning contents. This step introduces two questionnaire surveys conducted for the research. The first survey investigates the possible preference changes in mobile phone learning environment (Chapter 4) and helps to decide the attributes to be included in the student profile (Chapter 5). In the second survey, we try to analyze how students' preference changes are affected by various device capabilities attributes and locations. The methods for student profiles synchronization are also discussed (Chapter 6).

- ✧ Step 3: Based on the results analysis of the two surveys, the framework is designed that can dynamically and transparently transform student profiles between PC and mobile phone. This step includes the proposed framework for student profile transformation (Chapter 7).

- ✧ Step 4: Summarize and conclude the whole research. This step includes the conclusion and future work (Chapter 8).

1.7 Summary

In this chapter, we have gone through each development stage of adaptive learning systems. Today, the mobile phone has become a new media for adaptive learning which requires the adaptive learning systems to take the various device capabilities and locations into consideration when providing adaptive learning contents. In this chapter, the research objectives, research approaches and structure of the thesis have been presented.

Chapter 2 : Student Modeling Technology in Web-Based Adaptive Educational Systems

2.1 Introduction

This chapter first introduces the Adaptive Hypermedia technology and its application for education. Then the student modeling technology in Adaptive Hypermedia is discussed. Through a literature review on user modeling, we can find that today's adaptive Web-based systems are able to adapt to more than just user characteristics. The information about user data, usage data and environment data is also used for adaptive purposes. However, in our research, we will concentrate on investigating the possible changes of personal features of students, especially student preferences and learning styles information in the student model, on PC and mobile phone.

2.2 Adaptive Systems and User Modeling

Adaptive Hypermedia technology can actually be put into any application area for users with different goals and knowledge (Brusilovsky, 1996). Educational application is just one of these application areas. It is the variety of students' goals and knowledge that makes the educational application a very popular application area. Adaptive Hypermedia technologies can be classified into two distinct areas: content level adaptation or adaptive presentation and link level adaptation or adaptive navigation support (Brusilovsky, 2001). Both adaptation areas include some technologies such as adaptive multimedia presentation and adaptive link hiding. However, before these adaptations can take effect, there is still one thing that should be considered, i.e. user modeling. User modeling is the process of building and updating the user model in Adaptive Hypermedia systems. As mentioned in the

previous paragraph, Adaptive Hypermedia Systems provide personalized contents to the users based on user models. Therefore the first step towards adaptation should be user modeling. A figure has been presented by (Brusilovsky & Maybury, 2002) to clearly explain the structure of an adaptive software system (Figure 2-1).

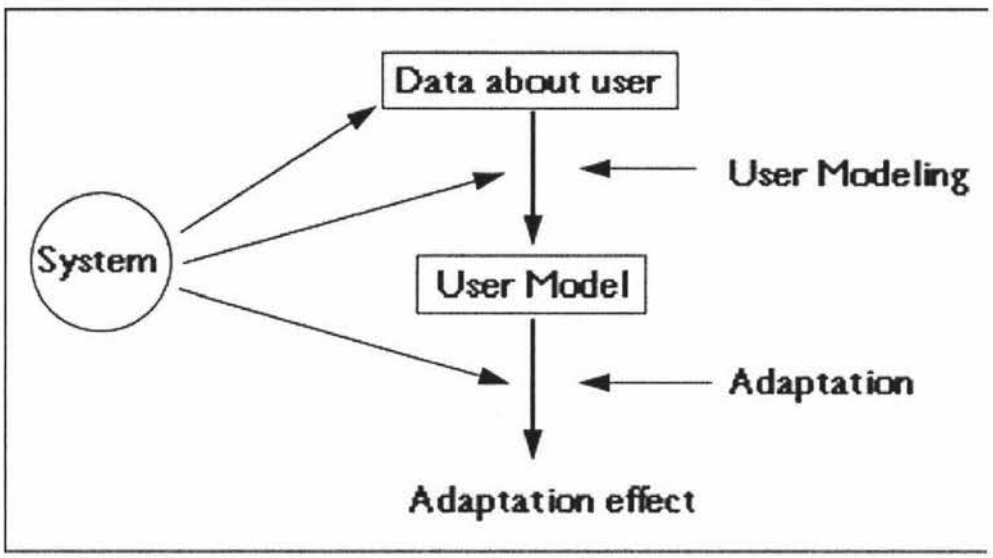


Figure 2-1: The structure of an adaptive software system (Brusilovsky & Maybury, 2002)

The above outline of adaptive system indicates that the information of a particular user is collected and processed to build a user model, which will then be used to guide the adaptation effect. It should be noted here that not only the Adaptive Hypermedia systems can collect and update the information for user modeling, the users themselves also have the opportunity to be involved in the user modeling process (Brusilovsky, 1996). Another issue that needs serious consideration is what information should be collected to build the user model. The early Adaptive Hypermedia systems only took into account user's characteristics (Brusilovsky, 2001). However, currently the situation has changed. The adaptive Web-based systems are able to adapt to things other than user characteristics, such as user data, usage data and environment data. The user data comprise various user characteristics, which are typically gathered for user modeling. The usage data comprise data about user interaction with the systems and the environment data comprise all aspects of the user

environment (Kobsa, Koenemann, & Pohl, 2001).

2.3 Student Modeling in Adaptive Educational Systems

As the basis for adaptation, user modeling is certainly a key step towards effective adaptation. It is obvious that the quality of adaptation is highly dependent on the preciseness of the data that will be gathered and used to build the user model. However, this does not mean that more data collected will guarantee effectiveness of adaptation. The data collected for user modeling should not only be adequate about particular users, but also be representative, and updated in timely manner during the whole interaction between the users and the adaptive system. For different adaptive systems, a unique set of data should be customized for each of them respectively.

A Web-based Adaptive Educational System is one of the popular applications of Adaptive Hypermedia technologies. Users of Web-based Adaptive Educational Systems are typically students. Therefore user modeling in Adaptive Educational systems is actually student modeling. The information and data gathered for student modeling should include both the characteristics of the student and any other necessary data to ensure the effectiveness of the adaptation (Kobsa et al., 2001).

In 1994, the information within the student model was divided into two major groups: domain specific information and domain independent information, based on the relationship with the subject domain (Brusilovsky, 1994):

- ✧ Domain Specific Information (also called student knowledge model (SKM)) represents a reflection of the student's state and level of

knowledge and skills in terms of a particular subject. Domain Specific Information can also include student's prior knowledge about the domain, records of learning behaviors (e.g. number of lectures taken, number of times help is asked for, frequency of mistakes made while solving problems, reaction/answering time while solving problems, etc.), records of evaluation/assessment (e.g. qualitative and quantitative scores) and so on.

- ✧ Domain Independent Information varies from system to system. It may include learning goals (Brusilovsky, 1996), cognitive aptitudes (Capuano, Marsella, & Salerno, 2000; Shute, 1995), measures for motivation state (Far & Hashimoto, 2000), preference (Brusilovsky, 1996, 2001; Danielson, 1997; Fink, Kobsa, & Nill, 1998; Kinshuk, Oppermann, Patel, & Kashihara, 1999; Schoech, Specht, & Weber, 1998; Specht & Oppermann, 1998), learning styles (Carver, Howard, & Lane, 1999; Carver, Howard, & Lavelle, 1996; Danielson, 1997; Gilbert & Han, 1999, 1999a, 2002; Lane, 2000; Specht & Oppermann, 1998), background and experience(Brusilovsky, 1996), and factual and historic data.

From these two definitions, we can see that both domain specific and domain independent information are about student characteristics only. This is obviously not enough for the current situation, especially in the mobile learning context. Therefore some recent work (Billsus, Pazzani, & Chen, 2000; Joerding, 1999; Kobsa et al., 2001) suggests that information such as usage data and environment data should be considered in addition to student characteristics. Thus, under the Web-based Adaptive Educational System context, the student models within different types of systems emphasize various aspects of information about students. Based on the relationship with the domain and with the subject of adaptation, information in the student model

can be summarized as follows:

- ✧ Student data: It stores the data about students themselves.
  - ♦ The first part is domain dependent: such as knowledge (the information of a specific domain that will be taught to the student), prior knowledge about the domain, records of learning behaviors (number of lectures taken, number of helps asked, frequency of mistakes made while solving problems, reaction/answering time while solving problems, etc), and records of evaluation/assessment.
  - ♦ The second part is domain independent: such as learning goals, cognitive aptitudes, measures for motivation state, preference, interest, learning styles, individual traits, background and experience, factual and historic data, and demography .

- ✧ Usage data: It stores data about how a student interacts with the educational system. It may be domain dependent or domain independent. For example, the time that a student spends on a particular web course is domain dependent usage data, while the navigation path that a student follows to explore a web educational system is domain independent usage data.

- ✧ Environment data: It stores the data about hardware, software, and bandwidth that the student uses. Obviously, it is domain independent.

2.4 Student Preference and Learning Style

So far, we have discussed the importance of the student model and what types of information it needs to contain. As discussed above, student preferences, individual

traits, and learning styles are domain independent. The definitions of these concepts are not very clear, and sometimes these concepts may overlay or interchange in different systems. Therefore, we suggest using personal features of students to describe all of these items. The personal features of students will include: student preferences (e.g. multimedia preferences), personality factors (e.g. introvert/extrovert), cognitive factors, and learning styles. Preferences selected by student may or may not match with his or her learning styles. For example he or she may select visual objects but may not be a student of visual learning style. In this sense, student may not know their own learning style.

Personal features of students are different from other information stored in the student model. These personal features can not be deduced from the system. They may be extracted by interviews, questionnaires, or psychological tests. Although many researchers agree on the importance of modeling and using individual traits or preferences, there is little agreement on which features can and should be used, and how to use them.

In this thesis, we attempt to research on the student profile transformation between PC and mobile phone based educational systems by investigating the possible changes in personal features of student, especially student preferences and learning styles, among different types of learning devices, including PC and mobile phone. A student's learning styles have close relationship with student's preference for certain educational content presentations. Furthermore, sometimes there will be conflicts between student learning styles and preferences, which is also a problem that needs to be discussed in this thesis. In the next part, the background of learning style theory will be presented in detail.

2.5 Summary

A literature review has been presented in this chapter on student modeling for Adaptive Educational System. The structure of the Adaptive Systems and the importance of user modeling are both described. Moreover, we discussed the classification of the information included in student models. Finally we defined the personal features of students, which can not be deduced from the system but have to be extracted by interviews, questionnaires, or psychological tests. Our research on student profile transformation will be based on the personal features of students, especially student preferences and learning style information in the student model.

Chapter 3 : Background of Student Learning Styles

3.1 Introduction

Each individual has his/her unique way of learning. We can always find situations where, for example, in the same class, some students will understand knowledge better in pictures (visual contents) while the others prefer knowledge being explained in texts (verbal contents). This is just what the learning styles theory is interested in. Learning styles are students' cognitive, affective, and psychological behaviors that can be used as relatively stable indicators of students' perceive, interaction with, and response to their learning environment (Keefe, 1979), or briefly, students' "characteristic ways of taking in and processing information" (Felder & Brent, 2005, p.57). Learning styles greatly affect the learning process, and therefore the outcome (Carver et al., 1999). When the instructional styles match the student's preferred learning styles, the student will be expected to learn more comfortably and as a result, the learning is expected to be more effective, although sometimes the student should also be given the opportunities to practice his less preferred learning styles to develop skills associated with those learning styles (Felder & Spurlin, 2005). In the web learning environment, where the same educational contents are accessed by even more varieties of students than in the traditional classrooms, it is better to tailor the educational contents to match all types of student learning styles, so that each student will learn in a more comfortable way.

In this chapter, we will first review the applications of learning styles in adaptive learning systems. Then the Felder-Silverman Learning Styles theory will be introduced in detail. To apply this theory in our research, we construct eight student learning preference questions according to the Index of Learning Styles (ILS). The

results of the eight questions can be used to decide student's learning style preference level on the four learning style dimensions.

3.2 Previous Systems Adapted to Student Learning Styles

In recent years, researchers have started to take into consideration the learning styles in educational hypermedia systems. There are a few existing systems that have the ability to adapt to student's learning styles. Some typical works are listed as follows:

- ✧ **Research of Carver et al.** (Carver et al., 1999; Carver et al., 1996): It uses Felder-Silverman Learning Style Theory that couples learning styles by active/reflective, sensing/intuitive, visual/verbal, inductive/deductive, and sequential/global and combines with adaptive hypermedia to provide tailored courseware presentation. The key of this system is the determination of what type of media is appropriate for different styles. Each media was rated on a scale from 0 to 100 to determine the amount of support for each learning style. Each hypermedia course element supports one or more learning styles. The system lists the course material by the weight of their supporting learning styles.
- ✧ **Arthur system** (Gilbert & Han, 1999, 1999a, 2002): Based on auditory, visual, tactile or a combination of these styles, the course instructors create all the course material in each style. When student enters the system at first time, the course content is delivered to student randomly. Then the system monitors student's learning process and based on student's evaluation, updates student's learning styles (auditory, visual, tactile or a combination of them). According to student's latest learning styles, the system provides the suitable course content. The learning styles supported by the system are not based on any educational learning

style theory, so its learning styles are more or less like preferences.

- ✧ **Adaptive Courseware Environment (ACE)** (Specht & Oppermann, 1998)**:** The system provides certain mechanism to adapt to student's learning styles. When students start to use a new courseware, they are asked for their learning strategies, such as learning by example, reading texts, or learning by doing. Based on the learning model, the domain model and the pedagogical model, the presentation component selects appropriate learning units and generates individual hypermedia documents for students. In strict learning style theory in education, its supporting learning styles may be classified into student preferences.
- ✧ **Paredes and Rodríguez's research** (Paredes & Roderiguez, 2002): This research uses Felder-Silverman Learning Style Theory and Index of Learning Styles to assess student's learning styles. Then the assessment result is used to automatically adapt Web-based educational systems' content sequencing for student. This methodology is implemented in the Web-based courses tool - Task-based Adaptive learNer Guidance On the Web (TANGOW). However, the system only supports two dimensions of the four dimensions in the Felder-Silverman Learning Style Theory.

As we can find from the systems introduced above, different systems have different ways to collect student's learning styles, such as interview, questionnaire, and monitoring student's behaviors. However, getting useful information about student's learning style is actually a psychological test process that is specially designed, and not just a simple unstructured interview (Brusilovsky, 2001). The current systems are all PC-based and have not considered any potential for the emerging learning environments such as mobile learning. The aim of this thesis is to create a framework to translate student profiles and provide transparently a full learning styles adaptation for mobile technology based learning environments.

3.3 Felder-Silverman Learning Styles Theory

In last several decades, a lot of efforts have been made to define and classify learning styles. There are many learning styles theories being used today, among which some important theories are listed as follows:

- ✧ **Kolb's learning style theory** (Kolb, 1984; Kolb & Fry, 1975): It defined the Kolb Learning Cycle including four quadrants, that is "why, what, how and what if". By teaching around the cycle from "why" to "what if", it was expected that the needs of all learners would be met.
- ✧ **Gardner's Multiple Intelligences Theory** (Gardner, 1993): This theory proposed that there is not a single "Intelligence", but rather that there are eight distinct forms of intelligence, that is linguistic, logical-mathematical, spatial, kinesthetic, musical, interpersonal, intrapersonal, and the naturalist. The theory broadened the perceptions of intelligent and suggested how various intelligences could be taught to students.
- ✧ **Felder-Silverman Learning Style Theory** (Felder, 1993; Felder & Silverman, 1988): This theory defines a student's learning styles by a sliding scale of five dimensions: sensing-intuitive, visual-verbal, inductive-deductive, active-reflective and sequential-global. The fifth dimension, inductive-deductive dimension, was deleted from the previous theory in 2002 because of pedagogical reasons. When instructional styles matched student's preferred learning styles, the student were expected to learn more comfortably.
- ✧ **Litzinger and Osif's Theory of Learning Styles** (Litzinger & Osif, 1993): It described learning styles as "the different ways in which children and adults think and learn." It broke the learning process into three segments: cognition, conceptualization and affective.
- ✧ **Myers-Briggs Type Indicator (MBTI)** (Briggs & Myers, 1977; Myers & McCaulley, 1985): It contained four separate indices, that is EI, SN,

TF and JP. Each index reflected one of four basic preferences including Extraversion-Introversion, Sensing-Intuition, Thinking-Feeling and Judgment-Perception. The preferences on each index is independent of preferences for the other three indices, so that the four indices would yield sixteen possible combinations called "types", denoted by the four letters of the preferences, for example ESTJ, or INFP.

To implement the student profile transformation framework, we choose the Felder-Silverman Learning Styles Theory from the existing learning styles theories. There are three reasons for this choice:

(1) Its Index of Learning Style (ILS) questionnaire provides a convenient approach to establish the dominant learning style of each student (Felder & Soloman, n.d.).

(2) The results of ILS can be linked easily to adaptive environments (Paredes & Roderiguez, 2002).

(3) It is found to be the most appropriate and feasible to be implemented in hypermedia courseware (Carver et al., 1999).

The Felder-Silverman Learning Styles Theory categorizes an individual's learning style preferences by a sliding scale of five dimensions: sensing-intuitive, visual-verbal, inductive-deductive, active-reflective and sequential-global (Felder, 1993; Felder & Silverman, 1988). In 2002, the inductive-deductive dimension has been deleted from the previous theory, because of pedagogical reasons. This theory defines a student's learning styles by a sliding scale of four dimensions: sensing-intuitive, visual-verbal, active-reflective and sequential-global. The descriptions for these four dimensions are as follows:

- "**Sensing/Intuitive:** Sensing learning prefer to first learn concrete and practical information oriented towards facts and procedures. Intuitive learners prefer conceptual and innovative information oriented

towards theories and meanings.

- ✧ **Visual/Verbal:** Visual learners obtain more data from visual representations such as graphs, charts, pictures, and diagrams. Verbal learners are more comfortable with verbal information such as written texts or lectures.
- ✧ **Active/Reflective:** Active learners learn by means of trying things out, and prefer doing something. Reflective learners progress in their learning process through thinking before doing things.
- ✧ **Sequential/Global:** Sequential learners prefer courses that are organized step by step and are very structured, not allowing many degrees of freedom for the student. Global learners prefer more flexible courses that are less structured, to build a knowledge map from the exploration of the course" (Paredes & Roderiguez, 2004, p.211).

Based on the descriptions of these four dimensions of learning styles, a questionnaire called Index of Learning Styles (ILS) has been developed (Felder & Soloman, n.d.). The aim of this questionnaire is to help learners to identify their own dominant learning styles. The questionnaire consists of 44 questions, each with two possible answers, "a" or "b". Each of the four learning style dimensions associates with 11 questions. For convenient statistical analyses of the questionnaire results, we can count all "a" responses for the 11 questions of a dimension and obtain a score on that dimension. The score will then be an integer ranging from 0 to 11. For example, on the active-reflective dimension, the scores can be explained as follows (Felder & Spurlin, 2005):

- ✧ **0 or 1:** strong preference for reflective learning;
- ✧ **2 or 3:** moderate preference for reflective learning;
- ✧ **4 or 5:** mild preference for reflective learning;
- ✧ **5 or 7:** mild preference for active learning;
- ✧ **8 or 9:** moderate preference for active learning;

- ✧ **10 or 11:** strong preferences for active learning.

One important thing about the above scoring scale of learning style dimensions is that the four dimensions are continua, not either/or categories. A student's preference for one or the other pole of a dimension may be mild, moderate or strong (Felder & Spurlin, 2005). Therefore, it is not suitable to predict that a student's learning style is "active" if he is not "reflective". Similarly, in the Web-based Educational System, each of the four learning style dimensions can not be simply a choice between "Yes" and "No", but be a set of preferences for the learning contents presentation which stands for a certain level on that learning style dimension scale. In next part, we will continue to discuss the implementation of the learning styles theory in Web-based Educational Systems.

3.4 Implementation of Learning Styles Theory in Web-based Educational Systems

In order to facilitate the implementation of the Felder-Silverman learning style theory, some requirements are identified from the view of pedagogical strategies. For all the 8 categories on 4 dimensions, the requirements are as follows:

(1) Requirements for Active/Reflective Dimension

Requirements for Active:

- ✧ Study in groups
- ✧ Discussing
- ✧ Explaining
- ✧ Guessing possible questions and answering them with other students
- ✧ Finding ways to do something with learning concepts
- ✧ Brainstorming

- ✧ Experimentation

Requirements for Reflective:

- ✧ Thinking about quietly before going ahead
- ✧ Stopping periodically to review what has been learnt
- ✧ Stopping periodically to think possible questions
- ✧ Stopping periodically to think possible applications
- ✧ Writing short summaries
- ✧ Watching and listening

(2) Requirements for Sensing/Intuitive Dimension

Requirements for sensing:

- ✧ Facts, concrete content, data
- ✧ Hands-on work
- ✧ Practical material
- ✧ Giving examples, followed by the expositions
- ✧ Applying theory in practice
- ✧ Relating information to the real work
- ✧ Solving problems by standard methods

Requirements for intuitive:

- ✧ Abstract, conceptual, theoretical content
- ✧ Abstraction and mathematical formulations
- ✧ Discovering possibilities
- ✧ Innovation
- ✧ Asking interpretations or theories that link the facts
- ✧ Exposition before examples
- ✧ Solving problems by new methods

(3) Requirements for Visual/Verbal Dimension

Requirements for visual:

- ✧ Pictures

- ✧ Graphs
- ✧ Diagrams
- ✧ Flow charts
- ✧ Time line
- ✧ Video
- ✧ Demonstration
- ✧ Concepts map
- ✧ Color notes with highlighters
- ✧ Slides with multimedia

Requirements for verbal

- ✧ Text: written words
- ✧ Spoken words: audio or sound files
- ✧ Visual representation of verbal information (handouts, slides, blackboard)
- ✧ Hypertext
- ✧ Summaries or outline course material
- ✧ Discussing: working in group (hearing and explaining)
- ✧ Lecturing

(4) Requirements for Sequential/Global Dimension

Requirements for sequential:

- ✧ Step by step logically presenting material
- ✧ Fixed order
- ✧ Outlining the material in logical order
- ✧ Slides
- ✧ Hypertext
- ✧ Audio and/or video depending on the content
- ✧ Traditional education approaches

Requirements for global:

- ✧ Large (overall) picture before mastering details

- ✧ Large jump
- ✧ Holistic
- ✧ Context and relevance of the subject
- ✧ Skimming through the entire sections to get an overview before going further
- ✧ Relating the subject to things learnt
- ✧ Exposing periodically to advanced concepts before these concepts would normally be introduced
- ✧ Order is not important
- ✧ Lesson objectives
- ✧ Hypertext
- ✧ Audio and/or video depending on the content

With the guide of these requirements, we can find out links from the learning style dimensions to some educational contents presentation methods, e.g. pictures for visual and text for verbal on the visual/verbal dimension. Then a set of content presentation preferences can be identified for each learning style dimension. The following list shows some typical content presentation preferences for all learning style categories:

(1) Active: study in groups to discuss, learn by trying things out

- Providing discussion area
- Providing practice exercises after a section

(2) Reflective: think about quietly before going ahead; write summaries for what have been taught

- Think before going ahead
- Writing summaries

(3) Sensing: facts, example followed by the exposition, hand-on work, practical material, standard solutions

- Example first, followed by the exposition
- Providing standard solutions

(4) **Intuitive:** abstract, concept, theory, new solutions

- Only principles and theories are presented
- Providing new solutions

(5) **Visual:** picture, graphs, diagram, flow chart, schematics, demonstration, concepts map, color notes, slides with multimedia

- More picture, graphs, diagram
- Animation and video demonstration

(6) **Verbal:** text, and audio

- text
- audio

(7) **Sequential:** Step by step logically presenting material, concentrating on the current learning subject

- Step by step presenting material
- Presenting the contents only within current topic area

(8) **Global:** Jump to anywhere in the course, learn in large leaps, holistic thinking process

- Showing a dropdown list for jumping to anywhere in the course
- Providing other related contents outside the current topic area

Certainly, this list has not included all the content presentation preferences for each learning style category. However, by testing these typical preferences in different environments, such as in PC and mobile phone, we can easily find out the changes of the learning style preference level on each dimension. By knowing students' learning style preferences, e.g. visual or verbal, we are not able to predict their answers to each question in the Index of Learning Styles (ILS). Therefore we are not able to predict their preferences for particular contents presentation. However, we can determine a student's learning style preferences by knowing his/her preferences for each type of

contents presentations. Since this thesis is an initial work towards the possible changes in student profile, we construct a list of eight questions that are more closely related with the typical content presentation preferences mentioned above by referring to the Index of Learning Styles (ILS). We name the results of eight questions as learning preferences in order to distinguish them from learning style preferences. Then, based on students' answers to these eight questions, we can understand their learning style preferences levels on the four dimensions. If the students give different answers to the same question, we can then determine that there are changes in their learning style preferences levels.

The eight questions are divided into four dimensions with two for each dimension. Further, because the number of questions for each dimension has been changed from 11 to 2, we adopt an approach that maps the 11 grade scale proposed by Felder-Silverman into a three level scale. Then, a combination of up to 12 possible learning styles can be formed (four dimensions with three possibilities each), which can be concluded in a figure (Figure 3-1) developed by (Paredes & Roderiguez, 2004). The student's learning style preferences can be either strong (dark in Figure 3-1) or well balanced (light grey in Figure 3-1) on each dimension.

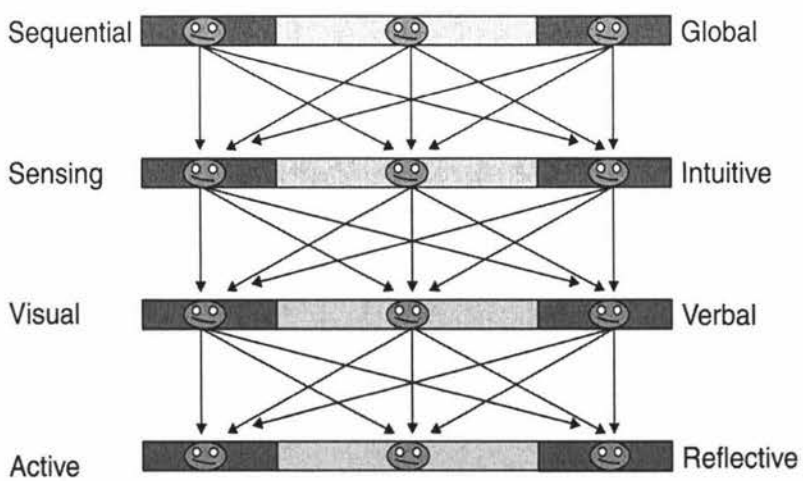


Figure 3-1: Possible learning styles (Paredes & Roderiguez, 2004)

On each dimension, we still count the "a" responses for the two questions and obtain

a score ranging from 0 to 2. Let us take the active-reflective dimension as an example again. The results can be explained as:

- ✧ **0 "a" response:** strong preference for reflective learning;
- ✧ **1 "a" response:** well balanced between active and reflective learning
- ✧ **2 "a" responses:** strong preference for active learning

By counting the number of "a" responses for each question, we can decide a student's level on certain learning style dimensions. However, the indicated level on dimensions should not be used to predict the responses for each question. The responses to the questions may be different under certain situations, i.e. students tend to behave differently from what their learning style profiles indicate under certain situations (Felder & Spurlin, 2005). In this thesis, we will try to discover how the mobile environment will influence student's responses for the eight questions retrieved from ILS questionnaire. After that, we expect to establish a framework that could relate changes in student learning style preferences with mobile environment attributes, such as device capabilities and locations.

3.5 Summary

A literature review has been conducted on learning styles theories in this chapter. The Felder-Silverman Learning Styles theory is chosen to be the guideline for our research on student profile transformation because its Index of Learning Style (ILS) questionnaire can be conveniently linked to adaptive learning systems. Based on the ILS, we construct eight learning preference questions that are more closely related with the typical content presentation preferences. By counting the student's responses towards these eight questions, we can understand the student's learning style preferences levels on four learning style dimensions. Thus, the student's possible changes of learning style preference level can also be observed for student profile transformation.

Chapter 4 : First Survey on Student Profile Transformation

4.1 Introduction

In order to investigate the influence of mobile environment on the student learning style preferences, a survey was carried out simultaneously in New Zealand and Taiwan. A total of 210 students (30 students in New Zealand and 180 students in Taiwan) completed a "Survey Questionnaire for Student Profile", which included 9 questions. Since many students were more comfortable with Chinese language, the questionnaire was prepared in both English and Chinese version. The questionnaire is enclosed in Appendix A.

The students' learning style preferences were tested by the eight questions we mentioned in section 3.4, which were named as learning preferences. The student's preferences for some common learning activities and multimedia elements on PC and on mobile phone were also investigated in the survey.

In this chapter, we will analyze the survey results and try to find out the answers to the following questions:

- ✧ What kind of experience students have with current web-based educational systems?
- ✧ What kind of concerns students have when using web-based educational systems on PC and on mobile phone?
- ✧ What are the possible locations for the mobile learning?

- ✧ Will the students have different preferences, including learning activities, multimedia and learning preferences, on PC and on mobile phone?

4.2 Analysis of the First Survey

Now, let us start with discussion on the survey results. The responses to all the nine questions for the first survey will be analyzed in the order as they appear in the survey questionnaire.

4.2.1 Analysis of Question 1

Are you currently enrolled in any courses in any institute/university?
___ YES ___ NO
If YES, what are you studying? (Qualification and subject) _____.
If NO, what is your highest qualification? _____.

The first question reflected the constitution of the participants. Most of the participants were current university students, either undergraduate or postgraduate. For those who were not students, they all had learning experience in tertiary institutions, i.e. they were at least undergraduate qualification holders. Among all the participants, 75% (158 participants) were at postgraduate level and the rest 25% (52 participants) were at undergraduate level. Their majors were versatile, including information sciences, business studies, accounting, art design, medical administration, foreign language studies and so on. The participants were all experienced students from various subjects. However, they were not necessarily full time students at the time of the survey. Some of them were working and some were taking part time courses. It was their relatively more learning experience that was valuable for this survey, because their responses to the survey would probably represent most students that the web-based educational systems are supposed to reach. The results are

described in Table 4-1.

Are you currently enrolled in any courses in any institute/university?	**YES**	**NO**	**Missing**
Number of answers	159	47	4
Percentage of total responses (including missing answers)	75.71%	22.38%	1.91%

Table 4-1: The constitution of the participants

4.2.2 Analysis of Question 2

Have you used any web-based educational applications, e.g. WebCT online courses?

___ YES ___ NO

If YES, please provide the names of those applications _____.

This question was designed to show the e-learning experience of all the participants. The survey result showed that only 61 out of the 210 participants (29.05%) had used web-based educational applications. Some participants even did not know what the web-based educational application was. In addition, among those who had used such application, there were still some people who mentioned that they only used the applications for limited time. Table 4-2 shows the details of the results.

Have you used any web-based educational applications, e.g. WebCT online courses?	**YES**	**NO**	**Missing**
Number of answers	61	145	4
Percentage of total responses (including missing answers)	29.05%	69.05%	1.90%

Table 4-2: Participants' e-learning experience

The reasons for the participants not to use web-based educational applications were not included in the survey questionnaire. However, some participants mentioned their reasons while filling in the questionnaires. Some of them said they did not know where to get the educational applications. They even did not know that there were educational applications on the web. Some said that the educational applications were hard to use and they would not waste time using them. Most people tended to care very much about the cost of using educational applications on the web. They said that they would try these applications if there were no costs involved. Otherwise, they would not bother to use them unless it was compulsory to do so.

However, there were still some nice examples used by participants in our survey. The educational applications such as WebCT, JoinNet, and NSYSU Cyber University, were among the popular ones (Figure 4-1). Out of the total 61 participants who had used web-based educational applications, 17 people (27.87%) had used WebCT, 13 people (21.31%) had used JoinNet, 10 people had used Cyber Unversity (16.39%) and the rest 21 people (34.43%) had used a variety of other educational applications. WebCT, JoinNet and Cyber University were mainly introduced to the participants by their universities as auxiliary methods, and the participants used these systems quite often in their universities. Therefore, the universities or education providers seem to play a very important role in encouraging the students to use web-based educational

applications. The students go to universities for receiving traditional forms of education. After their universities introduce suitable web-based educational applications to them, they are able to participate in learning activities from anywhere they have access to computers and internet connections. For example, they can view web-based lectures if available, they can discuss learning problems with others in web discussion forums, and they can also control their own style of learning. The web-based educational applications bring them many conveniences and benefits that traditional education lacks.

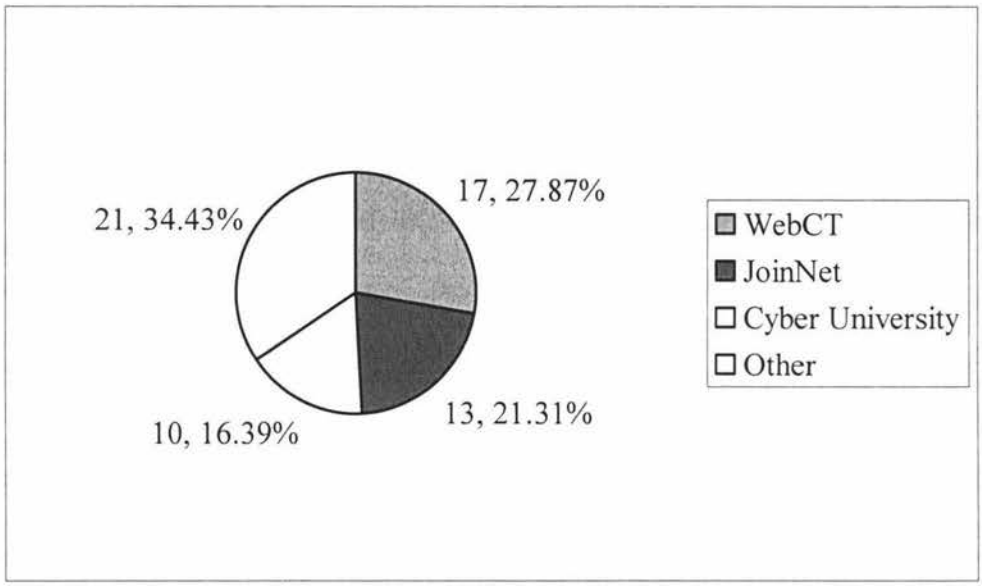


Figure 4-1: Some popular web-based educational applications & their users

So far, we have concluded from the survey results that educational providers are significant agents for web-based educational applications to reach their users. Then let us try to consider the users' perspective. What do the users expect from the web-based educational applications? What are their major concerns? It is certain that the answers are also different from person to person. The survey results for the next two questions will give us some ideas about the above two questions.

4.2.3 Analysis of Question 3

Suppose that you are using web-based educational applications via *Desktop PC*, which of the following factors you will be most concerned about? (Please choose one).

___ A. Educational Contents **___ B. Multimedia Effects**
___ C. Running Speed **___ D. Overall Costs**

This survey question sets the device environment to be desktop PC. It was assumed that under most circumstances, the web-based educational applications could be accessed via wired Internet connection. From the survey results, we saw that a lot of participants (129 out of 210, around 61.43%) cared about what kind of educational contents they would get. The second major concern was the running speed of the web-based educational applications. A total of 53 participants felt that the running speed was the most important thing when using web-based educational applications. The multimedia effects and overall costs seemed to attract much less attention than the previous mentioned two aspects, which were considered to be important by only 14 and 12 participants respectively. The details of the results are shown in Table 4-3.

Suppose that you are using web-based educational applications via *Desktop PC*, which of the following factors you will be most concerned about?	Number of answers	Percentage (%) of total responses including missing answers	Answers from those who have prior e-learning experience	Percentage (%) of answers from those who have prior e-learning experience
Educational Contents	129	61.43%	36	59.02%
Multimedia Effects	14	6.67%	3	4.92%
Running Speed	53	25.24%	18	29.51%
Overall Costs	12	5.71%	4	6.56%
Missing	2	0.95%	0	0

Table 4-3: The users' most concerned factor when using web-based educational application via desktop PC

The results at least show that the majority of the participants will concentrate on the educational contents itself rather than something else, such as multimedia effects, on PC. Furthermore, the results also indicate that the percentage of answers from those who have prior e-learning experience does not deviate too much from the percentage of total responses. However, this result does not mean that the applications should contain only plain text contents, but means that the contents should be closely related with the educational subject, or the contents should better serve the educational purposes. Irrelevant contents are unnecessary and may also make users upset with longer loading time, because running speed is still believed to be the first important thing by more than a quarter (25.24%) of all the participants. We can also know from the survey results that the overall costs of using PC to access web-based educational applications seem to be affordable to most of the participants, because only 5.71% of the participants are most concerned about the overall costs.

4.2.4 Analysis of Question 4

Suppose that you are using web-based educational applications via *Mobile Phone*, which of the following factors you will be most concerned about? (Please choose one).

___ A. Educational Contents **___ B. Multimedia Effects**
___ C. Running Speed **___ D. Overall Costs**

This question also focuses on users' most concerned factors when using web-based educational applications. The device environment has been changed from desktop PC to mobile phone. With such an environment change, it is now assumed that users can access web-based educational applications via mobile phones with wireless Internet capability. The location of using such educational applications will no longer be confined to certain fixed places. The students can now use the educational applications when moving from place to place.

The result for this question reflects the real life situations. Most participants (122 out of 210, around 58.10%) selected overall cost to be their most concerned factors, while at this time, only 28 participants insisted on selecting educational contents to be the most concerned factor. The number of the users that were most concerned about multimedia effects or running speed did not change too much, which was 46 and 10 respectively. Here again, the results also indicate that the percentage of answers from those who have prior e-learning experience does not deviate too much from the percentage of total responses. The details can be found in Table 4-4.

Suppose that you are using web-based educational applications via *Mobile Phone*, which of the following factors you will be most concerned about? (Please choose one).	**Number of answers**	**Percentage (%) of total responses including missing answers**	**Answers from those who have prior e-learning experience**	**Percentage (%) of answers from those who have prior e-learning experience**
Educational Contents	28	13.33%	7	11.48%
Multimedia Effects	10	4.76%	4	6.56%
Running Speed	46	21.90%	16	26.23%
Overall Costs	122	58.10%	34	55.74%
Missing	4	1.90%	0	0

Table 4-4: The users' most concerned factor when using web-based educational application via mobile phone

In order to get a better understanding of the changes in the results from last two questions, the results should not be analysed alone, but be compared with each other. The comparison bar chart between the results from the last two questions is presented in Figure 4-2.

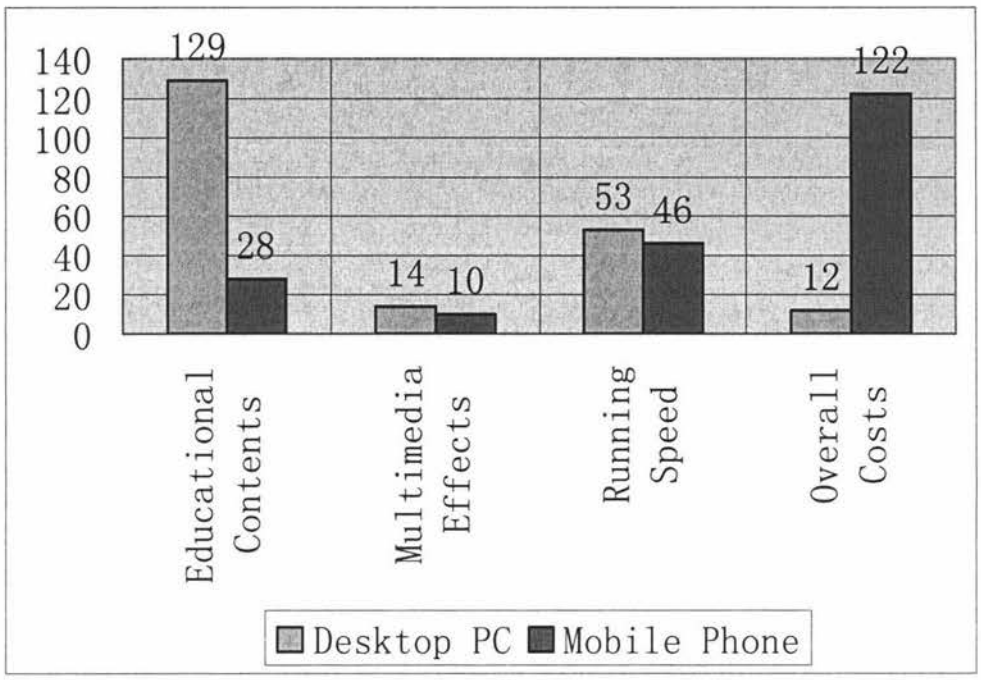


Figure 4-2: Comparison between results from survey question 3 and question 4

Compared with desktop PC, the cost of using mobile phone and wireless Internet seems to be too high for the users of web-based educational applications. For the great shift of participants' main concern from educational contents to overall costs in the survey results, there seem to be at least three possible reasons. First of all, the most obvious reason is that the usage fees for mobile Internet are still high, although the price of mobile phones has been cut down a lot in recent years. During the survey, we found that most participants have already established a link between mobile phones and high cost in their minds over a long period of time. Their first response to mobile educational applications was that it must be very expensive to use. Secondly, the users already have an alternative cheaper and more effective way to use web-based educational applications, i.e. desktop PC with wired Internet connection. The Internet is so popular today that almost every desktop PC is Internet enabled. It is very easy to get a PC to access the Internet today in many places with relatively more affordable costs and faster connection rate. The third reason is that there are few wireless Internet applications at the current stage, which directly results in a smaller number of wireless Internet users. If the users can get a lot of useful applications via

mobile phones and wireless Internet, for example, mobile chat room and mobile video streaming, I believe they will be more willing to pay the usage cost even if it is higher than the PC with wired Internet.

From the comparison, we can not say that the users of mobile educational applications do not care about the educational contents at all. They are students, although they may be more casual students. The fact that most of them are concerned about the overall costs of using mobile Internet shows that they will not use web-based educational applications via mobile phone as their first choice. Most of their educational activities are preferred to be carried out via desktop PC. They will use mobile phone as a backup and alternative method for the desktop PC. The next survey question attempts to discover students' favourite devices for each educational activity during an online course. The links between students' device preferences and each particular activity are discussed in more details.

4.2.5 Analysis of Question 5

Suppose that you are going to take an online course and you have *Desktop PC*, *PDA* and *Mobile Phone* to access this online course. For various learning activities during the online course, please use an "X" to choose your most preferred device for each of those activities.

Learning Activities	Desktop PC	PDA	Mobile Phone
Preview the course			
Learn new knowledge			
Check notices about the course			
Discuss problems with others			
Review the course			
Do assignments			

An online course usually involves a series of learning activities. During such an online course, will the students have different device preferences for each of the

learning activities? The results from the survey provide the answers to this question (Table 4-5 and Figure 4-3).

Learning Activities	Desktop PC		PDA		Mobile Phone		Missing	
	Number of answers	% of total answers	Number of answers	% of total answers	Number of answers	% of total answers	Number of answers	% of total answers
Preview the course	169	80.48%	34	16.19%	5	2.38%	2	1.00%
Learn new knowledge	174	82.86%	29	13.81%	5	2.38%	2	1.00%
Check notices about the course	80	38.10%	43	20.48%	85	40.48%	2	1.00%
Discuss problems with others	162	77.14%	17	8.10%	28	13.33%	3	1.00%
Review the course	176	83.81%	30	14.29%	2	0.95%	2	1.00%
Do assignments	200	95.24%	5	2.38%	2	0.95%	3	1.00%

Table 4-5: Device preferences for each of the learning activities

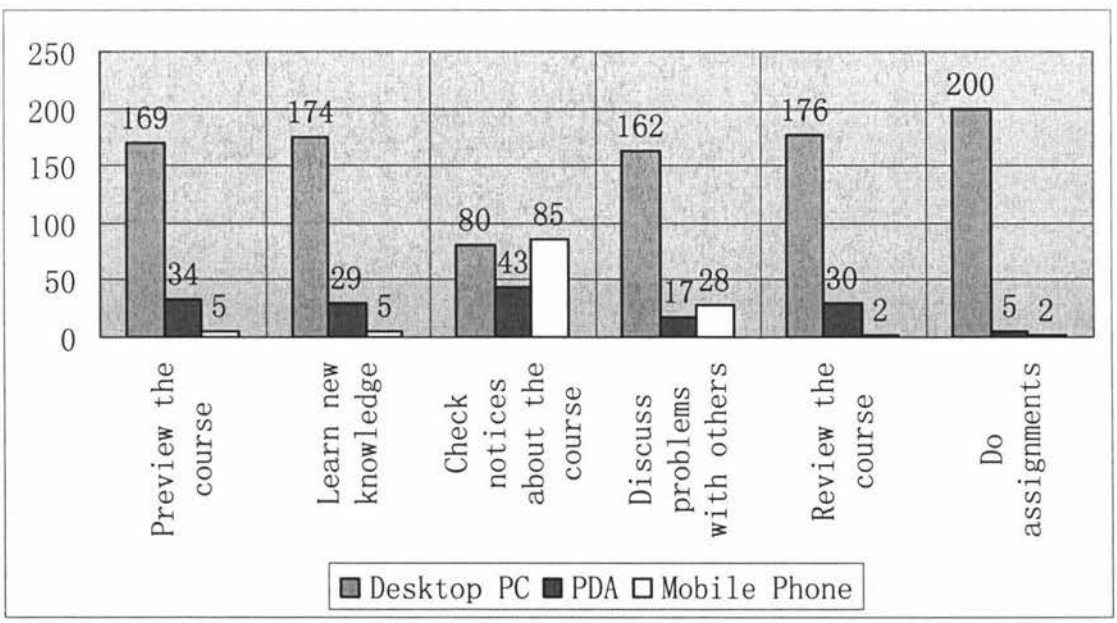


Figure 4-3: Comparison of preferred device for each of the learning activities

The answer is quite clear from the results of the survey. The majority of participants,

more than 75%, prefer to use desktop PC for each of the learning activities except "Check notices about the course". Especially for the activity "Do assignments", 95.24% of the participants prefer to use PC. As a widely accepted device for web-based education, desktop PC has such advantages as lower costs, faster running speed, larger screen, easier input, higher connection rate and so on. Therefore, we can say that desktop PC is still the most preferred device by most people for web-based education. The other two devices, PDA and mobile phone, are relatively new to web-based education. Though they are not as widely accepted as desktop PC, they still show some good potential in some aspects of web-based education.

Let us take a look at mobile phone first. There are 85 participants who prefer to use mobile phone to "Check notices about the course", which is just a little more than the 80 participants who prefer to use desktop PC for the same activity. This result indicates the advantage of mobile phone, i.e. convenience for instant information update. The notices about the courses are the things that need timely attention and quick response. A mobile phone is believed by many participants to be a better device for such learning activities. Though the costs of using mobile phone to check notices are more than PC, these participants' needs for instant information update are so urgent that they would rather use more convenient and handy devices at higher costs, such as mobile phone. When the emergency of instant information update needs cannot be well satisfied by PC, the value of mobile phone will then be realized by these participants. This should be the reason why there are 85 participants, which is 40.48% of all participants who prefer to use mobile phone to "Check notices about the course". Another learning activity that needs timely attention and quick response is "Discuss problem with others". There are 28 participants (13.33%) who prefer to use mobile phone for discussion. This is not so many as the number of participants who want to use mobile phone to check notices. The reasons include: (a) mobile phone's input method is awkward, and (b) the need for discussion is not urgent enough.

Besides mobile phones, there are also 43 participants (20.48%) and 17 participants (8.10%), prefer to use PDAs for "Check notices about course" and "Discuss problems with others" respectively. A PDA is very similar to a mobile phone in being capable of providing instant information updates. In addition, PDA beats mobile phones in both software and hardware performance. However there are still more people who choose mobile phone for the learning activities that require timely attention and quick response. This is very probably because more people own mobile phones rather than PDAs and thus mobile phones are more familiar to them. Some participants never heard about PDAs before. When they were told the full name of PDA (Personal Digital Assistant), they still could not figure out what it was. So when those people are asked to choose a handy device, their first option is very likely to be mobile phone.

Fortunately, the unpopularity of PDA does not mean that no participants will choose PDA as their favourite device for learning. We can find from the result that there are still some participants prefer to use PDA to "Preview the course" (16.19%), "Learn new knowledge" (13.81%), and "Review the course" (14.29%). These percentages are quite low compared with desktop PC, but if we consider the fact that many participants do not have PDA or have not used PDA before, it is not difficult to see that PDA has great potential for certain learning activities that involve more readings and less input.

4.2.6 Analysis of Question 6

Please rank the three most possible places from the following list, where you will use *Mobile Phone* to access web-based educational applications.

___ A. Campus
___ B. Classroom
___ C. Library
___ D. Café

___ E. Computer Lab
___ F. Bus stop
___ G. Home
___ H. Shopping Mall
___ I. On the road (in cars, buses or trains)
___ J. Other places _____ (please indicate)

This question investigates people's location preferences for using mobile phone to access web-based educational applications. Every participant was asked to choose three locations that they feel comfortable to use mobile phone, and rank these locations by preference order. I decided to analyze the survey results by counting the votes that each location receives. Then under this rule, every participant could vote for three locations that he or she was likely to use web-based educational applications via mobile phone. So there were a total of 630 votes (210 * 3). The results are summarised in Table 4-6.

Please rank the three most possible places from the following list, where you will use *Mobile Phone* to access web-based educational applications.	**Number of votes**	**Percentage (%) of total votes including missing answers**
Campus	78	12.38%
Classroom	32	5.08%
Library	53	8.41%
Café	93	14.76%
Computer lab	24	3.81%
Bus stop	88	13.97%
Home	49	7.78%
Shopping mall	47	7.46%
On the road (in cars, buses or trains)	131	20.79%
Other places	24	3.81%
Missing	11	1.75%

Table 4-6: Votes counted for preferred locations to use web-based educational applications via mobile phone

The result shown in the Table 4-6 can be more clearly presented by a comparison bar chart in Figure 4-4.

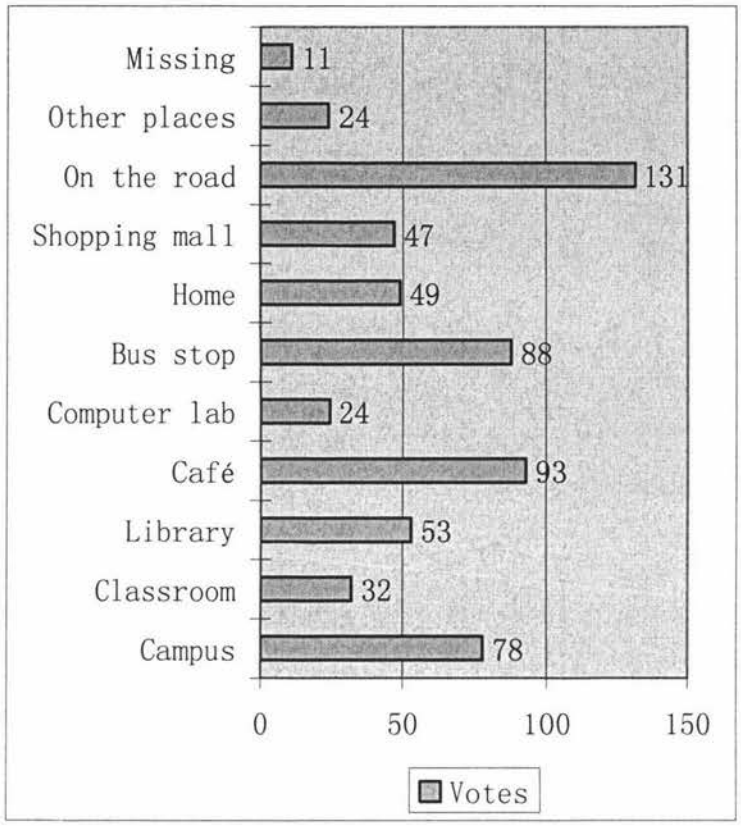


Figure 4-4: Comparison between votes that each location receives

The results shown in Figure 4-4 tell us that the most favourite location is "On the road", which receives 131 votes. Other locations that receive relatively more votes are Café (93 votes), Bus stop (88 votes) and campus (78 votes). These locations form the first group of all the location candidates. It is not incidental for these locations to be suitable for learning via mobile phones. These locations have something in common that can stimulate people's mobile learning needs. Let us try to discover these factors. First of all, we can see that people are waiting for something to happen in those locations. They are waiting for the buses to come, for the transport to reach the destination, for their courses to begin, and for the snack or lunch to finish. Secondly, since the things they are waiting for are still minutes or hours away, they should have some time, if not plenty of time, to do something else. They may take a break, or a rest. Of course, they can just do nothing other than waiting, but isn't it a better idea to do something else to make the waiting less boring? People with good learning habits will not waste time being idle. Instead, they will make use of every single minute to

learn, in various ways. Thirdly, in those locations, there is no better way to carry out learning activities. It is obvious that a desktop PC with Internet connection to access the web-based educational applications is not always conveniently available in such locations. Furthermore, the traditional way of learning, holding a book to read, also seems little cumbersome if we can read the electronic versions of these books on a device that we carry anyway. Compared to books, mobile phones are much easier to hold, to carry and to search. That is where the handy and popular mobile phones can be at the students' services.

The second group of locations include Library (53 votes), Home (49 votes) and Shopping mall (47 votes). People may vote for these locations for the same reasons as for the first group locations. The reasons why these locations receive relatively less votes are probably that people usually have particular scheduled things to do, or they can get easy access to desktop PC in such locations. For example, people usually go to library for the convenience of getting reference books for studying. Only when under certain circumstances that they have to access web-based educational applications and at the same time a desktop PC is not conveniently available to them, they will seek for the help from mobile phones.

The last group of locations gets a small proportion of votes, which includes Classroom (32 votes), Computer lab (24 votes) and Other places (24 votes). Classroom is a place where usually lectures are given. People are expected to listen to the lectures carefully and not to do anything else. Only under very special conditions should people learn via their mobile phones, for example someone is late for the lecture and wants to check out the chapters already completed. Computer lab is another place where mobile Internet will be used under special conditions, because there are normally plenty of PCs with Internet connections for people to use. People will turn to mobile phone for help when the PCs cannot realize certain functionalities or when the PCs are not enough for every one. The answers for other places are really imaginative. The participants will use web-based educational applications via mobile

phones in office (the part-time students), on the beach, in the park, and so on. It is clear that not many people will do this in these places, but it just shows the possibility and potential of applying mobile education these places.

4.2.7 Analysis of Question 7

The following is a list of statements about your Multimedia Preferences on *Desktop PC* and *Mobile Phone*. Please use an "X" to choose the proper devices for each statement (for each statement, you can choose one or both devices).

Multimedia Preferences	Desktop PC	Mobile Phone
I would prefer to watch quality VIDEOS if available on		
I would prefer to hear quality SOUNDS if available on		
I would prefer to watch quality ANIMATIONS if available on		
I would prefer to see quality IMAGES if available on		
I would prefer to read detailed TEXTS if available on		

This question tries to find out the difference in people's multimedia preference on desktop PC and mobile phone. By asking the participants to indicate their preference for five common multimedia elements, which are video, sound, animation, image and text, we assume that each participant may have a unique preference for those multimedia elements depending on his learning styles and device capabilities. The details of the replies to this question can be found in Table 4-7.

Multimedia Preferences	Desktop PC		Mobile Phone		Both PC and Mobile Phone		Missing	
	Number of answers	% of total answers	Number of answers	% of total answers	Number of answers	% of total answers	Number of answers	% of total answers
Quality Videos	184	87.62%	2	0.95%	22	10.48%	2	0.95%
Quality Sounds	144	68.57%	27	12.86%	37	17.62%	2	0.95%
Quality Animations	179	85.24%	6	2.86%	23	10.95%	2	0.95%
Quality Images	166	79.05%	14	6.67%	28	13.33%	2	0.95%
Detailed Texts	170	80.95%	14	6.67%	24	11.43%	2	0.95%

Table 4-7: Multimedia preferences on desktop PC and mobile phone

The comparison bar chart in Figure 4-5 shows more clearly the difference in multimedia preferences on PC and mobile phone.

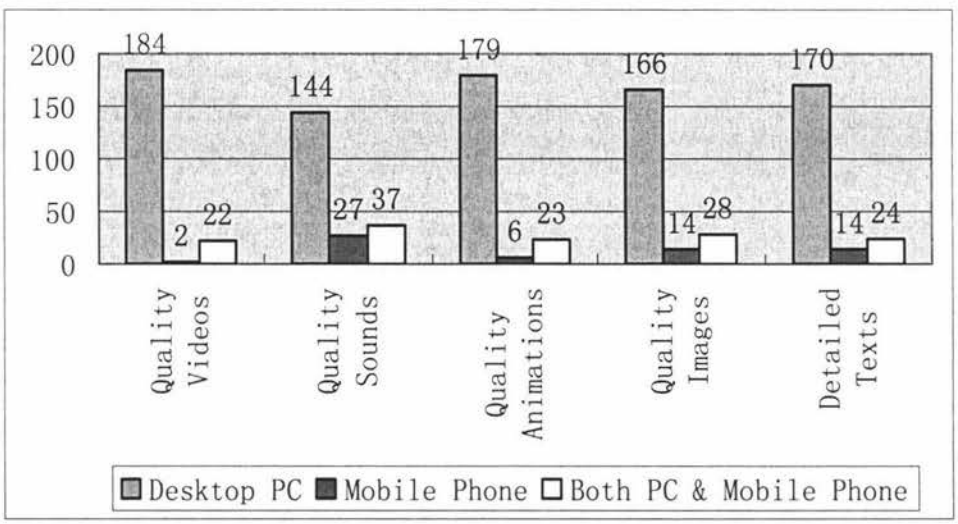


Figure 4-5: Comparison bar chart of multimedia preferences on desktop PC and mobile phone

Here, the desktop PC seems to prevail again. For each of the five multimedia elements, there are always more than two thirds of the participants who prefer quality media element on desktop PC only. For quality videos and animations, this percentage even reaches 87.62% and 85.24% respectively. Among those 61 participants who have prior e-learning experience, the percentages of participants

who prefer quality media element on desktop PC only are 91.80% (56), 73.77% (45), 83.61% (51), 78.69% (48), and 75.41% (46) for the five multimedia elements. Through the survey, we can propose some possible reasons for such responses. Firstly, it may result from the hardware and software advantages of desktop PC, it is quite reasonable for most participants to prefer quality multimedia effects on desktop PC. Secondly, it may result from the higher costs of using mobile phone, which is the first concern for most participants. Finally, the possible reason is that the quality of multimedia effects on mobile phones is very easily affected by environment factors, such as strong light, noises, bumpy journey and so on. The participants who prefer quality multimedia effects on mobile phone only may have quite diversified reasons. One of the possible reasons is that they have more time with their mobile phone than with their PC, or they even may own mobile phones only. Therefore, they can spend relatively more time on appreciating quality multimedia effects on mobile phone rather than on PC.

More than 10% participants choose to prefer quality multimedia effects on both desktop PC and mobile phone. It is obvious that those people care about the multimedia effects very much. Their preference for multimedia elements is less affected by other factors such as device, cost and environments. To them, the mobile phone is no longer just a communication tool, but a device that integrates the functionalities of both PC and phone. With the mobile phone integrating more and more functionalities from desktop PC, it will gradually become more and more compatible with PC, and finally, all applications that can run on PC will then run in the same way on mobile phone, including all the multimedia elements. Though the mobile phone will become much more powerful, its cost is expected to be continuously reduced to an affordable level, which is also different for different people. The costs of having quality multimedia effects on mobile phone have already reached at an acceptable level for those who prefer quality multimedia on both PC and mobile phone. Furthermore, the effects of environment on multimedia on mobile phones could be minimised by technology development. Some latest mobile phone

models have already improved the multimedia performances so that mobile phone users will be more comfortable to enjoy quality multimedia effects. In addition, the way these environment factors influence people's multimedia preferences is not the same for everyone too. That is why some of the participants here still prefer quality multimedia effects in such environments where others do not.

Another thing that needs to be mentioned is that quality sound has become the most preferred multimedia elements on mobile phones. A total of 64 participants (30.48%) preferred quality sound either on mobile phone only or on both PC and mobile phone. In this survey question, sound is the only multimedia element that is not perceived by eyes. Moreover, sound is a very important component for video and animation. Therefore, from the survey result of multimedia preferences, I suggest that the sound should be given more attention in the design of mobile educational applications.

4.2.8 Analysis of Question 8 & Question 9

The following is a list of eight pairs of statements about Learning Styles. Suppose that you are taking online courses via *Desktop PC* (In question 9 just suppose that you are taking online courses via *Mobile Phone*). Please choose one statement from each pair that is better suitable for you (please put an "X" in front of your selected statement).

No.	Learning Style Questions on Mobile Phone	
1	___ ***I prefer the course contents to be mostly concrete information*** *(e.g. facts, data and experimentation).*	___ ***I prefer the course contents to be mostly abstract concepts*** *(e.g. principles, theories and mathematical models).*
2	___ ***When I study, I prefer to master the standard solutions for problems*** *(e.g. master only the standard answer to a mathematical problem).*	___ ***When I study, I prefer to find out new solutions for problems*** *(e.g. want to find out other answers to a mathematical problem besides the standard answer).*
3	___ ***It is easier to understand the course contents that are explained visually*** *(e.g. by pictures, charts and diagrams).*	___ ***It is easier to understand the course contents that are explained verbally*** *(e.g. by lecturers' written and spoken*

		instructions and explanations).
4	___ ***I like to read books that have many pictures*** *(e.g. comic books).*	___ ***I like to read books that contain mostly texts*** *(e.g. novels).*
5	___ ***I can understand something better after I try it out*** *(e.g. some practices with database software will help you understand database theories better).*	___ ***I can understand something better after I think it through*** *(e.g. to think about all the procedures of manipulating database software will help you understand database theories better).*
6	___ ***I like to study in study groups.*** *(e. g. contribute your ideas in group discussions).*	___ ***I like to study alone*** *(e. g. sit back and listen to the discussion only).*
7	___ ***I like to learn course contents step by step*** *(e. g. study from easy level to difficult level in sequential order).*	___ ***I like to jump to advanced topics when learning*** *(e. g. proceed to study more difficult levels before completing all the easier levels).*
8	___ ***When learning a new subject, I stay focused on that subject and learn as much about it as I can*** *(e. g. when you study how to put texts on your web page, you will not go to find out how to put images on the web page).*	___ ***When learning a new subject, I try to connect that subject with related subjects*** *(e. g. when you study how to put texts on your web page, you will also go to find out how to put images, tables, buttons and other elements on the web page).*

Towards the end of the survey, we wanted to investigate people's learning style preference differences between desktop PC and mobile phone. The question 8 and question 9 are almost same except that the learning device is desktop PC in question 8 and mobile phone in question 9. In both survey questions, we can find eight pairs of statements. The participants were asked to choose one statement from each pair, which was then used to decide their learning style preferences. Their choice for each statement pair are called learning preference in this thesis. For each pair of statement, every participant actually chose twice, one for desktop PC and the other for mobile phone. The two choices may be identical, or may be different. We collected both of the choices, for desktop PCs and mobile phones respectively, and then compared the two choices for each statement pair to see whether they were identical or different. After that, we could decide how people's learning style preferences would be influenced when their learning device changed from desktop PC to mobile phone. The results for these two questions are hence arranged for each pair of statement. In order

to make it clearer to analyse, the left hand side statement in each pair is called S_{i1}, where i stands for the serial number of the statement pair (i=1 to 8). Accordingly, the right hand side statement is called S_{i2}. Well, let us first take a look at the survey results for question 8 and question 9, which have combined into a single table (Table 4-8).

Statement Pairs	Learning Devices	Number of participants that choose S_{i1}	Number of participants that choose S_{i2}	Missing answers
Statement Pair 1 (S_{11} & S_{12})	Desktop PC	174	34	2
	Mobile Phone	161	43	6
Statement Pair 2 (S_{21} & S_{22})	Desktop PC	91	115	4
	Mobile Phone	127	75	8
Statement Pair 3 (S_{31} & S_{32})	Desktop PC	137	71	2
	Mobile Phone	116	86	8
Statement Pair 4 (S_{41} & S_{42})	Desktop PC	147	61	2
	Mobile Phone	127	74	9
Statement Pair 5 (S_{51} & S_{52})	Desktop PC	157	51	2
	Mobile Phone	130	71	9
Statement Pair 6 (S_{61} & S_{62})	Desktop PC	143	65	2
	Mobile Phone	124	78	8
Statement Pair 7 (S_{71} & S_{72})	Desktop PC	180	24	6
	Mobile Phone	173	28	9
Statement Pair 8 (S_{81} & S_{82})	Desktop PC	72	135	3
	Mobile Phone	95	107	8

Table 4-8: Survey results for question 8 and question 9

The results in Table 4-8 only show us the number of responses for each statement pair on both desktop PC and mobile phone. Notably is the result for Statement Pair 2. We can find that fewer participants choose statement 1 (91) than statement 2 (115) on PCs, while more participants choose statement 1 (127) than statement 2 (75) on mobile phones. The reason for this difference is very likely to be the cost of using mobile phones, because to find out new solutions will take more time and consequently more costs on mobile phones. Therefore some participants who prefer to find out new solutions on PCs choose to only master the standard solutions on mobile phones. The results cannot help us to know how students' learning styles will change in

accordance with the switching of devices between desktop PC and mobile phone. Therefore, let us look at the results by another approach. We group all the participants into two groups based on their responses to the same statement pair in both question 8 and question 9. For those that choose the same statement for both of the questions, we can put them into a group called "Unchanged Learning Style Preferences". For the rest of the participants who chose different statements for the two questions, we can put them into the other group called "Changed Learning Style Preferences". Then the results look like in Table 4-9.

Statement Pairs	**Participants choosing the SAME statement for both PC and Mobile Phone including missing answers**		**Participants choosing DIFFERENT statements for PC and Mobile Phone including missing answers**		**Missing answers**
Statement Pair 1 (S_{11} & S_{12})	168	80.00%	36	17.14%	6
Statement Pair 2 (S_{21} & S_{22})	151	71.90%	49	23.33%	10
Statement Pair 3 (S_{31} & S_{32})	151	71.90%	51	24.29%	8
Statement Pair 4 (S_{41} & S_{42})	153	72.86%	48	22.86%	9
Statement Pair 5 (S_{51} & S_{52})	159	75.71%	42	20.00%	9
Statement Pair 6 (S_{61} & S_{62})	168	80.00%	34	16.19%	8
Statement Pair 7 (S_{71} & S_{72})	175	83.33%	22	10.48%	13
Statement Pair 8 (S_{81} & S_{82})	166	79.05%	35	16.67%	9

Table 4-9: Comparison between the choices for question 8 and question 9

Table 4-9 shows that the majority of participants, from 71.90% to 83.33% of all participants, chose the same statement from each statement pair regardless of whether the learning device will be PC or mobile phone. For these people, their learning style preferences will not change along with the change of devices. Therefore, the presentation of educational contents that those students are expecting should be same on PC and mobile phone. On the other hand, there are also 10.48% to 24.29% of participants who chose different statements for different devices. Their learning styles are expected to change. Although the proportion is not very high, it still proves that learning styles will change in accordance with the change of different types of devices.

From the survey results, we can find that the changes of people's learning style preferences on various types of devices are quite different from person to person. The same student will have some of his learning style preferences changed; while, at the same time, have some of his other learning style preferences unchanged. Moreover, his or her learning style preferences may be further changed under some other external influences, such as environmental factors. Here, it is only safe to say that each student's learning style preferences are different from each other. So how these learning style preferences will change under various conditions is diversified for every individual student. Thus instead of using a fixed model for the learning style preference transformation, it is better to use a more flexible and adaptable way for students to be able to choose their own learning style preferences in different devices. For example, when students change their learning device, their original learning style preference settings will be presented automatically as default settings when they use the new device. They can either leave the default settings unchanged or make changes to the settings manually.

4.3 Conclusion of the Survey

After we have gone through all the survey results, we now have a much clearer view about the changes of students' choices for the learning activities, locations, multimedia elements and learning style preferences within a web-based learning system. We can conclude from the survey results as follows:

- ✧ Many students are not familiar with web-based educational systems. Most of them have not used any of these types of systems. The popularity of such systems is highly dependent on educational providers' promotion;
- ✧ Many students are concerned more about the costs on mobile phone than on PC, which greatly affects students' preferences for educational contents;
- ✧ With the help of mobile phone, learning can take place in many locations outside the campus. These locations may have various environments.
- ✧ Most students' preferences for learning activities and multimedia effects are quite different on PC and on mobile phone, while most students' learning style preferences remain the same on both PC and mobile phone.

The student profile should be able to describe all of the students' preferences that will probably change in various learning environments, so that students can receive adaptive learning contents in various environments, such as in different devices or locations. The data we obtained from the survey provides very important guidelines for the design of student profile template in web-based learning systems on both PC and mobile phone. In the next chapter, we will continue to discuss what types of information the student profile should include for adaptive learning purposes in PC and mobile phone environments.

4.4 Summary

The results of the first survey questionnaire have been analyzed in this chapter. The survey analysis indicates that most students who took part in the survey do not have any web learning experience. Moreover, most of them are concerned about the mobile phone costs very much, which should be their major reason for not using mobile phones for web-based learning. However, we still received valuable feedback from this survey. The students selected many locations outside campus for mobile learning. The diversified environments in those locations need to be considered seriously when designing the web-based learning systems. Most students' learning style preferences remained unchanged between PC and mobile phone, while their learning activities preferences and multimedia preferences changed a lot. Each student's preference changes were not always the same with others'. Therefore we need a more flexible mechanism instead of a fixed one to capture and adapt to these preference changes in student profile between PC and mobile phone.

Chapter 5 : The Proposed Student Profile Template

5.1 Introduction

In the previous chapter, we analysed the results from a survey and we knew that student's learning activity preference, multimedia preference and learning preference will probably change in various devices (in this thesis, the device is either PC or mobile phone). If we want to construct a web-based learning system that is adaptive in both PC and mobile phone, we need to construct a student profile that will automatically reflect the possible students' preference differences in PC and in mobile phone learning environments. Therefore, we should first decide what kinds of information should be included in student profile for effective adaptation. In this chapter, we will discuss all categories of information that are essential to model students in various learning environments, ranging from basic personal identification to learning style preferences.

5.2 The Student Profile Template

Now, let us start to discuss necessary information in the student profile. Our proposed student profile is based on a Mobile Learning Metadata (MLM) schema (Chan, Sharples, Vavoula, & Lonsdale, 2004) that has been developed recently. The MLM schema is trying to expand the existing IEEE Learning Object Metadata (IEEE LOM) ("Draft standard for learning object metadata", 2002) and IMS Learner Information Profile standards ("IMS learner information packaging information model specification ", 2001) for educational systems to support mobile learning. The MLM schema consists of three top level categories, which are used to describe learning resource, learners themselves and context state of learning environment respectively.

The category that describes learner contains two sub-categories: one is the Learner Profile, which is about learners and their preferences; and the other is the Learner Model, which is about a learner's knowledge and their learning history (Chan et al., 2004).

Our proposed student profile template is different from the Learner Profile in MLM schema. The proposed student profile template includes all the three top level categories as in the MLM schema, which are learner, learning resource and context. These three categories are named as Student Identity, Learning Resource and Learning Context in this thesis. However, this thesis is a research on students' preference changes between PC and mobile phone. Therefore, the proposed student profile template concentrates on students' preferences. In order to highlight the preference changes in more detail and for easier future extension of the template to include more preferences, our proposed student profile puts students' preferences in separate categories instead of including all types of preferences in learner category. The information about learner's knowledge and learning history is not included in our student profile template because our research is only on students' personal features, such as preference and learning style. The other two categories, Learning Resource and Learning Context, are relatively simple compared with MLM schema. This is because our research is on students' personal features rather than the learning resource, and our research is investigating only two learning contexts, which are device and location.

From the survey results, we know that the students will probably change their learning activities preference, multimedia preference and learning preference on different devices, such as PC and mobile phone. So, in addition to the three top level categories that are adopted from MLM schema, the proposed student profile template should also include three other top level categories to describe the students' learning activities preference, multimedia preference and learning preference. In the following sections, we will introduce all these six categories in more detail.

5.2.1 Information about Student Identity

The most basic information about the students is their identification. As indicated by the meaning of the word "identification", such information is used to identify a student from the others. The information in this category should be provided by the students themselves. The personal details are one kind of identification. A student's "name", "gender" and "birthday" are all indispensable attributes for a student profile, which will enable the learning system to identify a particular student. However, "name", "gender" and "birthday" are not unique identification information for a particular student. There may be two students with the same name, the same gender and the same birthday (however small the probability may be). So we should also include a "User ID" attribute that has a unique value in the learning system to represent a particular student. This "User ID" could be any combination of text and number decided by the student. The identification function of the attributes "name", "gender" and "birthday" will be replaced by this "User ID". Their main function here is to provide more detailed personal information, which could be used for contact purpose. Contact details for the student are also included as "address", "email" and "phone number". These contact details also have some identification functions, while they will be mainly used for students' feedback for the learning system or for other educational purposes, such as learning material delivery. Table 5-1 shows the proposed attributes that are going to be used in the "Identification" category and their data type.

ATTRIBUTES	DATA TYPE	DESCRIPTION
1. Identification	*Category*	*Detailed personal information about the student himself*
1.1 User ID	Text	Unique text string to identify a student
1.2 Password	Password	Password for the user to login the system
1.2 Name	Text	First name and surname of the student
1.3 Date of Birth	Date	Birthday of the student
1.4 Gender	Text	Gender of the student
1.5 Address	Text	Address of the student
1.6 Email	Text	Email address of the student
1.7 Phone number	Text	Phone number of the student

Table 5-1: Attributes included in "Identification" category

5.2.2 Information about Learning Resource

The very basic information about the learning resource should be the "subject" of the web-based courses. The "subject" attribute defines the scope of student's learning activities. All of the student's learning should be carried out within the defined scope of "subject". It can also give the learning system a hint of which knowledge should be presented to the student. Thus, the "subject" attribute is closely related with a student's learning activities. It should be put into the student profile.

By using the attribute "subject", we have set the scope of the learning activities. Then we will define the "objective" of the learning. The attribute "objective" indicates the ultimate goal that all the learning processes are going to achieve. From another point of view, we can regard it as the requirements set for the student to fulfil or the level that the student should reach. After setting the ultimate goal, we also care about the duration in which the goal should be achieved. Therefore, another two attributes, "start date" and "due date" have to be included to set the time limit for the learning process so that the efficiency of the learning could be supervised. For different students, the "start date" and "due date" can be different. The "start date" and "due date" are usually fixed for all the students. However, there are still situations that

different students may start learning at their own most suitable dates. When they first log into the learning system, the "start date" will be set to the current date. The "due date" will also be set automatically by adding a certain period of time to the "start date". The time period for each student to learn the courses can be set to a fixed length, or it can be a variable depending on student's status, for example, part-time students should be given more time to learn than the full-time students.

After the subject and the time of the learning are determined, the student's learning progress should also be collected by the system, which can be a ratio of completed course contents to total course contents. . The attribute "current status" will take a percentage value to indicate the student's progress in learning. By knowing their own learning progress, students can gain better control over the duration and the work load of their learning. This attribute is also meaningful for the instructor to know the progress of all students who are taking the web-based course. Referring to the "current status" attribute, an instructor should be able to offer suitable help for students who are making little progress in learning.

The five attributes mentioned above represent very basic information about the learning source that the students are using, and they should be set by education providers. The information may be not enough to figure out all the details of the learning source, but it is enough to know how a student is making use of the learning source, which should be a major concern for the student profile. The five attributes are listed in Table 5-2.

ATTRIBUTES	DATA TYPE	DESCRIPTION
2. Learning Source	***Category***	***Information about the web course that the student is taking***
2.1 Subject	Text	The subject area of the web-based learning
2.2 Objectives	Text	The learning objectives for the student
2.3 Start Date	Date	The date when the web-based learning starts
2.4 Due Date	Date	The date when the web-based learning should be completed
2.5 Current Status	Percentage	A percentage that indicates how many learning materials have been completed

Table 5-2: Attribute included in "Learning Source" category

5.2.3 Information about Learning Context

All learning activities are carried out under certain learning contexts. Attributes describing the contexts in which a student is learning should also be an integrated part of a student profile, especially in a mobile environment. One important contextual attribute of mobile learning environment is student's devices. This is because the software capabilities of mobile devices are much more diversified from each other than the software of PC. In mobile devices, different versions of operating systems from various vendors coexist at the same time, such as Windows Mobile, Palm OS, Symbian OS, and Linux OS. Each mobile operating system has its own features and specifications, which are not always compatible with other operating systems; while in PC, Windows OS seems to be popular and widely installed already. In addition, the hardware capabilities of mobile devices are still varied a lot from one another. Some devices are of so limited capabilities that very few functions can be realized; while other mobile devices are able to realize most functions as the PC. It is the great differences in mobile software and hardware that need to be considered when we design web-based learning applications for students using various mobile devices.

The software and hardware differences in mobile devices are not the only thing that needs attention for learning contexts. Location is another attribute that is very

important when creating various learning contexts. Students using mobile devices will not remain at the same place for learning. They can move to different locations during their learning. Different locations will have different influences on the learning activities being carried out. For example, when students are learning via their mobile phones in a library, the sound of their mobile phones are better to be turned off, and the same will apply to classrooms and computer labs. Therefore, the location attribute seems to be more influential in mobile environment. Students using PC are supposed to remain at certain fixed locations during their learning. Therefore, the locations attribute will only show up to accept different values when the device attribute is set to mobile device. Both of the information in this category should be automatically detected and set by the system. We can get a clearer view of the attributes to describe the learning contexts in Table 5-3.

ATTRIBUTES	DATA TYPE	DESCRIPTION
3. Learning Context	***Category***	***Information describing the environment in which the student is learning***
3.1 Device	Text	The device that the student is using
3.2 Location	Text	Indicate the location where the web-based learning is carried out (only available when the device is set to mobile)

Table 5-3: Attributes included in "Learning Context" category

5.2.4 The Leaning Activities Preference

Previous section discussed various issues related to the student's identity. Although that information is enough to help identifying a particular student, it is not enough to reflect a student's preferences and learning styles during the whole learning process. Therefore, it is necessary to include attributes that can precisely indicate student's preferences into a student profile. In this section, we shall take student's preferences for learning activities into considerations.

A complete learning process usually involves a series of learning activities. In the survey, we have tested the students' preference for some common learning activities on PC and on mobile phone. From the survey results, we know that not all these learning activities are preferred by the students on both PC and mobile phone. Some learning activities are not preferred by most students on mobile phone. Thus, the students should provide their learning activities preferences for an adaptive learning system to personalize the availability of various learning activities on suitable devices. In this thesis, we propose that a complete learning process is comprised of six common learning activities: Preview, Learn, Check Notices, Discuss, Review, and Assignment.

Based on the survey results, we can conclude that most students prefer to carry out all the learning activities on PC except the activity "Check Notices". The notice checking activity is the only learning activity that is preferred by more participants on mobile phone than on PC. From this finding, we can decide the default value for the attributes in this category. For PC, of course, all attributes will be set to "True", which means the attributes are all enabled by default. For mobile devices such as mobile phones and PDA, only "Check Notices" will be enabled by default. The remaining five learning activities could be accessed depending on students' choices. The students can make changes to their student profiles to enable or disable these learning activities. Table 5-4 gives us the details of this category.

ATTRIBUTES	DATA TYPE	DESCRIPTION
4. Learning Activities	***Category***	***Learning activities that the student carries out for the web course***
4.1 Preview	True/False	Decide whether to include course preview activities
4.2 Learn	True/False	Decide whether to include course material learning activities
4.3 Check Notice	True/False	Decide whether to include course notices checking function
4.4 Discuss	True/False	Decide whether to include course related discussion function
4.5 Review	True/False	Decide whether to include course review activities
4.6Assignment	True/False	Decide whether to include course assignment activities

Table 5-4: Attributes included in "Learning Activities" category

5.2.5 The Multimedia Preference

Another preference that will be important in providing adaptive education is multimedia preferences. Based on the survey results, it is not too surprising to know that a student will prefer all the multimedia effect on a PC based educational system, but when on a mobile phone, it seems that not many students prefer multimedia effects. This means that many students who prefer multimedia effects on PC will not prefer them on mobile phone, i.e. their multimedia preference will change on different devices. Therefore, the students should also provide their multimedia preferences in the student profile so that the system can provide adaptation on PC and on mobile phone accordingly.

There are five basic types of multimedia preferences that will be put into the proposed student profile, i.e. video, sound, animation, image and text. These five multimedia effects are very popular components on a web page, thus they are potential candidates to be integrated into a web-based educational system. When using such educational

system, the same student will probably have different multimedia preferences on PC and mobile phone, which can be concluded from the survey result. Another thing that can be concluded from the survey results is the default settings for the multimedia preferences. The default settings for all the multimedia preferences on PC are "True" which means the multimedia effects are provided; while the default settings should be all "False" for the mobile phone, because all multimedia elements seems not to be welcome on mobile phone, which we believe to be a result of students' worrying about high mobile connection costs. Furthermore, we have mentioned in previous section that sound is a very important component for video and animation. We can notice that sometimes the sound of video or animation may contain more useful information, such as the explanation of video contents. Therefore, in our proposed student profile, it will be better to automatically turn on the sound (if it is off) when the video or animation is turned on. If the sound is turned on in this way, it should also be automatically turned off when the video or animation is turned off. The descriptions for this category are shown in Table 5-5.

ATTRIBUTES	DATA TYPE	DESCRIPTION
5.Multimedia Preferences	***Category***	***Common multimedia effects that will be provided by educational systems***
5.1 Video	True/False	Decide whether to provide videos
5.2 Sound	True/False	Decide whether to provide sounds
5.3 Animation	True/False	Decide whether to provide animations
5.4 Image	True/False	Decide whether to provide images
5.5 Text	True/False	Decide whether to provide detailed texts

Table 5-5: Attributes included in "Multimedia Preferences" category

5.2.6 The Learning Preferences

As we have discussed in previous section, each student has his or her own "characteristic ways of taking in and processing information" (Felder & Brent, 2005, p.57), which is based on student's learning styles. By understanding student's unique

learning styles, the web-based educational system can provide the educational contents in ways that help student to learn more comfortably. Therefore, it will be helpful to include student learning styles into the student profile for adaptation purposes.

The information that should be included in the student profile is certainly not just the four learning style preferences, which define a student's learning styles by a sliding scale of four dimensions (the fifth dimension, inductive-deductive dimension, was deleted from the previous theory in 2002 because of pedagogical reasons), i.e. sensing-intuitive, visual-verbal, active-reflective and sequential-global (Felder, 1993; Felder & Silverman, 1988). It will not be proper to predict student behaviours based on the student's level on learning style dimensions (Felder & Spurlin, 2005). Thus, we are not able to predict students' response to each question in the Index of Learning Style (ILS) questionnaire (Felder & Soloman, n.d.), i.e. their preference for each type of educational content presentation, by their learning style preferences. In this thesis, we constructed eight questions to relate a student's learning style preferences with certain educational content presentation methods in the web-based educational system by referring to the Index of Learning Styles (ILS) questionnaire (Felder & Soloman, n.d.). In order to distinguish those eight questions from learning style preferences, we named them as learning preferences. By calculating students' responses to these eight questions, we can finally decide their learning style preferences. Just as we have mentioned in the previous section, these eight questions could not completely indicate a student's preferences for all types of contents presentations, but they will be enough for us to observe and test the possible changes in learning preferences, and eventually in learning styles, in different devices such as PC and mobile phone. More questions can be added in future into the student profile to achieve a more detailed and precise indication of student's learning preferences and learning style. The eight questions included in Learning Preference category are shown in Table 5-6. The students can choose either answer "a" or answer "b" for each question.

ATTRIBUTES	DATA TYPE	DESCRIPTION
6. Learning Preferences	***Category***	***The way in which certain contents will be presented in the educational systems***
6.1 I prefer the course contents to be mostly (a) concrete information or (b) abstract concepts.	a/b	Decide whether concrete or abstract information should be provided
6.2 I prefer to (a) master the standard solutions or (b) find out new solutions.	a/b	Decide whether new solutions should be presented in addition to standard ones.
6.3 It is easier to understand the course contents that are explained (a) visually or (b) verbally.	a/b	Decide whether visual or verbal contents should be provided
6.4 I like to read books that (a) have many pictures or (b) contain mostly texts.	a/b	Decide whether pictures should be provided
6.5 I can understand something better (a) after I try it out or (b) after I think it through.	a/b	Decide whether practice exercises or questions should be provided
6.6 I like to (a) study in study groups or (b) study alone.	a/b	Decide whether a discussion area should be provided
6.7 I like to (a) learn course contents step by step or (b) jump to advanced topics when learning.	a/b	Decide whether the links that can jump to anywhere in the web course should be provided
6.8 When learning a new subject, (a) I stay focused on that subject and learn as much about it as I can or (b) I try to connect that subject with related subjects.	a/b	Decide whether provide related subjects

Table 5-6: Attributes included in "Learning Preferences" category

The responses for these eight questions should be provided by the students themselves, but a default setting is also available based on validation of

Felder-Soloman's Index of Leaning Styles, which suggests that more students are active, sensing, sequential, and visual than reflective, intuitive, verbal and global (van Zwanenberg, Wilkinson, & Anderson, 2000; Zywno, 2003). Therefore the default learning style is active/sensing/sequential/visual, which means that the default responses for all the eight learning preference questions are "a". The default value will be used to initialize student profile for both PC and mobile phone. After the students register their profile, the settings of these questions can be changed either by the students or by the system.

5.2.7 The Complete Student Profile Template

Based on the discussion above, we have proposed a list of various attributes that should be integrated into the student profile. Now we can get a complete student profile template shown as in Table 5-7.

ATTRIBUTES	DATA TYPE	DESCRIPTION
1. Identification	***Category***	***Detailed personal information about the student himself***
1.1 User ID	Text	Unique text string to identify a student
1.2 Password	Password	Password for the user to login the system
1.2 Name	Text	First name and surname of the student
1.3 Date of Birth	Date	Birthday of the student
1.4 Gender	Text	Gender of the student
1.5 Address	Text	Address of the student
1.6 Email	Text	Email address of the student
1.7 Phone number	Text	Phone number of the student
2. Learning Source	***Category***	***Information about the web course that the student is taking***
2.1 Subject	Text	The subject area of the web-based learning
2.2 Objectives	Text	The learning objectives for the student
2.3 Start Date	Date	The date when the web-based learning starts
2.4 Due Date	Date	The date when the web-based learning should be completed
2.5 Current Status	Percentage	A percentage that indicates how many learning materials have been completed

3. Learning Context	*Category*	*Information describing the environment in which the student is learning*
3.1 Device	Text	The device that the student is using
3.2 Location	Text	Indicate the location where the web-based learning is carried out (only available when the device is set to mobile)
4. Learning Activities	***Category***	***Learning activities that the student carries out for the web course***
4.1 Preview	True/False	Decide whether to include course preview activities
4.2 Learn	True/False	Decide whether to include course material learning activities
4.3 Check Notice	True/False	Decide whether to include course notices checking function
4.4 Discuss	True/False	Decide whether to include course related discussion function
4.5 Review	True/False	Decide whether to include course review activities
4.6Assignment	True/False	Decide whether to include course assignment activities
5.Multimedia Preferences	***Category***	***Common multimedia effects that will be provided by educational systems***
5.1 Video	True/False	Decide whether to provide videos
5.2 Sound	True/False	Decide whether to provide sounds
5.3 Animation	True/False	Decide whether to provide animations
5.4 Image	True/False	Decide whether to provide images
5.5 Text	True/False	Decide whether to provide detailed texts
6. Learning Preferences	***Category***	***The way in which certain contents will be presented in the educational systems***
6.1 I prefer the course contents to be mostly (a) concrete information or (b) abstract concepts.	a/b	Decide whether concrete or abstract information should be provided
6.2 I prefer to (a) master the standard solutions or (b) find out new solutions.	a/b	Decide whether new solutions should be presented in addition to standard ones.
6.3 It is easier to understand the course contents that are explained (a) visually or (b) verbally.	a/b	Decide whether visual or verbal contents should be provided
6.4 I like to read books that (a) have many pictures or (b) contain mostly texts.	a/b	Decide whether pictures should be provided
6.5 I can understand	a/b	Decide whether practice exercises or

something better (a) after I try it out or (b) after I think it through.		questions should be provided
6.6 I like to (a) study in study groups or (b) study alone.	a/b	Decide whether a discussion area should be provided
6.7 I like to (a) learn course contents step by step or (b) jump to advanced topics when learning.	a/b	Decide whether the links that can jump to anywhere in the web course should be provided
6.8 When learning a new subject, (a) I stay focused on that subject and learn as much about it as I can or (b) I try to connect that subject with related subjects.	a/b	Decide whether provide related subjects

Table 5-7: Complete student profile template

With the proposed student profile template in Table 5-7, we can create a student profile that will not only indicate student's preferences but also the learning contexts, such as device and location. The web-based educational system will provide educational contents that are adaptive to student preferences. At the same time, the system should also be fully aware of the learning context in which the student is learning, i.e. the system should consider the influences of different learning contexts on the student's preferences. Through the survey results, we know that a student's preferences are not the same on PC and on mobile phone. Further, such changes of preferences are different from one student to another. All students seem to have their own connections between their preferences and different learning devices. After knowing the unique connections of a student, the web-based educational system will be able to automatically apply corresponding preference changes in his or her student profile on different learning devices. Similarly the connections between students' preferences and different locations are also essential to achieve the automatic student profile transformation on various learning devices.

As we discussed in the previous section, personal features of student, such as preferences, can not be deduced from the system. They may be extracted by interviews, questionnaires, or psychological tests. Therefore students' preferences on various devices, including their possible preference changes, should also be extracted by interviews, questionnaires or psychological tests. What the web-based educational system can do is to apply preferences changes based on the connections between student's preference changes and the learning context, such as device capabilities and locations. The connections can be established whenever a preference change is made by the students. For an existing connection, the system should update it when the students make the same preference change.

In our survey, the connections between student's preferences and learning contexts are not identified clearly. There are two reasons for that. One reason is that survey questionnaire was designed to test the possible preference changes on PC and on mobile phone. It only tested the connection between preference changes and various devices, while most students seemed to worry too much about the costs of using mobile connections. Therefore, their preference changes on mobile phone were basically not caused by different learning devices, but by their worry of costs. The other reason is that no student had the experience of using mobile educational systems. Most of them had not even used any web-based educational system. Thus, their possible preference changes on PC and on mobile phone were mainly based on their assumptions. Since these two factors greatly influence students' preferences on mobile phone, their preference changes on mobile phone should not be used as proofs for building preference-context connections, which are essential for student profile transformation. With the survey results, we are not able to make any conclusion about possible preference changes in various learning contexts, include device capabilities and locations. Therefore, we carried out another survey which concentrated on the connections between students' preference changes and various learning contexts. Next chapter will present the details and analysis of the second survey.

5.3 Summary

This chapter proposed a student profile template based on the Mobile Learning Metadata (MLM) schema and the first survey results. The student profile template covers student's identification, learning source, learning context and preferences, such as learning activities preference, multimedia preference and learning preference. Through this template, we can model students in various devices and locations, so that they can get adaptive learning contents accordingly. Since many participants did not have any web-based learning experience and seemed to concern too much about mobile phone costs, the first survey did not get reasonable feedback on preference changes between PC and mobile phones. Therefore, the second survey was implemented on the relationship between student preference changes and device capabilities or locations.

Chapter 6 : Second Survey on Student Profile Transformation

6.1 Introduction

In the last chapter we have proposed a student profile template to model student's identification, learning source, learning context and preferences in a web-based educational system. To provide student with adaptive contents in various learning contexts, including device capabilities and locations, we need to identify the connections between students' preference changes and learning contexts. However, the first survey did not return enough information for us to build such connections because (1) students were seriously worried about mobile connection costs; and (2) they also did not have mobile educational system experience or even web-based educational system experience. Therefore we designed the second survey questionnaire to investigate the connections between students' preference changes and learning contexts. The research problems that were discussed in the second survey are:

- ✧ Which device capability attributes are responsible for students' preference changes?
- ✧ How can we synchronize student profiles in mobile learning environment and in PC?
- ✧ What are the students' opinions about the influence of various locations on their learning preferences?
- ✧ How can we resolve conflicts between learning preferences and other preferences in student profile?
- ✧ How the insufficient device capabilities will affect students' learning preferences?

From the survey results, we hoped to get answers for all the above problems in order to define a framework that will implement personalized student profile transformation between PC and mobile phone. In order to get more proper responses from the students, we aimed to overcome the above mentioned two factors that had influenced students' preference choices in first survey, by offering the students a demonstration education system to use on both PC and mobile phone. The students were told that there is no mobile connection cost involved in this survey because we connect mobile phone to PC for internet sharing. By doing this, we expected that the students would have some mobile educational system experience and their responses should reflect more precisely their real preference choices free of the influence from costs. Before describing the second survey analysis, this chapter first briefly introduces the web-based education system that has been used in the second survey.

6.2 A Web-Based Education System Demonstration

Since almost all students who participated in the first survey did not have any mobile learning experience, a demo web-based educational system called "Web Learning System" was developed to offer the students in the second survey some real web and mobile learning experience, so that they could give more precise responses to the survey questions. The demo system was developed by Microsoft ASP.net technology for both PC and mobile phone, so the students could access the system via both PC and mobile phone. The presentation of educational contents was controlled by preference settings in the student profile. By adjusting preference settings on PC and mobile phone, students could choose their most preferred presentation styles for the educational contents provided in the demo system.

In this survey, the devices for students to use the demo system are PC and PalmOne Treo 600 mobile phone. We chose to use Treo 600 in the second survey because we wanted to present the participants with all types of educational contents which were

closely related with learning styles, such as videos and pictures, on a mobile phone, and Treo 600 was capable of presenting all these types of educational contents. After using the demo system on Treo 600, the participants could obtain real experience of seeing or hearing various educational contents on a mobile phone. Although Treo 600 seems to be much more powerful than most mobile phones today, I believe that we can expect more and more mobile phones to perform even better than Treo 600, and eventually to have similar capabilities as a PC. Through this survey, we can find out how the capabilities of this latest mobile device will influence students' preference settings. Since the Blazer Web Browser in Treo 600 does not support webpage embedded animation and video, we used the MMPlayer for PalmOS to play all the animations and videos in the system as an alternative method, so that the students could know what the mobile animations or videos looked like and then they could decide their corresponding preferences on mobile phone. Next, let us take a look at the some major features of the demo system.

6.2.1 Student Profile Registration and Synchronization

Before the students use the educational system, the students are asked to register their identification information, such as username, password, email address, etc., together with their preference information, including learning activities preferences, multimedia preferences and learning preferences. After completing the registration the students can login the system with their registered usernames and passwords.

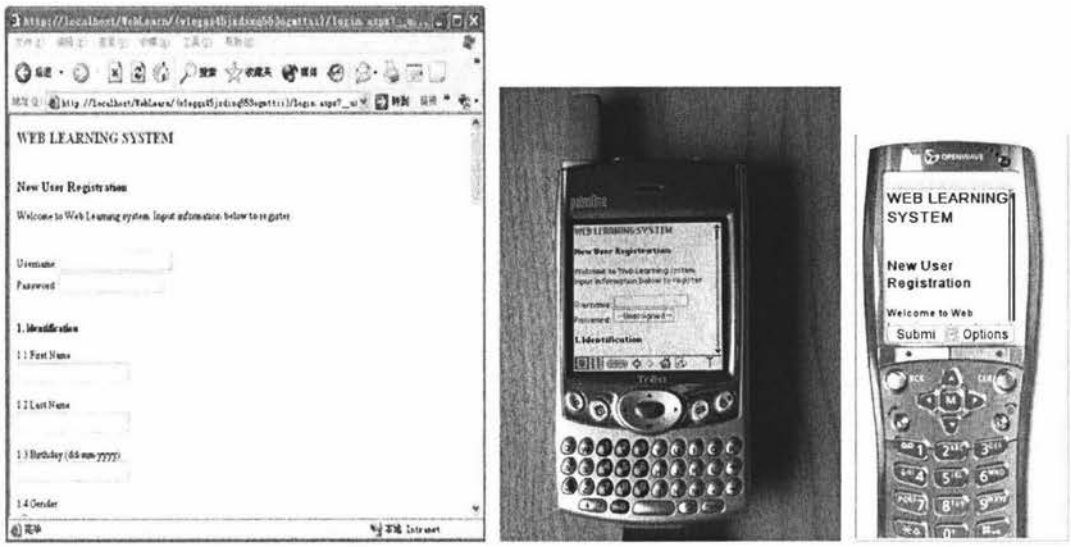


Figure 6-1: Demo system on PC, Treo 600 and Openwave simulator

The students can start to register their student profile via either PC or mobile phone. The system automatically identifies students' access devices and arranges the contents to fit the screen size of the devices. Figure 6-1 shows that the demo system is being accessed via PC, Treo 600 and Openwave mobile phone simulator respectively. According to different access devices, either PC or mobile phone, the system sets different default preference values which are concluded from the first survey results (Table 6-1).

Preferences	**Default Settings (At registration only)**	
Learning Activities Preferences	***On PC***	***On Mobile Phone***
Preview	True	False
Learn	True	False
Check Notice	True	True
Discuss	True	False
Review	True	False
Assignment	True	False
Multimedia Preferences	***On PC***	***On Mobile Phone***
Video	True	False
Sound	True	False
Animation	True	False
Image	True	False

Text	True	False
Learning Preferences	***On PC***	***On Mobile Phone***
6.1 I prefer the course contents to be mostly (a) concrete information or (b) abstract concepts.	a	a
6.2 I prefer to (a) master the standard solutions or (b) find out new solutions.	a	a
6.3 It is easier to understand the course contents that are explained (a) visually or (b) verbally.	a	a
6.4 I like to read books that (a) have many pictures or (b) contain mostly texts.	a	a
6.5 I can understand something better (a) after I try it out or (b) after I think it through.	a	a
6.6 I like to (a) study in study groups or (b) study alone.	a	a
6.7 I like to (a) learn course contents step by step or (b) jump to advanced topics when learning.	a	a
6.8 When learning a new subject, (a) I stay focused on that subject and learn as much about it as I can or (b) I try to connect that subject with related subjects.	a	a

Table 6-1: Default preference settings at registration

The default settings are preset at the time of registration if the student does not set any preferences. Then these default settings are saved into the student profile. The students can change their preference settings later after they have logged in the system. Of course, the students are free to choose any preference settings at the time of registration. Then, the default settings are not applied.

Each student has his or her student profile in two versions, one is PC version and the other is mobile version. These two versions of student profile are stored separately in two XML files. Figure 6-2 shows some example student profiles in an XML file.

```
<?xml version="1.0" standalone="yes" ?>
- <NewDataSet>
    <users name="" password="" devicematch="" firstname="" lastname=""
      birthday="" gender="" address="" email="" la1="" la2="" la3="" la4="" la5=""
      la6="" mp1="" mp2="" mp3="" mp4="" mp5="" lp1="" lp2="" lp3="" lp4=""
      lp5="" lp6="" lp7="" lp8="" course="" cla1="" cla2="" cla3="" cla4="" cla5=""
      cla6="" cmp1="" cmp2="" cmp3="" cmp4="" cmp5="" clp1="" clp2="" clp3=""
      clp4="" clp5="" clp6="" clp7="" clp8="" />
    <users name="p"
      password="516B9783FCA517EECBD1D064DA2D165310B19759"
      devicematch="t" firstname="alan" lastname="smith" birthday="1-11-
      1975" gender="Male" address="20 Hanson ave" email="sj@hotmail.net"
      la1="t" la2="t" la3="t" la4="t" la5="t" la6="t" mp1="t" mp2="f" mp3="f"
      mp4="t" mp5="t" lp1="1" lp2="1" lp3="1" lp4="1" lp5="1" lp6="1" lp7="1"
      lp8="2" course="c3" cla1="n" cla2="n" cla3="n" cla4="n" cla5="n" cla6="n"
      cmp1="n" cmp2="n" cmp3="n" cmp4="n" cmp5="n" clp1="n" clp2="n"
      clp3="n" clp4="n" clp5="n" clp6="n" clp7="n" clp8="n" />
    <users name="milo"
      password="F3D17DC763F95E629A7E71F9E2A2EE9DF43C8746"
      devicematch="t" firstname="milo" lastname="mao" birthday="21-07-
      1979" gender="Male" address="rm1, 41 hankey street"
      email="milospace@hotmail.com" la1="t" la2="t" la3="t" la4="t" la5="t"
      la6="t" mp1="t" mp2="t" mp3="t" mp4="t" mp5="t" lp1="1" lp2="2" lp3="1"
      lp4="1" lp5="1" lp6="1" lp7="2" lp8="2" course="c3" cla1="n" cla2="n"
      cla3="n" cla4="n" cla5="n" cla6="n" cmp1="n" cmp2="n" cmp3="n"
      cmp4="n" cmp5="n" clp1="n" clp2="n" clp3="n" clp4="n" clp5="n" clp6="n"
      clp7="n" clp8="n" />
  </NewDataSet>
```

Figure 6-2: Some example student profiles in an XML file

The two versions of student profile need synchronization to update the student's latest preference settings on various devices. If the student starts to use the system with the same device which was used for registration, the student profile matches that device. For example, suppose the student has registered via PC, he or she only registers the PC version student profile. When that student logs in the system via PC, the registered PC version student profile matches the device. Otherwise, if the student logs in the system via mobile phone, the PC version student profile will not match the device. The initial student profile synchronization will run when there is such a mismatch between student profile and access device. This initial synchronization is relatively simple. The student is prompted to either keep the existing version of student profile or create a new student profile for the current device. If the student chooses "keep", the registered student profile is copied to the current devices. If he or she chooses "create", a blank registration form is given to fill in various identification

and preferences information. Identification information includes things like the students' "First Name", "Last Name", "Birthday" and so on. The preferences information includes things like students' "Preference for Preview Course", "Preference for Quality Images", "Preference for Concrete Course Contents" and so on.

Another type of student profile synchronization is update synchronization. It runs when the student makes some preference changes on one device and then uses the system via the other device. For example, consider a scenario where after changing some preference settings on PC, the student logs out the PC version system and then restarts to use the system via mobile phone. Under such situation, the mobile version system will prompt the student that there are preference changes in the PC version student profile. The student has an option of either "update" or "neglect" those preference changes for the mobile phone version student profile. There are two things that need to be clarified here. One thing is that only the preferences that have been changed will be updated, i.e. the preferences that have not been changed will not be considered for student profile update. The other thing is that the changes of student identification will always be updated regardless of the student's choices for "update" or "neglect". For an individual student, his or her identification information should be updated immediately for all versions of his or her student profiles, so that a student's identification will be identical on any access devices.

By registering and synchronizing PC version and mobile phone version student profiles, the student's latest preference changes that may happen on various learning devices will be processed accordingly. Thus, on various devices, the student can always expect the educational contents to be presented adaptively to their latest preferences settings. The flowchart in Figure 6-3 shows the basic procedures of the two types of synchronization that may occur in the demo system.

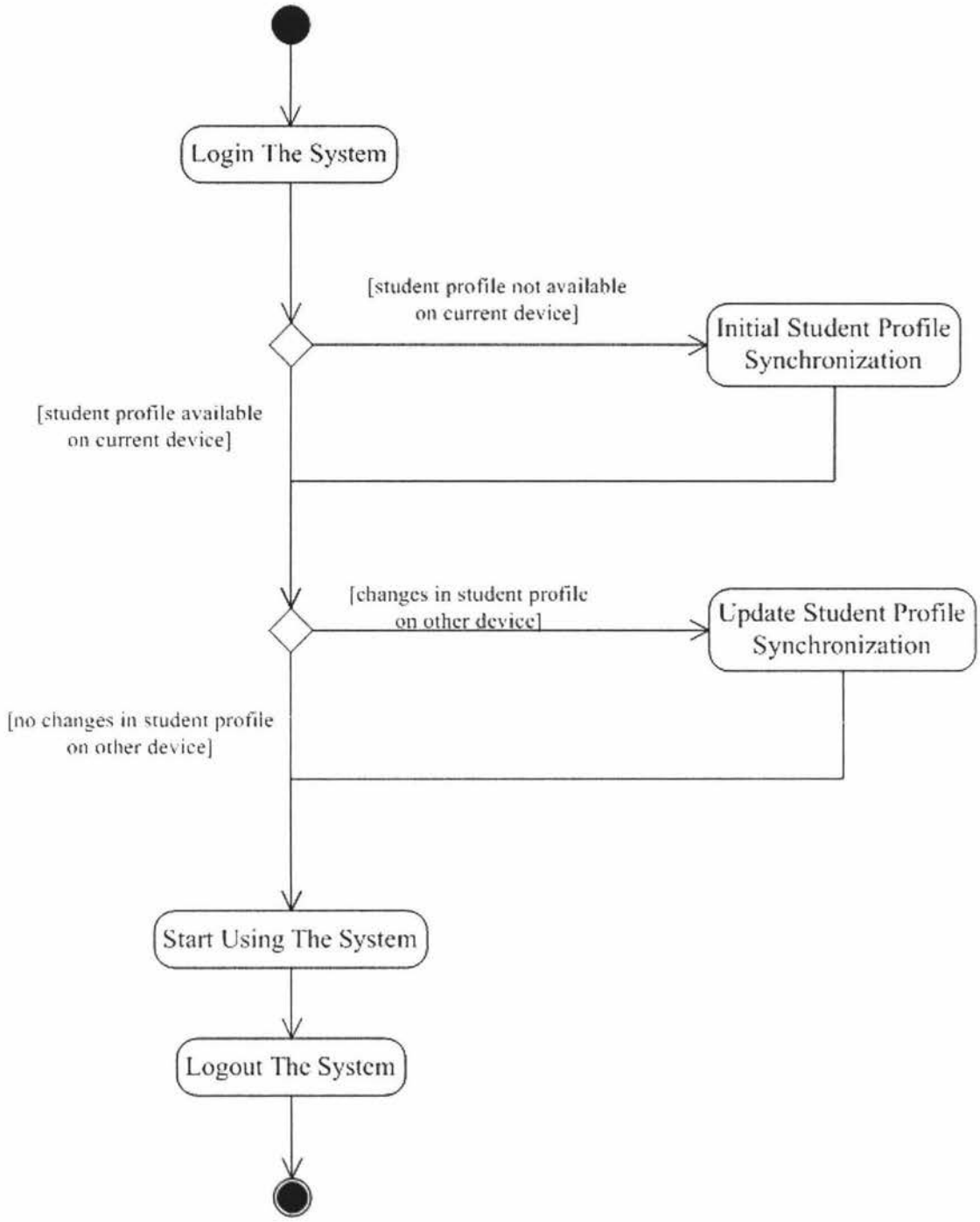


Figure 6-3: Two types of synchronizations in the demo system

There are sometimes conflicts between learning preferences and other preferences. For example, the students enable visual contents in their learning preference, and at the same time, disable images in their multimedia preference. When such situation occurs, the system or the student needs to decide which preference should have priority. In addition, it is also essential to decide whether and how to update the

preferences to achieve consistency in the student profile. In the demo system, the preference conflicts are not taken into consideration, but the second survey questionnaire asked for students' views on how to deal with such conflicts. By summarizing the survey results, we expect to find out a method to resolve the preference conflicts in student profile.

6.2.2 Demo System Functionalities

In the demo system, there are five options in the main menu: "Main Page", "Select Course", "My Profile", "FAQs" and "Log Out". After you have selected a course to learn, a course options menu is shown. The course options menu includes six options that represent six common learning activities we define in the student profile: "Preview Course", "Learn Course", "Check Notices", "Discuss Issues", "Review Course" and "Do Assignment".

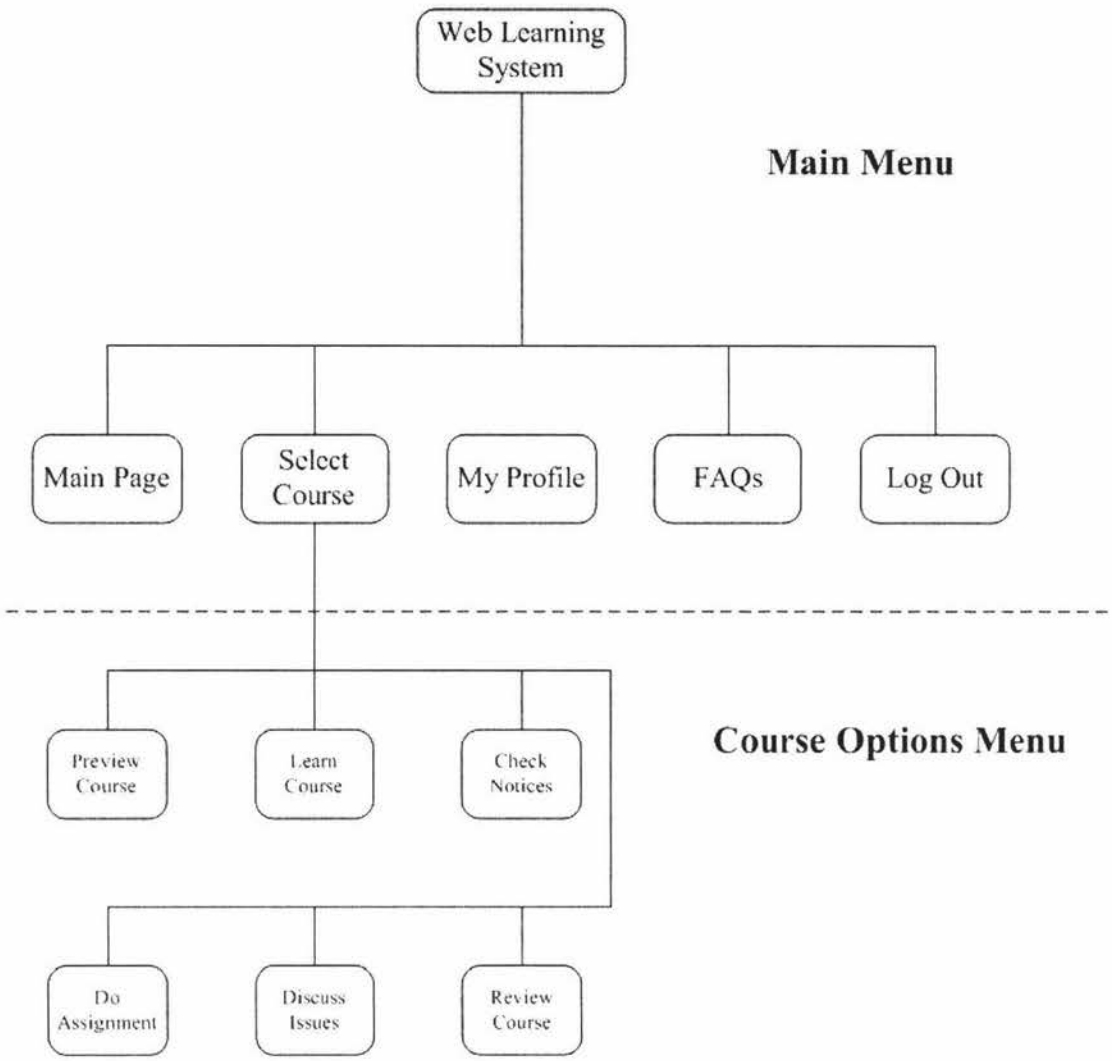


Figure 6-4: The hierarchy structure of the demo system

The hierarchy structure of the demo system is shown in Figure 6-4. Now, we will introduce these options one by one. The five main menu options are explained as follows:

- **Main Page**

  This is the default start page of the web-based education system. It contains a welcome message as most web-based systems do. However, this is not the only function of this page. Whenever this main page is loaded, the system will run either of the two types of student profile synchronizations. If there is a need for synchronization, a message will prompt the students to choose the process

methods for their profile synchronization in current device. When the prompt message pops up, the "Select Course" and "My Profile" options are both disabled in the main menu because the students should not continue learning without updating their student profile. After the students choose a profile updating method, the main page is then loaded and presented to the student. The students can then start to use the system.

- **Select Course**

This option is the entrance of a web-based course. The available courses are all listed here for the students to choose. Brief introductions for each course are also available to the students. The example course we use for this demo system is "Creating Queries in Microsoft Access". By selecting a course, students can start to learn the course and the course options menu becomes visible. The options in course options menu are explained later in this chapter.

- **My Profile**

The student profile is created at the time of registration. When the students use the system, they can change the information in their profile through "My Profile" option in the main menu. Both identification and preference changes are updated immediately in the current device. In the other device, these identification and preference changes will be updated next time when the student logs in the system via that device. However, the updates of identification changes are run without student's permission.

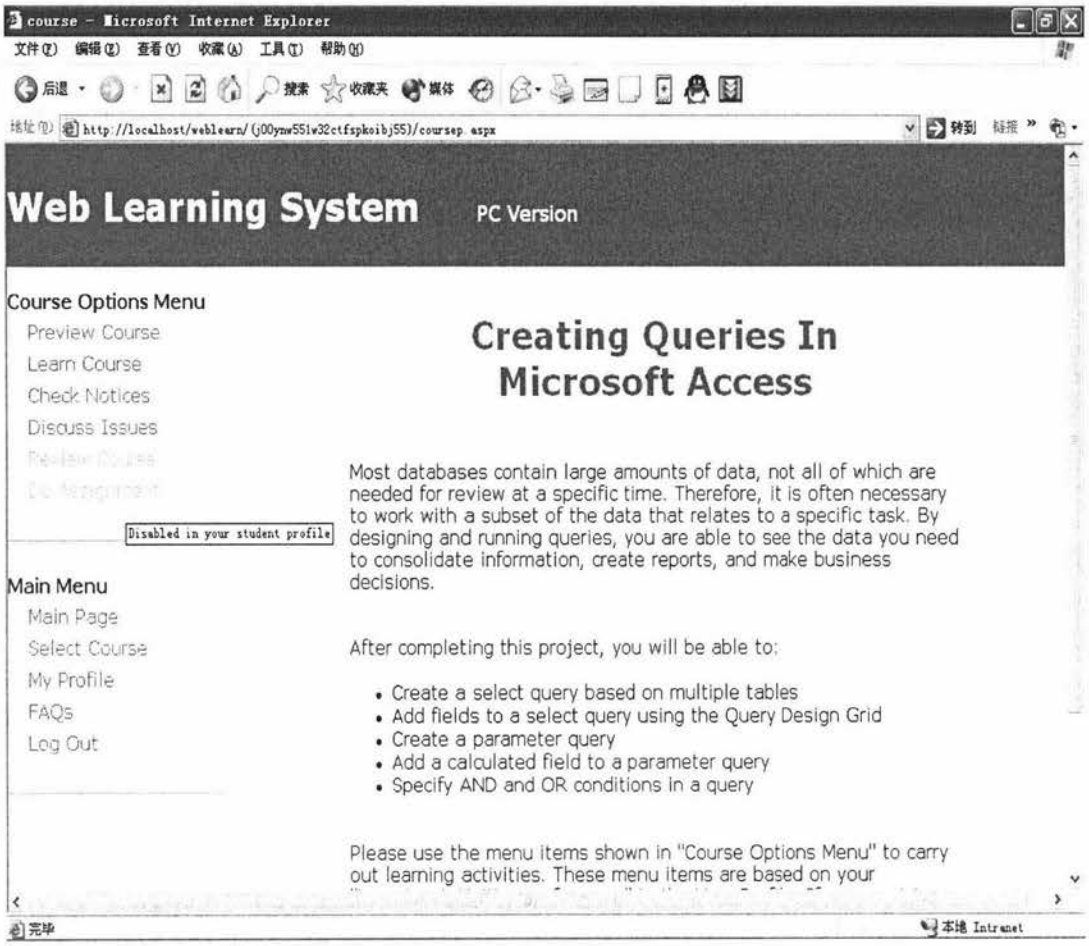
- **FAQs**

FAQ is the abbreviation of Frequently Asked Questions. Possible questions about the operations and functions of the system can be found here. This option is just like the online help function in most web-based systems.

- **Log Out**

After using the system, the students could use this option to log out of the system. This is also a quite common function in many web-based systems.

When the students click the "Select Course" option in the main menu and select a course to learn, the course options menu is displayed. The options under the course options menu are six common learning activities, which are controlled by student profile preference settings. Therefore all six learning activities options are not always enabled. The learning activities that are not preferred by the student become inaccessible to that student and hovering mouse over those options displays mouse-tip that the particular learning activity is "disabled in student profile" (Figure 6-5).



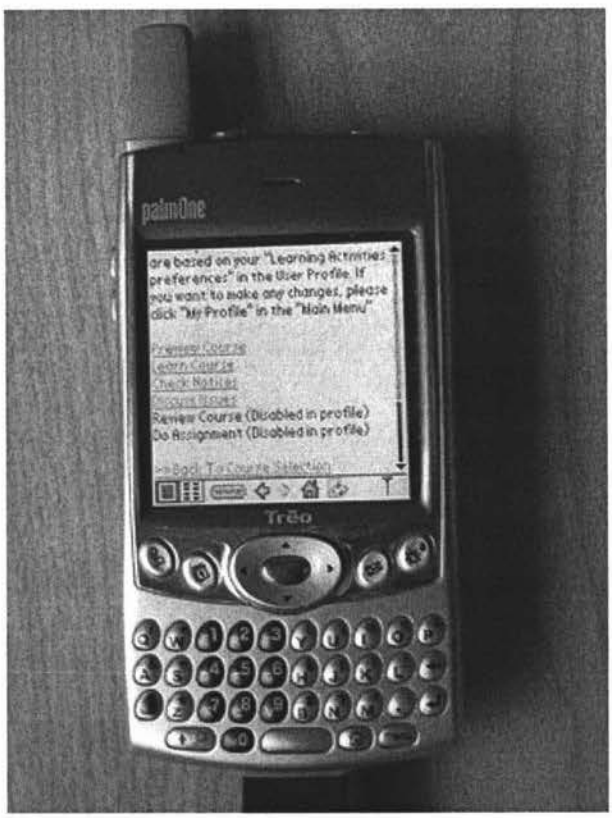


Figure 6-5: Learning activities controlled by student profile

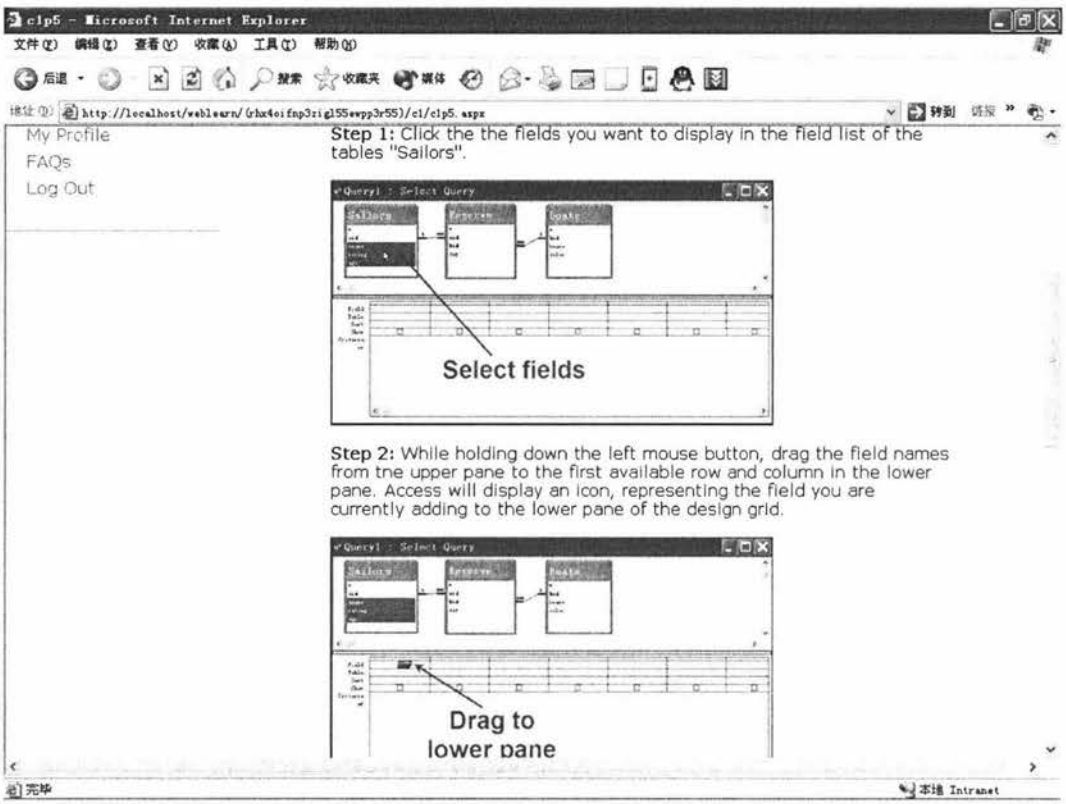
Let us briefly go through all the six course options in the course options menu:

- **Preview Course**

Before the course starts, the student can make some preparations for the course. In the "Preview Course" option, the student is given instructions to prepare for the course. Some links to the prerequisite knowledge are also provided here.

- **Learn Course**

This option presents the learning contents to the students based on the preferences in student profile. Learning preference, learning activities preference and multimedia preference can all control corresponding course contents presentation. For example, the animations in the course are shown on the web page only if the students enable animations in their multimedia preferences; the "Preview" option in course options menu is accessible only if the students enable it in their learning activities preferences; and the links to related subject are available only if the students like to connect current subject with related subjects in their learning preferences. By these preference settings in student profile, the system is able to arrange all the course contents in a way that the students will be more comfortable to learn. Figure 6-6 and Figure 6-7 show the web-based course contents with or without images.



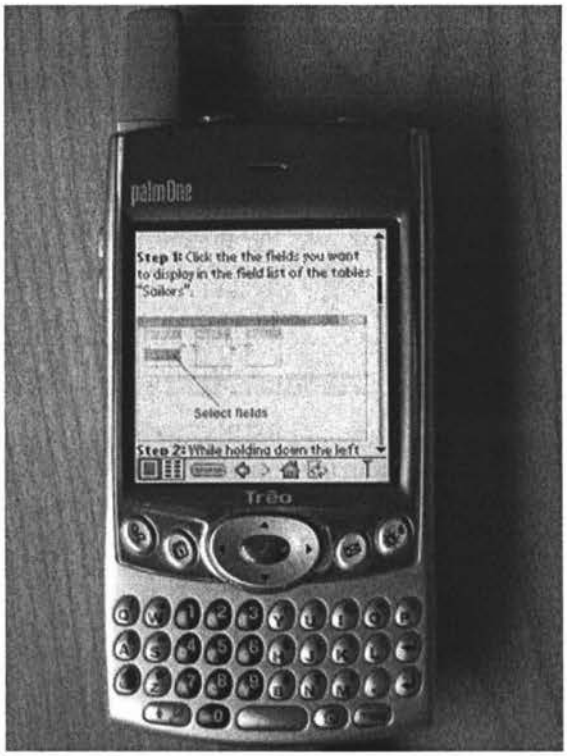


Figure 6-6: Course contents with images on PC and on mobile phone

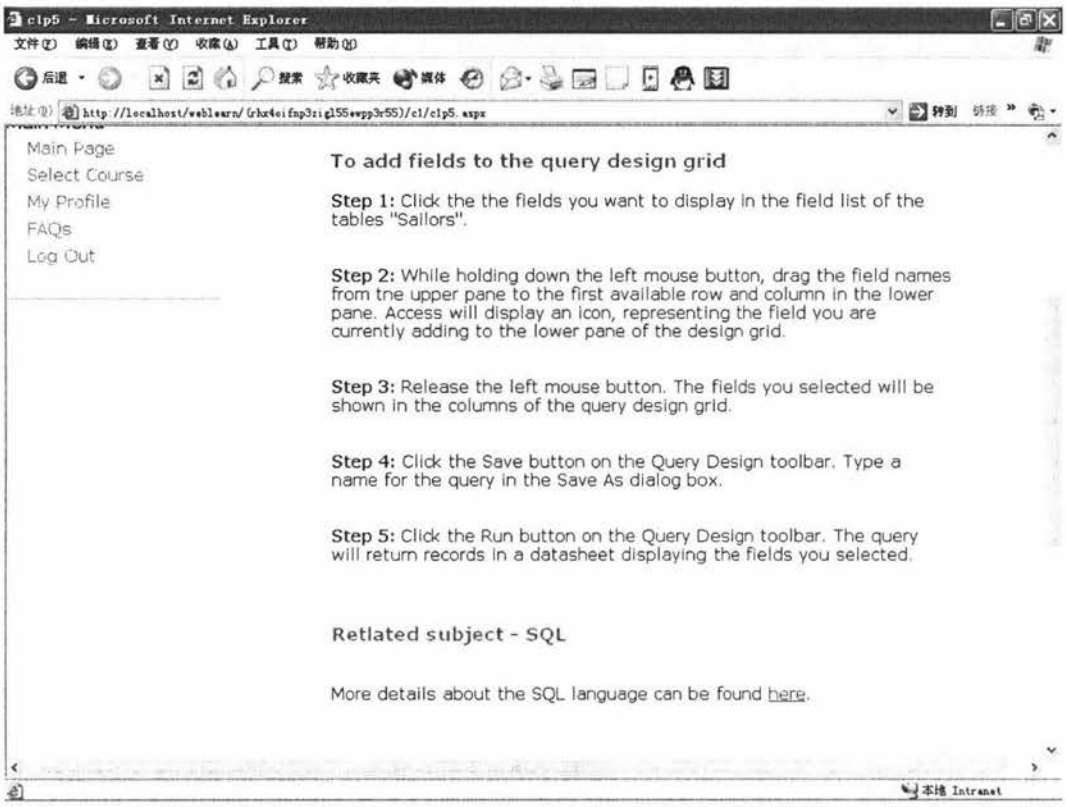


Figure 6-7: Course contents without images on PC and on mobile phone

- **Check Notices**

When a web-based course starts, there are various types of things that need

students' attention, such as assignment due date changes, online discussion commencement date, and probably the personal exam results. The "Check Notice" keeps the students updated with latest course related notices. This is the only learning activity that is preferred by more students on mobile phone than on PC according to first survey results.

- **Discuss Issues**

Discussion forum is the communication center where course related discussions can be carried out. The students who prefer to study in groups can ask questions, answer other students' question and participate in course related group discussions in the discussion forum. Since each course should have its own directory in the discussion forum, all the posters are categorized into such directories. Therefore, the students should not be distracted by irrelevant contents but always concentrate on the course related information.

- **Review Course**

In this option, all the key points of the current course are listed. The students can test whether they have fulfilled the course requirements by checking their understanding of the listed key points. The list also serves as a reminder of the course contents. By quickly going through the key points, the students are expected to get better understanding and retention of the knowledge they have learned from the course.

- **Do Assignment**

After learning, the students can complete the assignments online. The answers to various types of questions, such as multiple choices, filling in the blank and short answer questions, could be submitted to the system. The instructor will get those assignments from the system very conveniently.

All the students who participated in the second survey were asked to try the demo

system before filling out the survey questionnaire. They were also told how their student profiles control the content presentations. By gaining some real web-based learning experience on both PC and mobile phone, we expect that their responses to the survey questionnaire are more real and precise.

6.3 Second Survey Analysis

In this section we analyze the results of the second survey. The second survey questionnaire is enclosed in Appendix B. Since the second survey was conducted only in New Zealand and we only chose participants with at least one of web learning experience and mobile learning experience, a total of 20 students participated in the second survey. Among them, 10 students had participated in the first survey. All the participants were tertiary students in New Zealand (12 postgraduate and 8 undergraduate), whose majors included science, business, psychology and design. Similar to the first survey analysis, we analyze the second survey results question by question.

6.3.1 Analysis of Question 1

The following is a list of mobile phone capability attributes that will probably affect your preferences (learning activities preferences, multimedia preferences and learning preferences) on mobile phones. After using the demo system, please select the attributes that will eventually make your preferences on mobile phone different from those on PC. You can choose more than one attributes.

___ [A] Screen Size

___ [B] Color Display

___ [C] Screen Resolution

___ [D] Audio Quality

___ [H] Memory Size

___ [I] Operating System
(e.g. Windows Mobile , and PalmOS, etc.)

___ [J] Web Browser
(e.g. Mobile IE and Handspring Blazer, etc.)

___ [K] Internet Connection Speed

___ [E] Video Quality

___ [F] Input Method

___ [G] Battery Time

___ [L] Processor Speed

___ [M] Other (Please specify)

___ [N] None

The aim of the first question is to get a list of possible mobile phone capability attributes that will eventually change a student's preferences, including learning activities preference, multimedia preference and learning preference, on mobile phone. We provide twelve mobile phone capability attributes for the students to choose from. The students could choose more than one answers. By obtaining such a list, we can monitor the changes of the certain learning device capabilities along with the changes of student preferences, including learning activities preferences, multimedia preferences and learning preferences. Thus we are able to establish the relationship between device capability changes and student preference changes, which is essential to student profile transformation. The details of establishing the relationship will be discussed in next chapter. Here we shall first decide this list through the second survey results. The influence of these attributes on certain preference settings will also be discussed. All the student responses to the first question can be summarized in Table 6-2:

Mobile phone capability attribute	Number of students that select the attribute	Percentage of students that select the attribute
Screen Size	16	80%
Color Display	3	15%
Screen Resolution	5	25%
Audio Quality	3	15%
Video Quality	6	30%
Input Method	7	35%
Battery Time	9	45%
Memory Size	8	40%
Operating System	7	35%
Web Browser	1	5%
Internet Connection Speed	10	50%
Processor Speed	10	50%
Other	0	0%
None	0	0%

Table 6-2: Number and percentage of students that select each mobile phone capability attribute

From the results in Table 6-2, we can see that most students (80%) consider the screen size to be very influential for their preference changes. The screen size is the most obvious limitation of the mobile phone. In order to fit the web-based course contents into the mobile phone screen, the demo system automatically rearranges the course contents. Further, the smaller screen size directly results in the smaller size of web page elements, such as text, images, buttons and scroll bars, etc, which become a little hard to read and operate, especially the images. Therefore, based on this result, the screen size can be considered as an important factor that will cause the students to change their preference for visual contents.

The second important factor that can be concluded from the survey result is speed,

both Internet speed and processor speed. In the first survey, most students selected the cost of using mobile phone as their first concern. However, there were still more than 20% students choosing running speed as their first concern on both PC and mobile phone. In the second survey, students were asked to fill the questionnaire assuming that there is no mobile phone cost. Free from the influence of costs, the importance of running speeding is enhanced. 50% of the participants selected the Internet speed and also 50% of the participants selected processor speed as the factors that would make them change preference settings.

Battery time and memory size were selected by 45% and 40% of students respectively. With limited battery time, the students cannot always totally control their own learning process. Sometimes they have to stop learning because the battery is used up. Therefore, with the limited battery time, the learning activities that need longer periods of time to complete, such as learning courses and doing assignment, are difficult to be conducted continuously. Subsequently, the students' preference for such learning activities on mobile devices with limited battery time will be influenced. The limitation of memory size means the students have to spend more time on downloading the educational contents. To avoid waiting too much time, the students will very likely to turn off all the multimedia elements to save time. The memory size is also influential on the running speed of the web-based applications. Larger memory can guarantee larger cache for the application to run more quickly and smoothly.

Input method was selected by 35% of the students. The input method directly influences the preference that requires input operations, such as discussing issues and doing assignment. Another attribute that has been selected by 35% of students is operating system. How the operating system will influence the students' preference is not clear yet. During the survey, when we asked the students who chose the operating system, we were told that familiar operating systems would provide a more familiar user interface, which would be more convenient and comfortable to use. Moreover, they would prefer the operating systems that integrated more capabilities, so that they

do not have to bother installing any system drivers by themselves. The user interfaces and capabilities of the mobile phone operating systems are very different from each other today. If there are any preferences that involve further configurations or installations for the unfamiliar operating systems, the students are possibly discouraged from enabling those preferences. For example, if the system requires installation of some audio driver files to play sounds and such installation will be conducted in an unfamiliar operating system, it is very possible that the students would rather not listen to sounds.

The remaining five attributes were selected by fewer students. Video quality was selected by 30% of students. Just as its name, it will affect the students' preference for video. There are still situations that the lower video quality is not a result of the mobile phone capability but of the video file quality. Here we just assume that the video files are of proper quality and can be displayed clearly enough on PC. The same assumption should be applied to screen resolution, which was selected by 25% of students. The screen resolution attribute will not only influence students' preference for videos, but also other visual elements, including animations, images and texts. The students' learning preference for visual/verbal contents will be influenced consequently. Color display and audio quality were both selected by 15% of students respectively. As the screen resolution, color display is influential on students' multimedia preference for visual elements such as video, animation, image and text. The audio quality will be influential on students' multimedia preference for sounds. Therefore, color display and audio quality will also influence learning preference for visual/verbal contents. However, the survey result shows that most students are not influenced by color display and audio quality capabilities.

The web browser attribute was selected by only one student. It therefore does not seem to be very important for most students in the survey. Web browser capability sometimes also causes students' preferences changes. For example, some old mobile phones use WAP browsers displaying images in WBMP format that is black and

white and of lower resolution. If the students do not like to view such WBMP images, they will disable their multimedia preference for images.

We have discussed the results of the first question. Although some attributes are selected by more students and some by fewer students, all the twelve attributes seem to be possible factors for students' preference changes. No other attributes were suggested by the students in the second survey. Therefore we should monitor the mobile phone capabilities changes on all these twelve capability attributes along with the students' preference changes. However, for some multimedia preferences, not all the twelve attributes will be relevant. We have identified three such multimedia preferences, i.e. sounds, images and texts preferences. The students' sounds preference is irrelevant with screen size, color display and screen resolution. However, these three attributes will be relevant with the sound preference when the sound is turned on together with a video or animation preference. The images and texts preferences are both irrelevant with audio quality and input method. The other two multimedia preferences, videos and animations, together with learning activities preferences and learning preferences are all relevant with the twelve attributes. We will discuss in next chapter how to connect the twelve attributes with preference changes. In the following part, we will continue to analyze the second survey results.

6.3.2 Analysis of Question 2

If you make some changes for your learning preferences on PC, then on the mobile phone, you prefer:

[A] The system updates all these changes automatically
[B] Show me a list of all the changes and I will decide which ones should be updated
[C] Update the changes later manually by myself
[D] Not change anything for mobile phone preference settings

The second question tries to investigate whether the students prefer to synchronize their learning preferences in PC and in mobile phone. In addition, the most preferred

method of learning preference synchronization is also investigated in this question. Table 6-3 summarizes the total responses towards this question.

If you make some changes for your learning preferences on PC, then on the mobile phone, you prefer:	**Number of answers**	**Percentage (%) of total answers**
[A] The system updates all these changes automatically	11	55%
[B] Show me a list of all the changes and I will decide which ones should be updated	7	35%
[C] Update the changes later manually by myself	2	10%
[D] Not change anything for mobile phone preference settings	0	0%

Table 6-3: Students' preferences for learning preference synchronization

The results tell us that more than half (55%) of the participants would like the system to automatically synchronize all the learning preference changes in PC and in mobile phone. Automatic preference synchronization will update all the preference changes without students' permission. Therefore, by choosing the answer "A", those participants assumed that their learning preference changes will be applied to both PC and mobile phone. There are 35% of the participants would like to be first prompted with a list of all preference changes. These participants thought that some of their preference changes were not applicable to both PC and mobile phone, and that they should choose preference changes for updating. The rest two participants chose to update the preference changes by themselves. These two participants wanted to use the system and got some real learning experience in the other device before they could decide which preference changes should be applied for that device. No participant chose answer "D", which means there was no participant who would ignore the preference changes in other device.

From the survey results of this question, we can conclude that all participating students would like to update their student profile in mobile phone with learning preference changes in PC. The most preferred synchronization method is automatic update for learning preference changes. However, in order to make the system

adaptive enough for the rest of students, the system should offer the choice between automatic update and manual update. Both update methods should display the students a list of all the learning preference changes that have already been made in other devices.

6.3.3 Analysis of Question 3

If you have changed some of your learning preferences on PC in the middle of your current online course, when will you update your learning preferences on mobile phone?

[A] Update the changes immediately
[B] Update the changes after the current course is completed
[C] Both are ok with me
[D] Not update the changes

This question is still investigating the synchronization method for learning preference changes. However this question is focusing on the time of the synchronization. We can look at Table 6-4 for more details of the results for this question.

If you have changed some of your learning preferences on PC in the middle of your current online course, when will you update your learning preferences on mobile phone?	Number of answers	Percentage (%) of total answers
[A] Update the changes immediately	10	50%
[B] Update the changes after the current course is completed	7	35%
[C] Both are ok with me	3	15%
[D] Not update the changes	0	0%

Table 6-4: Students' preferences for the time of learning preference synchronization

From Table 6-4, we can find that half of the participants chose immediate update for learning preference changes, which means that the preference changes would take effect in both PC and mobile phone immediately after they had been made regardless of the course status. When choosing this method, the students assumed that their

learning preference changes were the same for both PC and mobile phone during current course. Those changes had to be updated immediately so that the students could continue their course in either PC or mobile phone in a more preferred style. From Table 6-4, we also find that seven participants (35%) would like to update the changes after completing current course, which means that those participants would make learning preference changes for the current course in current device only. The learning preference changes should not affect their current course learning in other devices. By doing so, the students can continue their online course in a fixed style throughout the course in other device. However, their learning preference changes will be applied in their current device immediately during the course. The rest three participants do not care about the time of updating. Further, no participants chose answer "D", which is the same as the result of question 2 and it means that no participants would ignore the learning preference changes in other devices.

Since the number of students choosing "update immediately" (10) and the number of students choosing "update after current course" (7) are both large in proportion, we find it necessary that the students have the final decision for the time of learning preference synchronization. An option should be provided so that the students can select their best time for learning preference synchronization.

6.3.4 Analysis of Question 4

When using the demo system, suppose that there are conflicts between your learning preferences and other preferences (multimedia preferences or learning activities preferences), e.g. your learning preferences show that you like "visual contents" but your multimedia preferences show that you don't like to view images, animations or videos. Which of the following methods do you prefer?

[A] Consider the learning preferences first and neglect other preferences
[B] Consider the other preferences first and neglect the learning preferences
[C] Update the learning preferences with other preferences
[D] Update the other preferences with learning preferences

There are sometimes conflicts between learning preferences and other preferences. This question investigates students' preference for the possible solutions for such conflicts. The results of this question have been summarized in Table 6-5.

When using the demo system, suppose that there are conflicts between your learning preferences and other preferences (multimedia preferences or learning activities preferences), e.g. your learning preferences show that you like "visual contents" but your multimedia preferences show that you don't like to view images, animations or videos. Which of the following methods do you prefer?	**Number of answers**	**Percentage (%) of total answers**
[A] Consider the learning preferences first and neglect other preferences	5	25%
[B] Consider the other preferences first and neglect the learning preferences	5	25%
[C] Update the learning preferences with other preferences	8	40%
[D] Update the other preferences with learning preferences	2	10%

Table 6-5: Students' preferences for preference conflicts solutions

From the results, we can see that a total of 7 participants (35%) selected answer "A" or answer "D". According to the question, these participants are more concerned about their learning preferences rather than other preferences. Therefore, we can consider this group of participants to be more sensitive to learning preference. Among them, two participants (10%) wanted to update the other preferences with their learning preferences to resolve possible preference conflicts. The remaining five participants (25%) just wanted the system to provide adaptive contents based on their learning preferences. The other group of participants who chose answer "B" (25%) and answer "C" (40%) can then be considered less sensitive to learning preferences. The number of participants in this group (13) almost doubles the number of participants in the other group (7). So we can conclude that the majority of students in the survey would resolve the preference conflicts by considering other preference (multimedia preferences and learning activities preferences) in priority. When designing framework for student profile transformation, the default method for

resolving preference conflicts should also consider other preferences in priority. The students should be able to change the conflicts resolving methods and decide whether learning preferences or other preference will be updated to achieve conformity when preference conflicts occur.

6.3.5 Analysis of Question 5

If some of your learning preferences are not supported by your current mobile phone, e.g. you prefer to view "visual contents" but your mobile phone doesn't support image or video display, which of the following methods do your prefer?

[A] Continue to learn and keep the learning preferences settings unchanged
[B] Continue to learn after changing the learning preferences settings to suit the mobile phone capabilities
[C] Continue to learn by using supported contents as a replacement, but keep the learning preferences settings unchanged
[D] Stop learning on mobile phone, because it can not fulfill my learning preferences

In present day, mobile phone capabilities are not as powerful as PC. The relatively limited capabilities will sometimes prevent the system from providing adaptive contents based on students' preferences on mobile phone. Under such situations, will the students change their preferences? Will the students use supported content as a replacement to deal with such situations? We try to find out the answers to these questions by analyzing the survey result of question 5 shown in Table 6-6.

If some of your learning preferences are not supported by your current mobile phone, e.g. you prefer to view "visual contents" but your mobile phone doesn't support image or video display, which of the following methods do your prefer?	**Number of answers**	**Percentage (%) of total answers**
[A] Continue to learn and keep the learning preferences settings unchanged	3	15%
[B] Continue to learn after changing the learning preferences settings to suit the mobile phone capabilities	7	35%
[C] Continue to learn by using supported contents as a replacement, but keep the learning preferences settings unchanged	5	25%
[D] Stop learning on mobile phone, because it can not fulfill my learning preferences	5	25%

Table 6-6: Methods for dealing with unsupported preference settings

There are 15 participants (who chose answer "A" or "B" or "C") who would like to continue to learn when their mobile phone cannot support some of their preferences. Only 5 participants would stop learning because of limited mobile phone capability not supporting their preferences, which also means they will not change their preferences. Among the 15 participants who would continue to learn, 35% of them would change their preferences, 25% would use supported contents as a replacement but keep preferences unchanged, and the rest 15% would just ignore the unsupported contents and keep preferences unchanged. Therefore, the number of participants that would not change their preferences was 13 (3+5+5), which was the number of participants who chose answer "A", "C" or "D". According to this result, it can be concluded that most students will not change their preferences when their mobile phone capabilities are too limited to provide the preferred contents. So the system should keep all of the students' preferences unchanged as default. We can also find in Table 6-6 that not too many participants (5) would use supported contents as a replacement. Therefore it is not necessary for the web-based learning system to automatically provide alternative contents for most students. However, it will be better if the web-based learning system could show the students with a list of supported alternatives to choose from.

6.3.6 Analysis of Question 6

When learning on mobile phone, my learning preferences tend to change based on various locations:

[A] Strongly agree
[B] Agree
[C] Not sure
[D] Disagree
[E] Strongly disagree

The students who access web-based learning system via mobile phone will be able to move around various places while using the system. The learning environments of these various locations are usually quite diversified. In this question, we try to investigate whether the various locations will be responsible for students' learning preference changes on mobile phone.

When learning on mobile phone, my learning preferences tend to change based on various locations:	Number of answers	Percentage (%) of total answers
[A] Strongly agree	1	5%
[B] Agree	10	50%
[C] Not sure	5	25%
[D] Disagree	3	15%
[E] Strongly disagree	1	5%

Table 6-7: The influence of various locations on learning preferences

From the results in Table 6-7, we can see clearly that more than half of the participants (55%) believe their learning preferences will change based on various locations. In the survey, only four participants (20%) believe that their learning preferences will not be influenced in various locations and five participants (25%) are not sure of the influence of various locations. Therefore, the location plays a quite influential role in most students' learning preference changes on mobile phone. It is very important to consider the influence of locations when transforming student profile between PC and mobile phone.

6.3.7 Analysis of Question 7

The default settings for learning preferences on mobile phone should be the same as on PC, and vice versa.

[A] Strongly agree
[B] Agree
[C] Not sure
[D] Disagree
[E] Strongly disagree

This question is about the default settings of learning preference in student profile. On mobile phone, if the default settings are preferred to be the same as on PC, then the learning preference on mobile phone can be automatically copied from PC. Otherwise, the learning preference should be either manually defined or be automatically set to all "a" (The eight learning preference questions are divided into four pairs, and the number of "a" responses to each pair can decide the level on each learning style dimension. That all the eight questions get "a" responses means that each of the four pairs will get 2 "a" responses, which can be explained as strong preference for "active/sensing/sequential/visual" on the four learning style dimensions.) at the time of registration. Table 6-8 shows the results of this question.

The default settings for learning preferences on mobile phone should be the same as on PC, and vice versa.	Number of answers	Percentage (%) of total answers
[A] Strongly agree	7	35%
[B] Agree	10	50%
[C] Not sure	3	15%
[D] Disagree	0	0%
[E] Strongly disagree	0	0%

Table 6-8: Default settings for learning preferences

The result for this question is one sided. A dominant number of seventeen participants (85%) agreed that the learning preferences on mobile phone should be the same as on PC as default and no participant disagreed with this method. The rest three participants (15%) chose "not sure". Based on such a result, it seems that to use the

same learning preference settings as default for both PC and mobile phone is acceptable by majority of students. This is probably because the students' existing preference settings on one device should be the most similar ones to their preference settings on other devices. There are students who even believe that their learning preferences will remain the same regardless of the accessing devices. So the default learning preference settings of the students on mobile phone should be the same as on PC, and vice versa.

6.4 Conclusion of the Second Survey

The analysis of the second survey has been completed. We have found out the answers for all the questions we have raised at the beginning of this chapter. The answers can be concluded as follows:

- ✧ In the second survey, all the proposed device capability attributes were selected by the participants as possible influential attributes for their preference changes. Among those attributes, the most influential attribute for most participants is screen size, while the least influential one is web browser. No other attributes were suggested by the participants.
- ✧ Based on the survey results, all the participants want their preference changes to be updated on every device they use to access the web-based learning system. For most participants, the synchronization of student profiles on PC and on mobile phone should be done by the system automatically and immediately. Further, most students prefer that the default learning preference settings on mobile phone should be the same as on PC, and vice versa.
- ✧ More than half of the survey participants believe that their learning preferences will be different in different locations. However, there are still 20% of the participants who believe that learning preferences will not change according to various locations.

- ✧ According to the survey results, most participants will either consider other preferences first or update learning preferences with other preferences.
- ✧ Most participants will not change their preferences when their mobile phone capabilities are too limited to provide the preferred contents. Some participants even would rather stop learning on mobile phone. However, there are still a considerable percentage of participants who will adjust their preferences to get supported contents on mobile phone.

6.5 Summary

The second survey tries to get more real and precise responses from the students by providing the students with a demo learning system to use. In this chapter, we analyzed the results of the second survey, based on which we investigated the mobile phone capabilities' influence on students' preferences, the preferred student profile synchronization method and the influence of various locations. The results of the first and the second survey give us a concrete and objective basis for proposing the student profile transformation framework, which will be discussed in next chapter.

Chapter 7 : Student Profile Transformation Framework

7.1 Introduction

Through the two surveys, we have obtained useful knowledge about what kind of information should be included in the student profile and how the environment factors, such as device capability and location, would influence students' preference settings. Based on the survey results, we can now start to construct a framework for student profile transformation. In this chapter, we will propose a framework that could transform student profile between PC and mobile phone, by fully considering the influences of environment factors, such as mobile phone capability and location, on students' preferences.

7.2 Connect Device Capability with Student Preference Changes

From the survey results, it is clear that students' preferences are influenced by device capability and location. However, the influences from device capability and location are very different for different students. Some students are very easily influenced by these two factors and will change their preferences easily. Some are just not aware of the two factors and will keep their original preference settings. Moreover, the factors that will result in a student's preference changes are not always the same for every student. Therefore, in order to achieve successful student profile transformation, it is necessary for the system to connect students' preference changes with device capability and location.

We found from the two surveys that the students' preference would change while they are using different devices to access the web-based learning system. The students' preference settings would be influenced by various mobile device capabilities. In this section, we will discuss how these device capabilities can be connected with student preference changes, which is a key element for the student profile transformation framework.

First of all, the web-based learning system should have a device profile to record all the capability differences of the accessing device. The students make preference changes because there are differences between the capabilities of their current devices and the capabilities of their previous devices. In the second survey, we suggested 12 device capabilities for the students to choose from and we did not get any new proposed device capability in that survey. Therefore, as an initial work, the device profile for the framework can just record these 12 device capabilities, which are listed as follows:

- ✧ Screen Size
- ✧ Color Display
- ✧ Screen Resolution
- ✧ Audio Quality
- ✧ Video Quality
- ✧ Input Method
- ✧ Battery Time
- ✧ Memory Size
- ✧ Operating System
- ✧ Web Browser
- ✧ Internet Connection Speed
- ✧ Processor Speed

Secondly, the capability or capabilities that make the students to change their preference settings should be identified by the web-based learning system. From the

survey results we know that the influences of the device capabilities on students are quite different. The device capabilities that will make the students to change their preference settings are also different for each student. When a student makes any preference changes on a certain accessing device, he or she will be the only one who knows best what makes him or her change the preferences. Therefore, the device capabilities connected with certain preference changes can be indicated by the students at the time they make such changes. In our proposed framework, each of the students' preference changes will always be connected with a subset or all of the above mentioned 12 device capabilities. Therefore, for each preference change, there are always Preference-Change related Device Capabilities, which could be named shortly as PCDCs. By doing so, we create a device environment in which a particular student will make a particular preference change. When the PCDCs in previous accessing device are the same with corresponding capabilities in current accessing device, the same preference change could be applied to that student's profile for current device. For example, when using previous accessing device, a student changes his or her image preference to "False" and selects "Screen Size" and "Internet Connection Speed" as the PCDCs. Suppose the "Screen Size" is 128*128 and "Internet Connection Speed" is 56 Kbps in previous accessing device. If the student is now using a device that has the same capabilities, that is, 128*128 Screen Size and 56Kbps Internet Connection Speed, then the student should also change his or her image preference to "False", which could be done by the system automatically.

However the automatic preference changes update should not occur only at the time when current accessing device has the same device capabilities with previous accessing device. If those PCDCs are not the same in current device and previous device, automatic preference change update should also be triggered. We can classify relationship between the PCDCs in current device ($PCDC_{cur}$) and the PCDC in previous device ($PCDC_{pre}$) into three types:

1. The $PCDC_{cur}$ is better than the $PCDC_{pre}$, which will be symbolized as ">" in

this thesis;

2. The $PCDC_{cur}$ is the same as the $PCDC_{pre}$, which will be symbolized as "=" in this thesis;
3. The $PCDC_{cur}$ is worse than the $PCDC_{pre}$, which will be symbolized as "<" in this thesis.

Since the $PCDC_{cur}$ and $PCDC_{pre}$ have to be read from respective device profiles, both previous device profile and current device profile should be available for getting PCDC values. If the current device is the student's first accessing device, that is, there is no previous device profile, a copy of the current device profile will be treated as a previous device profile as default. We can use D_n to define different devices, where n is the sequential order in which the student uses them for learning. Then the device profiles of all the devices can be defined as DP_n. The student's first accessing device is D_1 and his or her nth accessing device will be D_n. The device D_1 does not have a previous accessing device. So we could use D_0 to represent D_1's previous device and DP_0 to represent the previous device profile, where DP_0 is the same as DP_1. In addition, the student may change more than one preference in his or her current accessing device. Therefore we need to discriminate those changes by defining them as PCDCmn, where n is the accessing device sequential order and m is the preference change sequential order in the nth accessing device.

After defining all these terms, we can now use D_n to stand for current device, D_{n-1} for previous device and D_{n+1} for next device. Suppose the student makes the mth preference change. The Preference-Change-related Device Capabilities, $PCDC_{mn}$, will be indicated and attached to the mth preference change. The $PCDC_{mn}$ will then be compared with its counterpart, $PCDC_{m\,(n-1)}$ in the device profile, DP_{n-1}, of the previous device D_{n-1}. Through the comparison, we can conclude the relationship between $PCDC_{mn}$ and $PCDC_{m\,(n-1)}$, which should be one of the three types defined above. When the student starts to use the next accessing device D_{n+1} for learning, the device D_{n+1} will become the current device and D_n will become the previous device. We can

see such role changes of accessing devices in Table 7-1. Therefore, we could compare $PCDC_{m(n+1)}$ in current device $D_{(n+1)}$ with its counterpart, $PCDC_{mn}$, in previous device D_n, and then conclude the relationship between them. If the student makes a preference change because the PCDCs in current device D_n are worse than PCDCs in previous device D_{n-1}, it is certain that he or she will make the same preference change when his or her next device D_{n+1} has the PCDCs that are the same or even worse than PCDCs in D_n. This can be explained further in details by extending the last example: a student has set all his or her preferences in device D_1 and now starts to use D_2 as the accessing device. In D_2, the student changes his or her image preference to "False" and selects "Screen Size" and "Internet Connection Speed" as the PCDCs. Suppose the "Screen Size" and "Internet Connection Speed" of D_1 are 128*128 and 56 Kbps, and the "Screen Size" and "Internet Connection Speed" of D_2 are 64*64 and 48 Kbps respectively. We can say that the student's image preference changes because the PCDCs of current device D_2 are worse than previous device D_1. When the student starts to use D_3, the PCDCs of D_3, which are "Screen Size" and "Internet Connection Speed", will also be compare with the PCDCs of the previous device D_2. Suppose the "Screen Size" and "Internet Connection Speed" of D_3 are also 64*64 and 48 Kbps or even worse, the student should also change his or her image preference to "False". So this preference can be done by the system automatically. This example describes a scenario where the student's preference change is caused by insufficient device capabilities of current device. However, there are still scenarios that the preference changes are resulted from better device capabilities of current device. In such scenarios, the next "current" device should have the same or even better PCDCs for the preference changes to be updated automatically.

Sequential Order of Accessing Devices	**Previous Device**	**Current Device**
1	D_0	D_1
2	D_1	D_2
. . .	. . .	. . .
n	D_{n-1}	D_n
n+1	D_n	D_{n+1}

Table 7-1: Role changes of accessing devices in the sequential order

Sometimes, the scenarios are not as simple as we have discussed above. The PCDCs of the next "current" device are not always all better, worse or the same as the PCDCs of current device. Some PCDCs maybe better, some maybe the same and the others maybe worse. When such scenarios occur, the student needs to re-consider his or her preference settings. All the better capabilities and the worse capabilities included in PCDCs will be mediated by the student himself or herself to decide whether the same preference change will be preferred or not. The preference change will not be updated automatically. If the student still decides to change the preference, the PCDCs will also be recorded for next device. The conditions for automatic preference change update can be concluded as in Table 7-2. Suppose the particular preference change is the mth preference change in device D_n.

Current Device = D_n **Previous Device = D_{n-1}**	**Current Device = D_{n+1}** **Previous Deice = D_n**	**Automatic Preference Change Update**
$PCDC_{m\,(n-1)} < PCDC_{mn}$	$PCDC_{mn} \leq PCDC_{m(n+1)}$	True
	$PCDC_{mn} > PCDC_{m(n+1)}$	False
$PCDC_{m\,(n-1)} > PCDC_{mn}$	$PCDC_{mn} \geq PCDC_{m(n+1)}$	True
	$PCDC_{mn} < PCDC_{m(n+1)}$	False

Table 7-2: Conditions for automatic update of device capability related preference changes

It can be noticed that in Table 7-2, the relation "$PCDC_{m\,(n-1)} = PCDC_{mn}$" has not been included. The reason is that the same device capabilities will not result in preference changes. We know from the two surveys that different device capabilities will result in student's preference changes. If there are two devices with the same device capabilities, the student will not set different preferences for the two devices, unless the student has been influenced by other environment factors, such as locations. In next section, we will discuss about locations and preference changes in more detail.

7.3 Influence of Various Locations

In our second survey, more than half of the participants agreed that their learning preferences tend to change based on various locations. Therefore, it is essential to take the influence of locations into consideration for student preference changes. We have already investigated the popular locations for mobile learning in the first survey. Each of these locations has its own features and has different influences on individual student's preferences. Therefore, every student should have his or her preference settings for a particular location, which could be called Location Based Preference Changes (LBPCs).

The LBPCs are the preference changes that a student makes for a particular location. Therefore, those preference changes should only be triggered by various locations. The initial LBPCs are set manually by the student. The update method for LBPCs are much simpler compared with the update of preference changes caused by device capabilities. This is because we have not modeled every location by location characteristics. Each location is considered as one influential factor for preference changes. Therefore the condition for automatic update of LBPCs is that the location should be the same.

When considering automatic preference change update, we should first identify

whether the cause of the preference change is device capability, location or both, which again should be indicated by the student himself or herself. By using the conditions in Table 7-2, we can summarize the conditions for automatic update of both device capability related and location related preference changes in Table 7-3.

Cause of Preference Change	**Meet Automatic Update Conditions In Table 7-2**	**Same Location**	**Automatic Preference Change Update**
Device Capability	True	True or False	True
	False	True or False	False
Location	True or False	True	True
	True or False	False	False
Both Device Capability & Location	True	True	True
	False	True or False	False
	True or False	False	False

Table 7-3: Conditions for automatic update of both device capability related and location related preference changes

7.4 Solution for Unsupported Preference & Preference Conflict

After discussing the conditions for automatic update of student preference changes, we will continue to discuss another two factors that may result in student preference changes, which are unsupported preference and preference conflict.

The unsupported preferences are the result of device incapability, which is even worse than lower device capability. When the device is not able to support one of student's preference settings, the device usually just neglects that preference and does nothing. For example, when a device does not support images, it usually displays a blank

screen or displays an error message in the place where the image should be displayed. The result of the second survey shows that most students will continue learning but with different strategies for the unsupported preferences, such as neglecting the preference, change to a supported preference or to use a replacement preference. For each unsupported preference, the student should select one of the three solutions. Once the solution is selected, the solution can be automatically applied to the same subsequent unsupported preferences on other devices.

The preference conflicts are defined as the conflicts between learning preferences and other preferences (multimedia preferences and learning activity preferences) in this thesis. The majority of participants of second survey chose to consider other preferences as in priority. Therefore, as we have proposed in the second survey's analysis that "other preferences first" can be used as the default solution, but the student should also be able to choose to consider their learning preference first.

7.5 The Framework

By taking device capabilities, locations, unsupported preference and preference conflict into consideration, we are finally ready to propose a framework for student profile transformation between a PC and a mobile phone. The framework can be presented as in Figure 7-1.

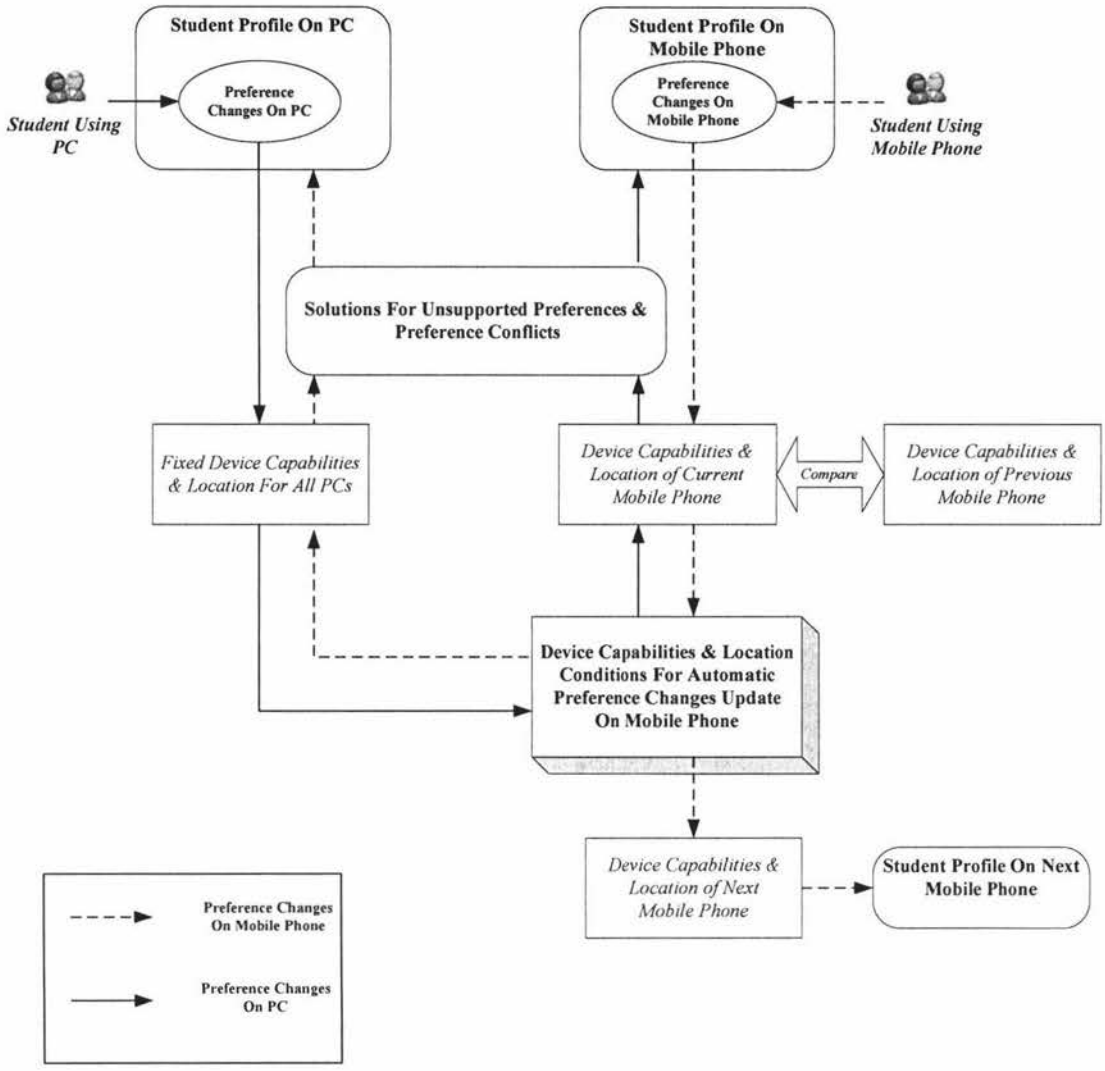


Figure 7-1: Framework for student profile transformation between PC and mobile phone

We can find in this framework that only the particular device capabilities and locations of the mobile phone will be considered when the profile transformation occurs. As we have discussed in chapter 5, this is because we assume that all PCs are of adequate capabilities to fulfill all the student preferences settings. Moreover, we assume that the location where a PC is used as accessing device is fixed. So in the framework, the device capabilities and location of PC are fixed for all PCs. Now let us go through the key components of this framework.

7.5.1 Student & Student Profiles

At first let us consider the student who is using the web-based educational system. The student is expected to have two different student profiles with different preference settings on PC and mobile phone. However, according to the second survey results, most students prefer that their default learning preference settings are same on both PC and mobile phone. They will first use the default preferences and then decide whether preference changes are needed. Therefore, in the proposed framework, both learning preferences and other preferences (multimedia preferences and learning activities preferences) will be same as default settings after a student sets up his or her first student profile. This means when the student constructs his or her student profile initially on PC, his or her profile on mobile phone will be same as default, and vice versa. Only after the student uses the web-based educational systems with these default preferences, he or she could make more practical preference settings, which are called as preference changes in this thesis.

7.5.2 Preference Changes, Device Capabilities & Locations

The preference changes are the most important components in the framework. The preference changes on the mobile phone will be connected with the current device capabilities and locations. Then by comparing current device with previous device, the conditions for automatic preference changes update can be obtained, which have already been discussed in the previous section. Only after the conditions are met, the same preference changes could be updated on PC and on next mobile phone. The preference changes on PC will not be related to particular device capabilities or the locations of a PC. However, fixed device capabilities and location will be used to decide whether the preference changes on PC can be automatically updated on mobile phone. One thing should be noted here that the preference changes on PC will not decide the conditions for automatic preference change update, but can only be obtained by comparing current and previous mobile phones.

In the framework, the preference changes on mobile phone are presented by broken arrows and the preference changes on PC are presented by solid arrows. When there is a preference change on mobile phone, the change will first be connected with certain device capabilities and location of current mobile phone. These device capabilities and locations will be compared with those of the previous mobile phone. Through this comparison, the conditions of automatic preference change update could be obtained. If the current mobile phone is the first mobile phone that a student uses as accessing device, the previous mobile phone will be considered to have the same device capabilities and locations as the current one. After the conditions are obtained, the PC's capabilities and location will be checked against the conditions to see whether these preference changes can be automatically updated on a PC. The conditions will also be used for automatic preference change update on next mobile phone in the same method.

If the preference change is made on PC, the fixed PC capabilities and location will be compared with the mobile phone capabilities and locations to decide whether the conditions for automatic preference changes are met. If the conditions are met, the preference change on PC will continue to update the student profile on mobile phone. If the conditions have not been set yet (for example, when the student has not used mobile phone or has not made any preference changes), the preference change on PC will also pass the condition and continue to update student profile on mobile phone.

Therefore in the framework, the preference change on mobile phone has two functions. One is to set the student profile on mobile phone and the other is to set the conditions for automatic preference changes, while the preference change on PC can only set the student profile on PC.

7.5.3 Solution for Unsupported Preferences & Preference Conflicts

When the preference changes on PC have passed the conditions and are ready to update the student profile on mobile phone, or when the preference changes on mobile phone have passed the conditions and are ready to update the student profile on PC, all the preference changes need to be checked for possible unsupported preferences and preference conflicts. Any unsupported preferences or preference conflicts should be solved before the preference changes update student profile. The solution is based on the second survey result, which has been presented in previous section.

7.6 Summary

In this chapter, we proposed a framework based on the results of the two surveys. The framework takes the influence of device capabilities and locations into consideration. Moreover, the framework also provides solutions for unsupported preferences and preference conflicts which are likely to occur during student profile transformation.

Chapter 8 : Conclusions & Future Work

8.1 Introduction

Based on the literature review, demo system development, and two survey analyses, we proposed a framework for student profile transformation. In this chapter, we will conclude the contributions of this research and then, the possible future work will be discussed.

8.2 Contributions of the Research

In this research, we conducted two surveys and subsequently proposed a student profile template and a student profile transformation framework. The main contributions of this research work can be concluded as follows:

- ✧ Two surveys have been conducted during the research to get feedback from students about their possible preference changes between PC and mobile phone. The survey results indicated that student's preferences are influenced by device capabilities and locations, but the influences are different for different students. Further, the surveys also found that most students would like to consider their other preferences, which include multimedia preferences and learning activities preferences, as a priority rather than learning preferences.
- ✧ This research proposed a student profile template that integrates student identity, learning resource, learning context, multimedia preference, learning activities preference and learning preference. The student profile template can not only provide necessary information about the students and course, but also records students' preferences in particular devices and locations.
- ✧ In order to get more precise responses from the students in the survey, a demo

web-based educational system has been developed for survey participants to use before they filled out the survey questionnaire. The system could provide students with personalized educational contents based on their preferences settings on a PC and on a mobile phone. The synchronization of each preference change in the system was decided by the students. This system was a useful initial step towards further implementation of the student profile transformation framework.

- ✧ A framework has been proposed, based on the survey results for student profile transformation between PC and mobile phone. The framework fully considered the factors such as device capabilities, locations, unsupported preference and preference conflicts during student profile transformation.

8.3 Future Work

The above mentioned contributions basically fulfill the objectives of this research project. Students' preference differences between PC and on mobile phone have been investigated and then integrated into a framework, which connect students' preference changes with contextual factors, such as device capabilities and locations, for learning using mobile phones. However there are still some future works that can be done in this area.

8.3.1 Considering More Device Capabilities

This research only investigated students' preference changes between PC and mobile phone, which is not the only mobile device that can be used as accessing device to web-based educational system. Presently, mobile devices are evolving very rapidly and new functions and new mobile devices keep emerging. In order to include other mobile devices into our proposed framework, it is essential to update the device capabilities list that will be used in the framework. Further, research should also be

done to investigate how those updated device capabilities will influence students' preferences on mobile devices.

8.3.2 Defining Location Characteristics

The other important contextual factor, location, was only generally considered in this research. For example, if two locations have the same names, the two locations will be assumed to have the same influences on students' preference changes. However, this is not always true. The environment in the same locations also changes over time. Therefore, it will be better to connect location characteristics rather than location names with students' preference changes. It is just the same as we connect device capabilities rather than device model names with students' preference changes. In addition, whether and how the students' preferences will be different when they are standstill or mobile in the same location still needs investigating.

8.3.3 Implementation of the Framework

The proposed framework needs to be developed into real systems for evaluation in future work. Through the development and evaluation, it is expected that we can get more useful feedback for improving the framework. The demo system we developed in this research could be an initial step towards the implementation of the framework.

8.3.4 Integrating More Preference Settings in Student Profile

This research concentrated on students' multimedia preference, learning activities preference and learning preference in student profile. Other types of preferences should also be investigated for both PC and mobile learning environments. Moreover, we selected only eight most representative questions from the Index of Learning Styles questionnaire to determine students' learning preference. In order to get more

detailed and precise images of students' learning preferences, we should construct more learning preference questions on each of the four learning style dimensions.

8.4 Summary

This chapter concludes the main contributions of the research project on student profile transformation between PC and mobile phone, which fulfill the objectives of this research. Some future works have also been suggested on considering more device capabilities, identifying location characteristics, developing a prototype to evaluate the framework and integrating more preferences settings for the framework.

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Appendix A: First Survey Questionnaire

Survey Questionnaire for Learner Profile

1. Are you currently enrolled in any courses in any institute/university?
   ___ YES ___ NO
   If YES, what are you studying? (Qualification and subject)_____.
   If NO, what is your highest qualification? _____.

2. Have you used any web-based educational applications, e.g. WebCT online courses?
   ___ YES ___ NO
   If YES, please provide the names of those applications _____ .

3. Suppose that you are using web-based educational applications via *Desktop PC*, which of the following factors you will be most concerned about? (Please choose one).

   ___ A. Educational Contents ___ B. Multimedia Effects
   ___ C. Running Speed ___ D. Overall Costs

4. Suppose that you are using web-based educational applications via *Mobile Phone*, which of the following factors you will be most concerned about? (Please choose one).

   ___ A. Educational Contents ___ B. Multimedia Effects
   ___ C. Running Speed ___ D. Overall Costs

5. Suppose that you are going to take an online course and you have *Desktop PC*, *PDA* and *Mobile Phone* to access this online course. For various learning activities during the online course, please use an "X" to choose your most preferred device for each of those activities.

Learning Activities	Desktop PC	PDA	Mobile Phone
Preview the course			
Learn new knowledge			
Check notices about the course			
Discuss problems with others			
Review the course			
Do assignments			

6. Please rank the three most possible places from the following list, where you will use *Mobile Phone* to access web-based educational applications.

___ A. Campus
___ B. Classroom
___ C. Library
___ D. Café
___ E. Computer Lab
___ F. Bus stop
___ G. Home
___ H. Shopping Mall
___ I. On the road (in cars, buses or trains)
___ J. Other places _____ (please indicate)

7. The following is a list of statements about your Multimedia Preferences on *Desktop PC* and *Mobile Phone*. Please use an "X" to choose the proper devices for each statement (for each statement, you can choose one or both devices).

Multimedia Preferences	Desktop PC	Mobile Phone
I would prefer to watch quality VIDEOS if available on		
I would prefer to hear quality SOUNDS if available on		
I would prefer to watch quality ANIMATIONS if available on		
I would prefer to see quality IMAGES if available on		
I would prefer to read detailed TEXTS if available on		

8. The following is a list of eight pairs of statements about Learning Styles. Suppose that you are taking online courses via *Desktop PC*. Please choose one statement from each pair that is better suitable for you (please put an "X" in front of your selected statement).

No.	Learning Style Questions on Desktop PC	
1	___ ***I prefer the course contents to be concrete mostly information*** *(e.g. facts, data and experimentation).*	___ ***I prefer the course contents to be mostly abstract concepts*** *(e.g. principles, theories and mathematical models).*
2	___ ***When I study, I prefer to master the standard solutions for problems*** *(e.g. master only the standard answer to a mathematical problem).*	___ ***When I study, I prefer to find out new solutions for problems*** *(e.g. want to find out other answers to a mathematical problem besides the standard answer).*
3	___ ***It is easier to understand the course contents that are explained visually*** *(e.g. by pictures, charts and diagrams).*	___ ***It is easier to understand the course contents that are explained verbally*** *(e.g. by lecturers' written and spoken instructions and explanations).*
4	___ ***I like to read books that have many pictures*** *(e.g. comic books).*	___ ***I like to read books that contain mostly texts*** *(e.g. novels).*
5	___ ***I can understand something better after I try it out*** *(e.g. some practices with database software will help you understand database theories better).*	___ ***I can understand something better after I think it through*** *(e.g. to think about all the procedures of manipulating database software will help you understand database theories better).*
6	___ ***I like to study in study groups.*** *(e. g. contribute your ideas in group discussions).*	___ ***I like to study alone*** *(e. g. sit back and listen to the discussion only).*
7	___ ***I like to learn course contents step by step*** *(e. g. study from easy level to difficult level in sequential order).*	___ ***I like to jump to advanced topics when learning*** *(e. g. proceed to study more difficult levels before completing all the easier levels).*
8	___ ***When learning a new subject, I stay focused on that subject and learn as much about it as I can*** *(e. g. when you study how to put texts on your web page, you will not go to find out how to put images on the web page).*	___ ***When learning a new subject, I try to connect that subject with related subjects*** *(e. g. when you study how to put texts on your web page, you will also go to find out how to put images, tables, buttons and other elements on the web page).*

9. Now, suppose that you are taking online courses via *Mobile Phone*. Please choose one statement that is better suitable for you from each pair and place an "X" in front of your choice.

No.	Learning Style Questions on Mobile Phone	
1	___ ***I prefer the course contents to be mostly concrete information*** *(e.g. facts, data and experimentation).*	___ ***I prefer the course contents to be mostly abstract concepts*** *(e.g. principles, theories and mathematical models).*
2	___ ***When I study, I prefer to master the standard solutions for problems*** *(e.g. master only the standard answer to a mathematical problem).*	___ ***When I study, I prefer to find out new solutions for problems*** *(e.g. want to find out other answers to a mathematical problem besides the standard answer).*
3	___ ***It is easier to understand the course contents that are explained visually*** *(e.g. by pictures, charts and diagrams).*	___ ***It is easier to understand the course contents that are explained verbally*** *(e.g. by lecturers' written and spoken instructions and explanations).*
4	___ ***I like to read books that have many pictures*** *(e.g. comic books).*	___ ***I like to read books that contain mostly texts*** *(e.g. novels).*
5	___ ***I can understand something better after I try it out*** *(e.g. some practices with database software will help you understand database theories better).*	___ ***I can understand something better after I think it through*** *(e.g. to think about all the procedures of manipulating database software will help you understand database theories better).*
6	___ ***I like to study in study groups.*** *(e. g. contribute your ideas in group discussions).*	___ ***I like to study alone*** *(e. g. sit back and listen to the discussion only).*
7	___ ***I like to learn course contents step by step*** *(e. g. study from easy level to difficult level in sequential order).*	___ ***I like to jump to advanced topics when learning*** *(e. g. proceed to study more difficult levels before completing all the easier levels).*
8	___ ***When learning a new subject, I stay focused on that subject and learn as much about it as I can*** *(e. g. when you study how to put texts on your web page, you will not go to find out how to put images on the web page).*	___ ***When learning a new subject, I try to connect that subject with related subjects*** *(e. g. when you study how to put texts on your web page, you will also go to find out how to put images, tables, buttons and other elements on the web page).*

Survey completed. Many thanks for taking this survey!

Appendix B: Second Survey Questionnaire

Survey Questionnaire for Student Profile Transformation

1. **The following is a list of mobile phone capability attributes that will probably affect your preferences (learning activities preferences, multimedia preferences and learning preferences) on mobile phones. After using the demo system, please select the attributes that will eventually make your preferences on mobile phone different from those on PC. You can choose more than one attributes.**

___ [A] Screen Size	___ [H] Memory Size
___ [B] Color Display	___ [I] Operating System (e.g. Windows Mobile , and PalmOS, etc.)
___ [C] Screen Resolution	___ [J] Web Browser (e.g. Mobile IE and Handspring Blazer, etc.)
___ [D] Audio Quality	___ [K] Internet Connection Speed
___ [E] Video Quality	___ [L] Processor Speed
___ [F] Input Method	___ [M] Other (Please specify)
___ [G] Battery Time	___ [N] None

2. **If you make some changes for your learning preferences on PC, then on the mobile phone, you prefer:**

[A] The system updates all these changes automatically

[B] Show me a list of all the changes and I will decide which ones should be updated

[C] Update the changes later manually by myself

[D] Not change anything for mobile phone preference settings

3. **If you have changed some of your learning preferences on PC in the middle of your current online course, when will you update your learning preferences on mobile phone?**

[A] Update the changes immediately
[B] Update the changes after the current course is completed
[C] Both are ok with me
[D] Not update the changes

4. **When using the demo system, suppose that there are conflicts between your learning preferences and other preferences (multimedia preferences or learning activities preferences), e.g. your learning preferences show that you like "visual contents" but your multimedia preferences show that you don't like to view images, animations or videos. Which of the following methods do you prefer?**

[A] Consider the learning preferences first and neglect other preferences
[B] Consider the other preferences first and neglect the learning preferences
[C] Update the learning preferences with other preferences
[D] Update the other preferences with learning preferences

5. **If some of your learning preferences are not supported by your current mobile phone, e.g. you prefer to view "visual contents" but your mobile phone doesn't support image or video display, which of the following methods do your prefer?**

[A] Continue to learn and keep the learning preferences settings unchanged
[B] Continue to learn after changing the learning preferences settings to suit the mobile phone capabilities
[C] Continue to learn by using supported contents as a replacement, but keep the learning preferences settings unchanged
[D] Stop learning on mobile phone, because it can not fulfill my learning preferences

6. **When learning on mobile phone, my learning preferences tend to change based on various locations:**

[A] Strongly agree
[B] Agree
[C] Not sure

[D] Disagree
[E] Strongly disagree

7. **The default settings for learning preferences on mobile phone should be the same as on PC, and vice versa.**

[A] Strongly agree
[B] Agree
[C] Not sure
[D] Disagree
[E] Strongly disagree

Survey completed. Many thanks for taking this survey!