Design of a Learner-Directed E-learning Model

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Abstract

How can one create online educational material that support and motivate students in guiding their own learning and make meaningful instructional decisions? One of the main focuses on designing e-learning is about creating an environment where learners can actively assume control and take responsibility for their own learning with little or no guidance from the tutors. This research aims to discover a new way to design learning that would cater to individual choices and preferences. The idea goes beyond learner-centred design; it is about learner control and direction. As an option, learners should be able to choose to be in the driver's seat, to direct their own learning journey.

As a starting point, this research explores the use of two educational theories - Experiential Learning Theory (ELT) and Self-Regulated Learning (SRL) theory as the underpinning instructional design for a Learner-Directed Model to support students' online learning in both domain knowledge and meta knowledge in the subject of computer programming.

One unit material from an online Introduction to Java Programming course has been redesigned based on the proposed Learner-Directed Model for the experimental design study. The study involved a total of 35 participants divided randomly into one Experimental Group and one Control Group. They were assigned to either a Learner-Directed Model (Experimental Group) or a linear model (Control Group). Pre/post tests, survey, follow-up interview as well as log file analysis were instruments used for assessing students' domain knowledge, meta knowledge and their attitudes for their overall learning experience. Learning experience is further broken down into perceived ease of use and user satisfaction; system usability; learner experience; and perceived controllability.

The results of the study have revealed that there is statistically significant difference between the survey results for the Experimental Group and the Control Group. The Experimental Group reported a higher level of overall learning experience and better attitudes in general. However, there was no statistically significant difference existing between the two groups on the domain and meta level knowledge improvement. Based on these results, I have proposed further research directions and put forward a number of recommendations and suggestions on learner-directed e-learning design.

Keywords: learning theory, learning preferences, self-regulated learning, E-Learning, instructional design, learning design

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List of Acronyms

4C/ID – Four Component Instructional Design

AC – Abstract Conceptualizations

AE – Active Experimentations

AEHS – Adaptive Educational Hypermedia Systems

AHS – Adaptive Hypermedia Systems

ARCS Model – Attention, Relevance, Confidence, and Satisfaction Model

CAD – Canadian Dollars

CoRL – Co-regulated Learning

CE – Concrete Experience

CRI Framework – Criterion Referenced Instruction Framework

ELT – Experiential Learning Theory

IDE – Integrated Development Environment

ITS – Intelligent Tutoring System

LDL – Learner-Directed Learning

LDM – Learner-Directed Model

LMS – Learning Management System

LSI – Learning Style Inventory

LX – Learner Experience

MOOC – Massive Open Online Courses

PCF – Participant Consent Form

PIS – Participant Information Sheet

RO – Reflective Observation

SDRL – Self-Directed Regulated Learning

SRL – Self-Regulated Learning

UX – User Experience

Glossary

Co-regulated Learning (CoRL) – the interplay between learners and agents – both human tutors and pedagogical agents

Constructivism – this theory takes on the view that learners interpret information and the world according to their own personal reality, and that they learn by observation, processing, and interpretation, and then personalise the information into personal knowledge (Cooper, 1993; Wilson, 1997).

Experiential Learning Theory (ELT) – A learning style theory that emphasises experience as the central focus in learning (D. Kolb, 1984).

Golden Circle - Golden Circle, inspired by the concept of golden ratio, is a model to help people understand why we do what we do (Sinek, 2009). It begins with the question “Why” in mind.

Likert Scale - is a psychometric scale that uses questionnaires. The questions are formatted in which responses are scored along a range.

Learner Control - students are able to regulate their own learning, and can exercise choice and discretion over the sequence, pace and amount of information they can process (Chung & Reigeleuth, 1992).

Learner-Directed Learning (LDL) – a theory that is grounded on Self Regulated Learning theory with a meta-cognitive and learner control focus.

Learner Experience (LX) – a learner’s perception, responses, and attitudes that emerges from interacting with a learning system.

Meta-cognition – a higher order thinking that involves active control over the thinking processes engaged in learning (Lai, 2011; Livingston, 1997).

Millennial – referred to anyone that was born between 1982 and 2002. Also known as Generation Y.

Self-Regulated Learning (SRL) Theory – a learning theory that emphasises autonomy and control by the individual who monitors, directs, and regulates actions toward goals of information acquisition, expanding expertise, and self-improvement (S. Paris & Paris, 2001).

Student Model – a type of user model that is intended for use in an educational teaching and learning context.

User Experience (UX) – a person's perception and responses that result in interacting with a product/system (9241-210:2010, 2010).

User Model – a model of users residing inside a system or computational environment (Fischer, 2001).

Chapter 1: Introduction

"The real voyage of discovery consists not in seeking new landscapes, but in having new eyes." – Marcel Proust

1.1 Background to the Study

1.1.1 Journey Into E-learning

First generation of e-learning is a lot like travelling by trains: you need to get from point A to point B at a certain time, so you look up the train schedule on the rail website, show up at the train station on said time, you are given one route, one speed, and maybe a choice between two types of seating arrangement. As a traveller, you can't contribute to the journey, take an alternative route, or determine the course of the outcome. The type of learning material is static, linear, and it is mostly designed in a slideshow or a page-turner format: with forward and backward buttons to guide you through the module with a clearly defined structure.

Certainly, there is appeal to travel by train – you know for certain you will get to point B with a predictable course of action; there are signposts in place to help you understand where you are going; and listening to the universal sound of a train whistle brings back a sense of nostalgia. People in general are drawn to what is familiar to them. However, after sitting through a few repetitive train rides, you might start to wonder how you might arrange things differently to better suit your needs and desires. Perhaps you wish for a more scenic route, or the option of taking a break to wine and dine halfway through the journey. At times, you might even want to make changes to the interior design of a train compartment, adding a comfy cushion here or a bike rack there.

The evolution of the internet into "Web 2.0" in the early 2000s allows users to be more active participants instead of passive passengers. Sites started to have features for people to give feedback, collaborate with each other, and to create user-generated content that is increasingly personalised. In essence, the web has shifted from being a medium into a platform “in which content was created, shared, remixed, repurposed, and passed along.”(Downes, 2005). Similarly, in the e-learning sphere, static page-turner content begins to morph into more modular learning activities that consist of some interactive components – Flash-based games, quizzes, videos and audio podcast lectures, RSS feeds, blogs, wikis, and online discussion forums – to make use of the readily available social media tools and services online. In parallel with Web 2.0, the term “e-learning 2.0” was being coined roughly around the same time (Downes, 2005).

You could say that the e-learning 2.0 movement is a lot like having a new management team to overhaul the train service. Imagine yourself at the ticket booth of a train station, instead of asking for one single journey ticket, you were presented with a series of options: economy, first, super deluxe or family sleeper class? Smoking or non-smoking? Silent or non-silent area? Upon boarding the train, you are further invited to select and use various dining options and maybe even choices of internet speed and preferred channels on TV stations. There will be ways to provide feedback everywhere and there will be areas in the cart for you to reconfigure the seats based on your own preference.

Yet, a train journey is still a train journey. You are a passenger, and your travelling has to fit into the confines of the train schedule, the routes, the locations of the stations, and by-and-large, you don’t get to choose where to go and when to arrive. You might have more input and influence with a new service, but you are still not in charge (Kanuka, 2006).

At the dawn of e-learning 2.0, the use of Learning Management System (LMS) became mainstream and it helped organise learning content in a systematic way – to divide material into courses, modules, sections, files, assignment areas, discussion forum, and in most cases, also to help manage student records. Despite using a new platform, e-learning models still largely mirror traditional classroom teaching – sequential lecture-style presentations, a cohort of students, semester-based format – essentially a one-size-fits all model.

As Web 2.0 technologies mature, and social media tools become increasingly easy to use, the barrier to user-participation and user-to-user interaction online has been significantly reduced. Globally, people are spreading social media like wild fire. As of 2012, there are 70 million WordPress blogs worldwide; one hour of video is uploaded to YouTube every second; and Twitter is growing at a rate of 11 accounts per second (Pring, 2012). Web 2.0 had truly realised what Tim-Berners-Lee envisioned as the read/write web (Gillmor, 2006).

Meanwhile, Web 2.0 technologies are gradually making their way into e-learning. LMS such as Moodle has built-in RSS feeds, wikis, blogs, and user forums. It also has additional plug-ins for Twitter, OU blogs (created by Open University in the UK), and e-portfolio functionalities. Constructive approach to learning, known as constructivism, focused on student-centred learning, is a central theme in e-learning 2.0. Constructivism theory states that people construct their own understanding of the world upon the foundation of their prior knowledge and experiences (Hoover, 1996). Learning materials and activities being developed from the start of e-learning 2.0 onward have attempted to incorporate this view of learning into the instructional design methodology.

Technologies, learning theories and design methods are not the only factors affecting change in e-learning. The new generation of learners, known as the millennial, is also demanding a new way of learning and exploring the world. The millennial, the newest generation in America, referred to anyone that was born between 1982 and 2002, and that this group has distinctive characteristics that set them apart from the previous generations (Howe &

Strauss, 2000). According to the Pew Research Center, the millennial are "the first generation in human history who regard behaviours like tweeting and texting, along with websites like Facebook, YouTube, Google and Wikipedia, not as astonishing innovations of the digital era, but as everyday parts of their social lives and their search for understanding." (Keeter & Taylor, 2009). Indeed, they are accustomed to moving in and out of multiple technologies, learning new software programs, searching for the best websites to download music, communicate with others in short, truncated sentences on smart phones, and playing multi-player online games with strangers. The millennial are what Palfrey and Gasser (2008) called "digital natives", as they are the first generation that are born into and grew up in the digital world. They speak the native tongue of the internet, smart phones, video games, and virtual reality. As learners, they don't acquire and apply knowledge the same ways their parents or grandparents do. The digital natives prefer to interact with information in a modular way – they pick up bits and pieces of information and learning content as they go about their days (Palfrey & Gasser, 2008). They are active learners, wanting to engage in the learning process instead of being told what to do. After all, they are a generation of bloggers, Twitterers, Instagramers, Facebookers, YouTubers, Wikipedians, and Pinteresters. These days, most digital interactions ask users to at least "like" or "share" the information, if nothing else. No wonder youngsters who grew up in the age of Web 2.0 would expect read/write/remix/create/share relationship everywhere.

In general, the millennial have higher expectations of the quality of learning material as well as the methods to deliver them. The elevated expectations came from having convenient (and mostly free!) access to multiple resources and the easy ability to compare their learning experience with the rest of the world in a click of a mouse. The current state of e-learning, while using LMSs that have Web 2.0 components, supporting interactivities, allowing students to comment and collaborate with each other, and providing quizzes and tests that track scores, is still not fully handing the control over to learners. The millennial are pushing the limits of e-learning and hunger for more than a course-in-a-box learning model.

In sum, the millennial do not travel by trains. They want to drive, not ride. They want to go about things their way; to have an individualised experience that suits their needs at a time that is convenient to them. Train travel is still an option, but the new generation of learners strives for more. This research stems from the curiosity and the desire to discover a new way to design learning that would cater to individual choices and preferences. The idea goes beyond learner-centred design; it is about learner control and direction. As an option, learners should be able to choose to be in the driver's seat, to direct their own learning journey.

1.1.2 Defining E-learning

Although the origin of the term e-learning is not certain, but literature suggested that it was most likely started in the early 1980s when the term online learning also started to emerge (Moore, Dickson-Deane, & Galyen, 2011). The definition of e-learning has been subjected to the constant change in technology, instructional design, and education framework, and there is arguably no single agreed definition – it means quite different things in different sectors ranging from small mum-and-pop business, multi-national corporations, higher education, non-profit organizations, military, to training and development field (Nicholson, 2007; Stein, Shephard, & Harris, 2011). For small businesses, providing e-learning could mean a single sales training course hosted on an external LMS; for larger organizations, it could be a series of health and safety webinar sessions with real-time videos and interactive quizzes; for military training, it could be the application of immersive learning environment with 3-D avatars.

Furthermore, there are many methods for delivery of e-learning. Currently, there is instructor-led training, self-paced individualised module, cohort-based learning, one-on-one coaching, real-time discussion, and community or peer-led courses. Content are also presented in different media, Khan Academy made its name by creating 10-minute videos by subject matter; Codeacademy provides a hands-on approach to learn simple computer codes; Quora is a text-based question-and-answer site for complex topics. The recent blooming of e-learning start-up companies such as Coursera, edX, Knewton, and Udacity are adding another flavour to e-learning with content being open to anyone in the world and enrollment numbers in hundreds of thousands. It is known as the Massive Open Online Course (MOOC) format.

Having stated the diversity of e-learning, there are many definitions that fit different types of e-learning. Some broad definitions are as follows:
Rossett & Sheldon (2001) define e-learning as "training that resides on a server or host computer that is connected to the World Wide Web." Echoing this definition, Marc Rosenberg (2001) similarly defines e-learning as "the use of internet technologies to deliver a broad array of solutions that enhance knowledge and performance." Tony Karrer (2007) went beyond the internet and covers a wide range of applications and processes in his blog: "web-based learning, computer-based learning, virtual classrooms, and digital collaboration. It includes the delivery of content via internet, intranet/extranet (LAN/WAN), audio- and videotape, satellite broadcast, interactive TV, and CD-ROM."

While the above definitions are inclusive and cover just about every type of e-learning, there appears to be lack of focus on the students. A more learner-oriented definition can be found by Ellis, Ginns, & Piggott (2009) and also Diana Laurillard (2006). They define e-learning as the use of any information and communication technologies to support learners to improve their learning. To further extend this learner-centred definition, this research proposes to define e-learning with the following characteristics:

- It caters to individual learners, and is learner-directed
- It is flexible and non-linear, with options for students to pick and choose
- It empowers students to take responsibility of their own learning

- It supports learners at different levels of learning (novice, intermediate, expert)
- It provides learning in modular, contextual format

All in all, this definition is minimizing the role technology plays in e-learning, while focusing on how this new way of learning can be optimised from a student's point of view.

To limit the scope, the focus of this thesis will be on the type of e-learning that is designed for asynchronous, self-paced study format for higher education. This format was chosen because it is the most commonly used format in the author's home institution and it is the format that is most mature and has the largest market share in North America with an annual growth rate of 4.4% and accounted for 61.7% of the total worldwide self-paced e-learning market (Ellis, 2012)

Computer science, in particular computer programming was selected as the domain of this study because it has one of the largest enrolment (300 students) as well as the highest attrition rate (35%) at the author's institution. Computer programming is part of a core competency required for engineering, computer science, and information systems and management graduates. Developing good computer programming skills online require a multitude of skill sets as well as addressing a range of learning support issues. The following section will discuss some of these issues and explore options to support learning computer programming online.

1.1.3 Learning Computer Programming

Learning computer programming is challenging. Learners not only need to have knowledge of a particular programming tool and languages, they also need to have problem-solving skills, and effective strategies for program design and implementation (Ala-Mutka, 2003). There is also difficulty inherent in the language itself; the students usually apply learning styles that do not favour cognitive and meta-cognitive abilities (Oroma, Wanga, & Ngumbuke, 2012). In many subject areas, students are conditioned to memorise facts and information such as historical dates and names. In computer programming, memorization of codes and syntaxes without applications would not get you very far. In addition, learners' perceptions and attitudes could also present a mental barrier to learning computer programming. Students might or might not perceive computer science as one of the viable career choices. While there is little difference between race and ethnicity, there is a big gap between gender: 67% of male students rated computer science as a "very good" or "good" career choice, but only 9% of female students rated it as "very good", and 17% as "good" (boyd, 2009). It is especially true for younger females as the digital natives are shunning away from studying computer science. The general impression of the subject matter is that it is "for geeks" and considered boring (Shepherd, 2012). According to the Higher Education Statistics Agency, women made up 19% of all students on undergraduate computer science degrees in the UK in 2004; by 2009 (the most recent statistic available), that figure had fallen to 16% and it is continuing to fall further. Additional explanations about why there is a declining interest in studying computer science could be that the new generation has a different set of expectations about computer science and programming. A New Image for Computing (NIC) report found that millennial interested in computer science associate computing with words like "video games," "design," "electronics," "solving problems," and "interesting." (boyd, 2009). There is definitely a gap between what is on offer at higher education institutions and what these students are expecting.

Although there are many new and interesting ways being proposed to teach programming, there have been few empirical studies indicating the impact of these ways in terms of learners' experience. Some of the ideas include the use of intelligent computer-assisted instruction (ICAI) technology to teach introductory programming courses (Anderson & Skwarecki, 1986) peer assessment with web-based technology (Sitthiworachart & Joy, 2004); and hands-on approach that incorporate gamifications by Codeacademy (http://www.codecademy.com). The reasons why few researches dealt with and measured learner experience could be the lack of understanding in what constitute a learner's experience and why it would be useful/relevant in measuring it. There could also be the fact that user experience (and by extension, learner experience) as an established field has only been recognised since Donald Norman coined the term in 1995 (Regan, 2010). Initially, the term was applied to measuring customers' satisfaction on product design, and Norman stated that he wanted a term that "covers all aspects of the person's experience with the system including industrial design graphics, the interface, the physical interaction and the manual" (Regan, 2010). Eventually, user experience found its way into website design, interaction design and e-learning design. Learner experience, as an extension to user experience, is even less known.

To understand why learners struggle to learn programming, there are many possible cognitive factors to consider - attitudes and perceptions of students, attitudes and perceptions of instructors, learning environment, learning experience, technology experience, student's learning styles and motivation. Of all the cognitive factors, this research will zero in on two of the more prominent factors: learning style and motivation (Jenkins, 2002). It is argued that some subjects may require a certain approach of learning, and that students, especially distance and online students learning on their own, are more prone to adopting the wrong learning style or sticking with the style which has served them best in the past. As mentioned above, memorization and regurgitation might work for subjects that require an accurate recall of facts, but computer programming demands learners to have a diversity of skill sets ranging from planning, breaking down tasks, mapping tasks into the construct of the programming language, and debugging (Sleeman, 1986). Jenkins (2002) asserted that the best strategy is to use a mixture of learning styles, such as the "deep" and "surface" approaches (Marton & Saljo, 1976) and a combination of meta-cognitive skills such as knowing when to ask for help, and understanding what types of questions to ask when encountering problems.

In terms of learner motivation, research suggested that students who struggle in programming are more likely to have an extrinsically driven motivation as opposed to students who might have a genuine interest in the domain (Sheard & Hagan, 1998). In an online environment, reasons for lack of intrinsic motivation could be that there is a lack of student support; substandard course material; inexperienced tutors; problem with technology; poor time management skill; poor work-life balance management skill; and poorly designed courses. This thesis will focus on the motivational factor that concerns the inappropriate or poor instructional design of course material. One advantage on individualised e-learning is that students are able to set their own pace of learning. If they missed or misunderstood a basic concept, they could go back and revisit the material at their own leisure. Yet, currently, online modules provide little control for users, and even less for supporting students to learn in different ways. There are opportunities here to put learners' in the drivers' seat. In addition to having the freedom to set one's own pace, there could be flexibility in choosing what learning activities to study, which sequence to follow, and whether the students want more or less supplementary meta-cognitive support. The next section will discuss what meta-cognitive support are and how to appropriately integrate them into learning computer programming online.

1.1.4 Meta-Cognitive Support for E-learning

Meta-cognition is defined as "a higher order thinking that involves active control over the thinking processes engaged in learning" and it is commonly known as "thinking about thinking" (Lai, 2011; Livingston, 1997) or "critical analysis of thought" (Flavell, 1979). Meta-cognition basically consists of two components: knowledge and strategy/regulation (Flavell, 1979). Meta-cognitive knowledge includes knowledge about one's own learning process; knowledge about learning strategies; and knowing when and how to use the strategies such as when to pause to ask a question and take notes when reading online. Meta-cognitive strategy/regulation concerns the abilities for learners to monitor their own learning, setting goals, planning, as well as evaluating the outcomes of these strategies/regulations.

One cannot talk about meta-cognition without cognition. Cognition means the action or faculty of knowing (Chaney, 2013). Meta-cognitive activities provide insights on one's learning process, and in turn, this helps facilitate the ability for the learner to regulate cognition. This ability to self-regulate enables a more positive learning experience and thus links to the issue of motivation (Lai, 2011).

As discussed above, learning computer programming is challenging; it doesn't rely on a single skill. Rather, learners can benefit from mastering a set of skills, especially meta-cognitive skills to optimise learning (Azevedo & Cromley, 2004; Winne, 1995). Furthermore, it is important to embed these meta-cognitive skills as part of the learning process within the domain instead of providing them in isolation. Currently, a popular approach to providing these kinds of skills is by extra-curricular "study skills" courses by learning support centres external to the academic departments (Gamache, 2002; Haggis & Pouget, 2002). This is known as the "bolt-on" approach (Bennett, Dunne, & Carre, 2000) as opposed to the "built-in" approach proposed by Wingate (2006) where learning is developed through the subject taught. Commonly, online courses provide generic study skill advice on how to write essays, take notes, etc., without tailoring it to subject-specific content. The limitation of the "bolt-on" approach is that often students don't make the connection between these skills and how to apply them to their subject (Drummond, Nixon, & Wiltshire, 1998; Durkin & Main, 2002).

Furthermore, according to experiential learning theory by Kolb (1984), effective learning takes place when learners experience a problem, reflect on their action, form concepts on the basis of their reflection and apply these concepts in new situations. The “bolt-on” approach with instructional text gives little opportunity for students to try things out and to experience learning in an ongoing, iterative process. At the time of writing, there is a lack of framework for designing online courses with the explicit integration of context-specific meta-cognitive skills for learning computer programming. Thus, it became one of the main reasons that propel this research. In the next section, inspirations and motivations that drive this research study will be explained.

1.2 Inspirations and Motivations for this Research

In e-learning, questions concerning how one can create online material that support and motivate students in guiding their own learning and make meaningful instructional decisions have attracted an increasing number of research interests ranging from areas in adaptive learning systems design to personal learning environments and learning styles/preferences theories. One of the main challenges of learning online remains how learners can be actively assuming control and taking responsibility in their own learning with little or no guidance from the tutors. It is especially difficult when topics are complex and unfamiliar and it is not always clear to the learners if their learning decisions are optimal (Azevedo, Cromley, Seibert, & Tron, 2003). When topics are complex and unfamiliar, they require more time and cognitive process to retain the information. These extra efforts could be de-motivating as students might not be given adequate resources and supports accordingly. Moreover, learning computer programming is a “radical novelty” and it needs a different instructional design approach (Dijkstra, 1988). Jenkins (2002) stated that programming courses should be designed to be flexible to allow differing learning styles.

Research into adaptive e-learning systems has attempted to facilitate the learning process by providing recommendations with respect to classifying learners into preferred learning styles and by associating recommended learning paths with these learning styles (Brusilovsky, 1998). Another work has described a user modelling approach that is beneficial to learners who are interacting with complex learning applications in an online environment (Adisen & Barker, 2007). However, system-initiated learning aid has its limitations such as the tendency to stereotype; the need to collect relatively large amount of user data before it becomes useful; and the users might not always be able to provide relevant data (Rich, 1979). Aspects of natural language processing and user modelling are problematic: most of the natural language systems are research prototypes, and they are limited in both functionalities and domain availabilities. In addition, few of the user models support an entire interaction cycle - understanding a user's requirements, followed by a possible adjustment of the user model, the generation of a response, the understanding of new requirements, and so on (Zukerman & Litman, 2001). Learning style theories and the use of learning style inventories, while useful in its framework, often tend to fall into the prescriptive model where learners are matched to a certain learning style(s), and are often not flexible enough to accommodate changing context and shifting of learning preferences that students have.

There is an opportunity to create a more holistic approach to e-learning – an approach that supports a comprehensive learning design that has a mix of delivery modes, domain-specific learning activities, and meta-cognitive learning support embedded contextually.

The next section will provide the scope of the thesis including the aim, objectives as well as the research questions proposed for this study.

1.3 Scope of Thesis

1.3.1 Aim

The aim of this research is to design, develop, and evaluate an e-learning system that delivers learning based on sound learning style and educational theories within the domain of computer programming.

1.3.2 Objectives

Specifically, the objectives of this research are to:

1. Find the requirement of such system
2. Investigate which learning style theories could be useful as a design framework
3. Examine which education theories could be useful as a design framework for creating unobtrusive learner support for meta-cognitive activities
4. Develop the application
5. Test the application on target learners
6. Analyse the learners' performance and experience of using such an application

1.3.3 Research Questions

This study was designed to answer the following research questions:

1. Which learning style theory and education theory would be useful to develop an e-learning system?
2. How could an e-learning system be developed based on the learning style and education theories?
3. What is the effectiveness an e-learning system based on a model of learning style and education theories?
    a. What would the effect of such a system be on the performance of learners?
    b. What would be the attitudes and learner experience (LX) of learners to be using such a system?

1.4 Research Contribution/Significance of the Study

This research shall contribute to the better understanding of designing a different e-learning model for learning computer programming with a specific focus on the role learner control plays in learner experience in e-learning.

As discussed in Section 1.2, many attempts have been made in learner-centred design models so as to address some of the challenges of online learning: adaptive technology, user modelling, learning style theories and learning style inventories. While they are useful in providing some learning options and personalization, they lack flexibility, scalability, and they do not provide adequate options for learners to control their learning paths.

To sum up, some of the challenges e-learning professionals face when designing effective student-centred online learning material are:

- Lack of learner control
- Rigid instructional design
- Inappropriate instructional design for the subject matter
- One-size-fits-all learning style
- Lack meta cognitive support and contextual integration

Currently, there is no existing e-learning model to address the above challenges into one learner model. This research attempts to develop such a model that place the control and responsibility of the learning into the students' hand with integrated and contextual support for meta-cognitive skills for learning computer programming.

The framework and the findings of this research are expected to help higher education e-learning professionals and educators to gain insight in and help improve the design of online learning in the area of computer programming for post-graduate university level study. With some adaptations, other subject areas can also be applied using this learner model. Other sectors such as private corporations, government, the military, and non-profit organizations would also benefit from this research as it can be implemented in corporate training and development online, as well as repurposing it as a public education and information model.

1.5 Scope of the Research

The scope of this research is limited to the following factors:

1.5.1 The Substantive Limits

This research is limited to the examination of the effect on adult learners on domain-knowledge, meta-cognitive knowledge, and their overall learning experience (LX) based on data collected quantitatively online and self-reporting from the participants with qualitative methods such as interviews and survey. The research will be limited to the adaptation of one unit from an introduction to programming course (COMP268) typically available for first or second year students at Athabasca University in Alberta, Canada. The course is part of a regular offering at the School of Computing and Information Systems (SCIS), Faculty of Science and Technology, one of the largest faculties at Athabasca University.

1.5.2 The Time and Place Limits

This research is limited to undergraduate students who are enrolled in Athabasca University, Canada's Open University, headquartered in Athabasca, Alberta, Canada, with satellite campuses in Edmonton and Calgary, Alberta. Students are all adult (age 18+) distance learners, located across Canada and the rest of the world; they can access the web-based material from anywhere using a computer or mobile devices with internet connection.

1.5.3 The Limits of Technology

This study is confined to the e-learning students with access to Moodle, the LMS of choice at Athabasca University. The study is conducted entirely online and from a distance, thus, is limited to the availability and setup of technologies (i.e. computers, internet speed, software/plug-ins) that students have on their end. The university mandates that in order for students to participate in the online courses, students must meet technology requirements that include the access to the internet, and a computer that conforms to Athabasca University's minimum hardware and software standard.

1.6 Thesis Outline

In this section, the thesis outline was presented in detail. The structure of the thesis is organised by the research activities undertaken during the course of this study.

This chapter has provided an overview of the research study. The remainder of the thesis consists of a further six chapters. Chapter 2 provides a detailed literature review that forms the conceptual background of this research, which focuses on current instructional design and e-learning models, education theories, learning styles, meta-cognition, and user experience (UX). Chapter 3 looks at an alternative view on providing learner control and learner-directed learning in the lens of student modelling. The relationship between adaptive and adaptable learning approaches is examined. Chapter 4 proposes a new design approach for a Learner-Directed Model that caters to learner control. Chapter 5 gives a detailed account of the experimental design set up, the choice of methodology, procedure, along with how the data was collected and measured. Chapter 6 presents and analyses the results of the data collection, including quantitative and qualitative data. The final chapter, Chapter 7 revisits the research questions, discusses the research findings, recaps on the contribution along with its strengths and limitations. Direction for possible future work is also suggested.

Chapter 2: Literature Review

“The more I read, the more I acquire, the more certain I am that I know nothing” – Voltaire

2.1 Introduction

One cannot focus on building a future without learning from the past and observing in the present. Chapter 1 painted a picture of what a learner-directed e-learning could potentially be for the millennial, and what some of the characteristics associated with it are. This chapter will review relevant past and current literatures in five broad topics that have catalysed and shaped this research study. The five topics are instructional design, educational theories, learning styles, meta-cognition, and user experience (UX). Figure 2.1 illustrates the five topics with the subtopics.

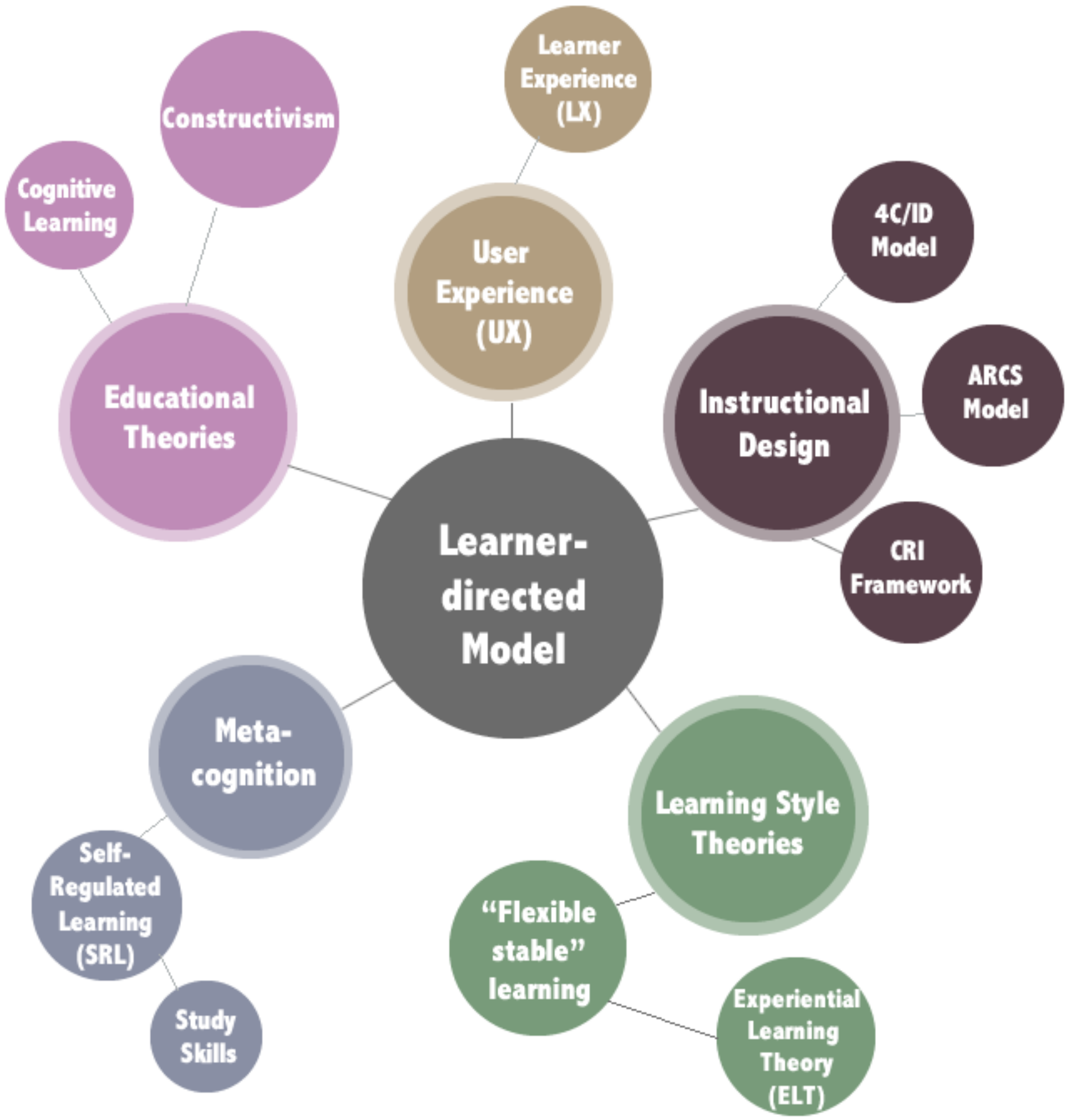

Figure 2.1: Overall topics for literature reviews

These five topics are selected based on the fact that they all cover some aspects of the issue of learner control, and within each topic, there are ideas on how to create a learner-directed learning. The construct "control" is defined as "having power over events, strategies or circumstances, including the dimension of interpersonal control" (McLoughlin & Oliver, 1995). In an educational context, learner control means that students are able to regulate their own learning, and can exercise choice and discretion over the sequence, pace and amount of information they can process (Chung & Reigeleuth, 1992). Learner-directed learning goes a step beyond learner control where learners are actively choosing learning strategies and preferences that suit their needs and learning outcomes within a particular module. Thus, learner-directed learning occurs when a learner is in active control of her own learning path and explicitly configures which resources will be most effective in helping her to construct or acquire what knowledge she needs, when she needs it (Zimmerman, 1998).

The first topic outlines popular instructional design theories that have learner-control components. The aim of this section is to provide a foundation for what relevant instructional design models have been proposed and applied, as well as where the current gaps are in designing online learning that enhances the learner experience. Instructional design models are built on educational theories, so the second topic will cover educational theories with a focus on cognitive learning theories and constructivism. Learning styles theories, as part of the cognitive school of learning, forms the third topic. This section provides an evaluation of the most influential learning style theories and the focus in this section will be in the group of learning style theories that provide more flexibility and adaptability in their applications for online learning design. The fourth topic is on meta-cognition and its relationship to cognitive learning theories. Effective learning design needs to involve the appropriate use of cognitive as well as meta-cognitive strategies (Brokowski, Carr, & Pressely, 1987; Garner, 1990). Finally, this chapter concludes with user experience (UX) review, connecting UX to learner-centred design and learner experience (LX) in online course design.

In the context of this research, different terminologies have been used for describing concepts and ideas. Terms that are being used include “theory”, “model”, and framework”. By definition, a theory refers to “an organised set of propositions that are syntactically and semantically integrated and that serve as a means of predicting and explaining observable phenomena.”

(Snelbecker, 1999). To phrase it more simply, a theory can be seen as a testable hypothesis that can predict what would happen in the world and to provide a cause-and-effect explanation. To differentiate it from the term “model”, Snelbecker (1999) explained that some authors might prefer the term “model” to concretise a theory or to provide a narrower defined scope of explanation. Using a theory, one could then construct a specific model. Therefore, a model can be seen as an application of a theory used to describe the world or to apply to a specific case. In this thesis, “model” will be used to describe a specific application that can be used to solve a real-world situation, and has a relatively narrow focus of scope. Finally, a framework is used as a basic structure underlying a system or a concept. Within the interaction and web design field, a framework is defined as “a set of tools, libraries, conventions, and best practices that attempt to abstract routine tasks into generic modules that can be reused” (Croft, 2007). For the purpose of the current study, a framework is seen as a predefined set of concepts, practices, and criteria that can be customised and/or used as references in solving similar problems.

2.2 Instructional Design Models

In e-learning, quality of learning is influenced by sound instructional design in combination with the appropriate selection and application of technology (Bates, 2005; Schramm, 1977; Twigg, 2003). Some even claimed that technology is “merely vehicles” that deliver the content and serve as a platform of hosting content; it doesn’t directly enhance learning (Clark, 2001). At any rate, instructional design matters and it plays a pivotal role in providing a positive learning experience. Good instructional design not only guide, engage, and motivate learners; it should also empower them to take charge of their own learning. It is assumed that learners will be more motivated if they are allowed to be in control of their own learning (Keller & Kopp, 1987; Lee & Lee, 1991; McLoughlin & Oliver, 1995; Tennyson, Park, & Christensen, 1985). As learner control and learner direction is the central theme of this thesis, this section will describe the types of instructional design models available, with the specific aim to examine the ones that support learner-control and learner-directed learning.

2.2.1 What is an Instructional Design Model?

Instructional design models offer explicit guidance and principles on how to help people learn and develop. The types of learning may include cognitive, emotional, social, physical and spiritual (Reigeluth, 1999). Furthermore, instructional design models represent a framework of thinking; it is more than a process and the resulting product (Driscoll & Carliner, 2005).

According to Reigeluth (1999), Instructional design models in general have the following characteristics: (Reigeluth, 1999)

- It is design-oriented – it provides prescription rather than a description of the methods
- It identified methods of instruction – the methods are identified with the goal of facilitating human learning, and the methods offered are situational rather than universal
- Methods of instruction can be broken down into more detailed component methods and can be designed in different ways
- Methods are probabilistic rather than deterministic – that is, if the designers follow the methods, it would probably increase the chances of attaining the learning goals rather than ensuring the attainment of the goals

It is also important to further clarify that instructional design models this section covers do not include education theories. Education theories are descriptive in nature and it describes how the learning process takes place as opposed to providing guidance and principles on how to design learning (Reigeluth, 1999). However, effective instructional models are based on education theories as they explain the relationship between pre-existing knowledge and new information we are trying to acquire. Education theories will be covered in Section 2.3, followed by a review of learning styles theories as they relate to the current research in Section 2.4.

2.2.2 Typology of Instructional Design Models

Schneider (2006) proposed that there are at least six types of instructional design models as indicated in Table 2.1 below:

Table 2.1: *Typology of Instructional Design Models*

Model Types	What It Does	Examples
1. Pedagogic strategy model	Describes a pedagogic strategy in detail	Inquiry-based learning (Bruner, 1961a)
2. Related to quality of a design	Concerns the evaluation of design quality	Merrill's First principles of instruction (Merill, 2008)
3. Provide a method to create a design	Prescribes explicit guidance on the design process; a step-by-step process	ADDIE (Branson et al., 1975)
4. Complementary models that will enhance a design	Provides related learning models/theories that can be incorporated to enhance learning design	Self-regulated learning model/theory (Winne, 1995; Zimmerman, 1990)
5. Change management related model	Addresses the issues of introducing new pedagogies and how it impacts the learning process	Activity theory-based expanded learning (Yoon & Ardichvili, 2010)
6. Describe functions of a learning environment	Identifies components of a learning environment and how to use these components to optimise learning	The Sandberg learning environment functions (Sandberg, 1994)

Of the six types of instructional design models, models 1, 3, and 4 fit closely with how I envisioned this research focus would be: to create a learning model that combines pedagogic strategies (model 1), provides a method for design (model 3), and compliments with education theories that would enhance the design (model 4). These three areas will be examined more closely in the following section.

2.2.3 Instructional Design Models that Support Learner Control and Learner Experience

All instructional design models provide some level of learner control (Williams, 1996). Thus far, the models that have made learner-control explicit and provide learner-direction/support overall learning experience include the following:

Criterion Referenced Instruction (CRI) framework - developed by Robert Mager (1975, 1988), it promotes the importance of setting measurable performance objectives, and it includes a set of methods for the design and delivery of training programs. It emphasises learner initiative and self-direction. Its chief principles are that instructional objectives are derived from job performance and it reflects the competencies that need to be learned. Students can choose to study only those skills they have not yet mastered to the level required by the objectives. Students have some freedom to choose the *order* in which to complete the modules and progression is self-directed based on the mastery of the objectives. However, this model falls short of focusing on performance objectives while undermining the importance of learner engagement, motivation and diversity. Some critics of the theory also pointed out that there is a behaviourist undertone to the model as learners are seen as subject to be conditioned to meet behavioural objectives (Clark, 2012).

This model is relevant to the current study because it is designed in a way that students are free to sequence their own learning material within the constraints of the pre-requisites and progress is managed by their own competence. This freedom to skip around and to select one's own preferred learning path serve as a starting point in formulating a Learner-Directed Model. While the CRI framework provides some learner control, the emphasis on meeting performance objectives undermine the overall learning experience and learning preferences.

ARCS Model of Motivation Design – John Keller (1983, 1987b) created the ARCS Model and put forward four steps for promoting and sustaining motivation in learning. The four processes are: Attention, Relevance, Confidence, and Satisfaction (ARCS). Out of the four processes, of particular interest and relevant to the current research are Confidence and Satisfaction. Under Confidence, it states that learners should feel some degree of control over their learning and that success is a direct result of the amount of effort they have put forth. Similarly, the Satisfaction process suggests that learning needs be a satisfying experience and that satisfaction is based upon motivation whether it is intrinsic or extrinsic. Proponents of this model claim that it provides well-defined design strategies and reinforces learner-centred design; however, affective outcomes are often hard to evaluate and this model provides no strategies on how to go about measuring learner motivation (Mohler, 2006).

The current study is interested in measuring learner's overall learning experience. The ARCS Model is one of the few instructional design models that mentioned affective outcomes. Even it lacks strategies on measurement, it raised awareness on the aspect of learning that focus on learner satisfaction and learner experience.

Four Component Instructional Design (4C/ID) - 4C/ID by Van Merrienboer & Paul (2008) is a model that comprises of four basic components: learning tasks, supportive information, procedural information, and part-task practice. This is a holistic design approach that deals with separate elements in learning but at the same time being able to create interconnections between them. The two components of interest to my research are the learning tasks and the supportive information as they provide meta-cognitive learning support and employ scaffolding technique to grow learners' confidence and competency. The learning task component is organised in easy-to-difficult task classes with diminishing learner support throughout each task class. The emphasis here is on the ability to sequence tasks, and to introduce the concept of "fading". Fading takes place when contextual and procedural support is gradually reduced as learners gain more experience in mastering the skills/knowledge. Supportive information aims at providing meta-cognitive help for students to perform non-routine aspects of learning tasks such as problem solving and reasoning skill. Critics of the model cautioned that due to the complexity of the model, learners might experience cognitive overload, especially when learners do not perceive the same connection between the components as the designer/instructor. As a result, it could lead to learner frustration and produce a negative learning experience (Barker, 2008). It is also potentially time consuming to develop, as it requires extensive analysis and preparation.

Overall, this is a well-balanced model that places some emphasis on learner experience, and it closely aligned with my present research idea on the development of a learner-centred, Learner-Directed Model. Additionally, meta-cognitive learning support and scaffolding technique are two components that I plan to incorporate into the current research model. However, 4C/ID does not seem to provide domain-related meta-cognitive learning support and it appears that these supports are not optional; hence there is a danger of cognitive overload on the learner's part when deploying a 4C/ID model.

As mentioned at the beginning of this section, sound instructional design is key to support learner control and learner-directed learning. Instructional design models are grounded on educational theories. As there are many education theories to follow, the next section aims to focus on the ones that empower learners as active participants in charge of their learning process.

2.3 Education Theories

Early stages of e-learning were designed based on behaviourist approach to learning (Ally, 2008). The behaviourist approach believes that learning is a change in observable behaviour caused by external stimuli in the environment (Skinner, 1974). The stimulant – response approach claims that behaviours can be measured, trained, and changed (Watson, 1913). Of learning, it means that observable behaviour in terms of results and performance is the main indication on whether the learner has learned something. Critics of this approach state that not all learning is overt, observable behaviours, and that behaviour cannot be explained without reference to non-behavioural mental (cognitive, representational, or interpretative) activity (Graham, 2010). The criticisms about the lack of concern for mental process led to the rise of cognitive psychology and the associated cognitive learning theories.

Cognitive psychology is the study of mental processes. The American Psychological Association defines cognitive psychology as "The study of higher mental processes such as attention, language use, memory, perception, problem solving, and thinking" (Gerrig & Zimbardo, 2009). Cognitive theory is a learning theory of psychology that attempts to explain human behaviour by understanding the thought processes. The assumption is that humans are logical beings that make the choices that make the most sense to them. Learners come with knowledge, skills, and related experiences to the learning situation. Learning is deemed as an internal process, not external behaviour. It involves the use of memory, motivation, and thinking; furthermore, reflection plays a big part in learning (Craik & Lockhart, 1972; Craik & Tulving, 1975). The role of the learners is that they are active participants in the learning process, and they will use various strategies to process and construct their personal understanding of the content to which they are exposed (Ausubel, 1974).

One of the cognitive learning psychologists, Jerome Bruner, proposed that learning is a development of conceptual understanding, cognitive skills and learning strategies rather than the acquisition of knowledge (Bruner, 1961b). Learners should be encouraged to discover solutions, application of relevant critical thinking skills and that the aim of education is to create autonomous learners (Bruner, 1977). Although targeting on childhood education at the time, Bruner's ideas in *spiral curriculum* - structuring complex information from simplified to complex levels (Bruner, 1977); *discovery learning* - learning by problem solving and construction of meaning (Bruner, 1961b); and *scaffolding* - built-in steps to restrict what learners can do for each level of learning before they can move on to the next level (Wood, Bruner, & Ross, 1976) have relevant applications in the adult learning world, particularly in a self-paced online learning environment where learners need to be more self-reliant than classroom students.

A subset of cognitive learning theories included meta-cognition as their focal concept. Meta-cognition is generally defined as "knowing about knowing"; it includes knowledge about when and how to use particular strategies for learning or for problem solving (Metcalfe & Shimamura, 1994). A key learning focus within meta-cognition is related to self-regulated learning in which students manage their behaviours and anxieties to facilitate learning, actively avoiding behaviours and cognitions detrimental to academic success (Byrnes, Miller, & Reynolds, 1999; Stallworth-Clark, Cochran, Nolen, Tuggle, & Scott, 2000). Section 2.5 will cover more details on meta-cognition and how it relates to current research.

Cognitive learning theorists stated the importance of individual differences and they included a variety of learning strategies to accommodate learners' preferences. Learning style is defined as "characteristic strengths and preferences in the ways they take in and process information" (Felder, 1996).

As catering to the learners' preferences falls within the realm of learner-directed learning, section 2.4 will examine major learning style theories, with special attention on the ones that provide flexibilities and adaptabilities for creating an online learning design framework.

The term "cognitive style" was introduced by Witkin (1967) as a concept that individuals consistently display stylistic preferences for the ways in which they acquire knowledge and process information. It is usually described as a stable characteristic and is persistent across context. While learning style and cognitive style are terms often used interchangeably, there are subtle differences between the two. Cognitive style is generally considered to be hard-wired into the brain, whereas learning styles are more context-dependent (Tennant, 1988). In the educational context, cognitive style and learning style are equivalent (Keefe, 1979). For this research, learning style is perceived as flexible preferences that learners exercise to process learning material in a self-paced learning environment.

Following from cognitive learning theories, constructivism became the predominant school in education theory (Ertmer & Newby, 1993). Constructivism proposes that learners interpret information and the world according to their own personal reality, and that they learn by observation, processing, and interpretation, and then personalise the information into personal knowledge (Cooper, 1993; Wilson, 1997). Constructivists recommend that learners should construct knowledge rather than being given knowledge through instruction (Duffy & Cunningham, 1996). The way that constructivists see learning as an active process fits well with the concept of learner-directed learning. In order for a learner-directed learning to occur, learners need to take an active part in knowing what to select and construct the knowledge that align with their prior experiences. To put it in an e-learning context, there should be guided freedom in giving learners the ability to choose the type of learner-content interaction they prefer in the sequence they want. The next section will look at the various types of learning style theories that cater to learner preferences.

2.4 Learning Style Theories

It is a common belief that we have individual learning styles. Indeed, most of the time, people tend to favour certain methods of interacting with and processing new information and knowledge. It is claimed that students will become more motivated to learn by knowing more about their own strengths and weaknesses as learners, and that it is required to attend to the needs of individual learners (Felder, 1996; Kolb, 1984; Riding & Cheema, 1991). However, the research on learning style is far from conclusive. Competing and sometimes contradicting ideas about learning styles have implications for pedagogy. Some researchers proposed that the notion of styles imply fixed traits and that they are stable over time whilst others argued that learning styles are context-specific and that could change over time, situation, and environment. This section will review and classify different models of learning style, their applications and shortcomings, as well as their implications for online learning.

In terms of classification, learning style theories grouping is seen as a subset of education theories as mentioned in Section 2.3 above. However, it requires special attention in this thesis because of its inherent relation to active learner control and learner direction. Learning style theories categorise different learning modes and the goal is to help students build their skills in both their preferred and less preferred modes of learning, so that the learning needs of students in each theory category are met at least part of the time (Felder, 1996). The following classification of learning style theories is selected from the report by Coffield et al. (2004) on the literature review on learning styles and the examination of the 13 most influential theories (See Appendix 1 for the listing of the 13 theories). According to Coffield et al (2004), learning style research is mainly divided into three main areas of activities: theoretical, pedagogical, and commercial. The focus of this research is on the pedagogical area of learning styles. This area can be further classified into five sub-groups as listed in the following section.

2.4.1 Learning Style Theory Classification

Within the pedagogical area of learning style research, there are different theories broadly being classified from most fixed-traits oriented to the most flexibly-based theories in a continuum as listed below (see also Figure 2.2):

1. Constitutionally-based learning styles and preferences
2. Cognitive structure
3. Stable personality type
4. "Flexibly stable" learning preferences
5. Learning approaches and strategies

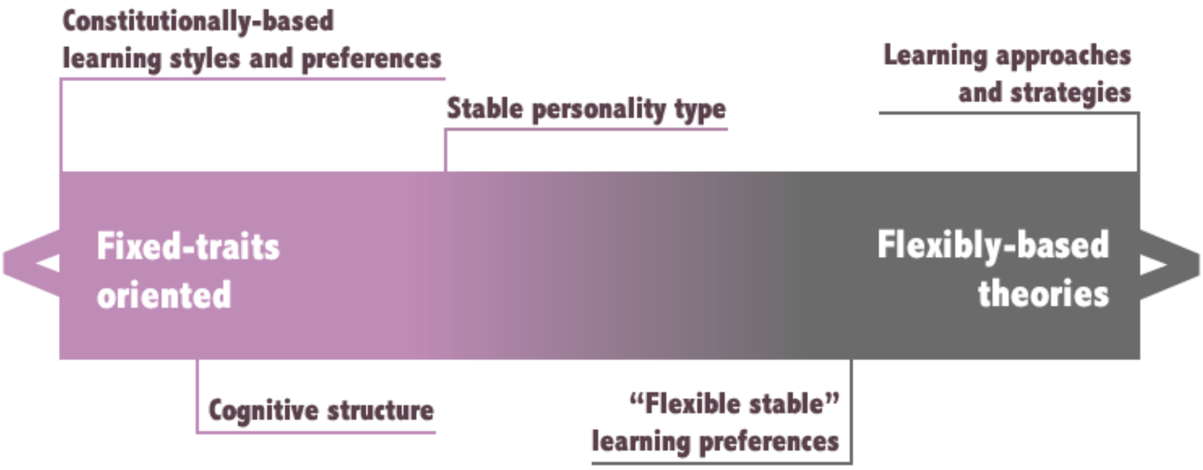

Figure 2.2: Learning styles theories in a continuum from most fixed-traits oriented to the most flexibly-based theories.

The following paragraphs provide a more detailed explanation and examples for each of the grouping of theories.

2.4.1.1 Constitutionally-based Learning Styles and Preferences

This family of theories believes that learning style is fixed and born with, focus on "matching" as an instructional technique. It claims that there is a limit in changing each person's ability. Examples of theories under this category is Gregorc's Mind Style Model (Gregorc, 1979).

Gregorc's Mind Style Model states that there are inborn inclinations towards one or two of the channels, and they are not amenable to change or it will cause harm to oneself when attempting to change. He proposed a Mind Style Model based on the assumption that the minds interact with the environment through "channels", and according to Gregorc (2002), all learners can make use of all channels, but he claimed that learning styles are God-given and one should not work against one's personal style as it will lead to harm. However, critics have challenged the unsubstantiated claims made about harmfulness and that this theory lacks reliability and is too rigid to change.

Overall, this family of theories takes on a highly structured view of learning preference, "matching" a style to a learner is too rigid and might lead learners to self-limit their styles as opposed to being open to try out other learning preferences. While there are merits in identifying and connecting students' individual learning styles, the view this family of theories takes is far too fixated on prescription; thus it is not suitable for the current research to consider as a potential learner-directed framework.

2.4.1.2 Cognitive Structure

This family of theories considered learning styles as "structural properties of the cognitive system itself" (Messick, 1984). It concentrates on the interactions of cognitive controls and cognitive processes (Riding & Rayner, 1998). Furthermore, cognitive styles are not particularly amenable to change. An example theory coming from this grouping is Riding's Cognitive Style Analysis (Riding & Rayner, 1998).

Riding and Rayner (1998) saw cognitive style as "the way the individual person thinks" and "an individual's preferred and habitual approach to organizing and representing information". The theory has two independent dimensions: holistic-analytic (cognitive organization); and verbal-imagery (mental representation). In this theory, it was recommended that teachers should deal both with generalities and particulars; they should structure material so that part-whole relationships are clear; to make demands on both deductive and inductive reasoning; and make use of both visual and verbal form of expressions.

While this theory makes logical sense, one should be cautious in the application on the overly simplistic and bipolar nature of the theory (Coffield et al., 2004). There is a progression from constitutionally-based learning styles to cognitive structure theories with a sense that the latter theories take into consideration of looking at learning styles in a more holistic way instead of the focus on matching a type of learner to a type of style. Even though this grouping of theories is dichotomous in nature, the concept behind it is somewhat related to the current study. There is an attempt to design learning in a way that different learners' needs are catered to in a less rigid format (i.e. non-matching); however, students are still not considered as decision makers in what they can do during the course of their study, and there is a definite lack of learner control support.

2.4.1.3 Stable Personality Type

Stable Personality Type focus on "constructing instruments which embed learning styles within an understanding of the personality traits that shape all aspects of an individual's interaction with the world". (Coffield et al., 2004). Jackson's Learning Styles Profiler (LSP) is one example of theories fits under this classification as Jackson perceived learning styles as a sub-set of personality and have a biological basis (Jackson, 2002). Four learning styles are proposed within this theory: initiator, reasoner, analyst, and implementer.

This theory is relevant to the current study as learner experience has started emerging as a topic of relevance and usefulness in this theory, and within this classification, the focus started to shift more to the learners and their developments and building of multiple strengths for learning.

2.4.1.4 Flexibly Stable Learning Preferences

This division of theories identifies learning preferences not as a fixed trait, but a difference preference for learning, which changes slightly from situation to situation. However, this group maintains that there is some long term stability in learning styles (Kolb, 2000). One of the most influential theories is David Kolb's Experiential Learning Theory (ELT) (Kolb, 1984). According to this theory, effective learners need four types of abilities to learn: concrete experience (CE); reflective observation (RO); abstract conceptualizations (AC); and active experimentations (AE).

Overall, the flexible stable learning preferences family details that learning styles are more of a preference than style; and it promotes learner progression over time/stages/context. The idea of growth is realistic and it promotes a well-balanced, holistic learning experience. Of all the learning style theories, this family closely resembles the current research concept in a way that it acknowledges individual learning preferences without imposing a set sequence or a prescription on the learners. Learner initiation and learner control were taken into consideration in this theory as Kolb (1984) stated that learners are free to explore the four types of abilities to learn without a start or an end point. Instead of matching learners to a particular style, they are encouraged to gain insights by experiencing different learning modes in changing context, different stages, and over time. More in-depth review and analysis of this theory will be covered under Section 2.4.2.

2.4.1.5 Learning Approaches and Strategies

The last grouping takes on a broader view on learning preference. Instead of learning styles, the focus here is on strategies and approaches to pedagogy. Entwistle's Approaches and Study Skills Inventory for Students (ASSIST) is an example of a learning approach/strategy rather than a style. This approach describes the way in which students choose to deal with a specific learning task. It takes into account the effects of previous experiences and contextual influences (Entwistle, 1998). The emphasis is on learner's choices and control, instead of a prescription.

Entwistle also defined the features of different approaches to learning based on Marton and Saljo's work on deep and surface learning (1976). Deep and surface learning approaches are defined as: "If students have a sophisticated conception of learning and a rich understanding of the nature of knowledge and evidence, then they have a deep approach to learning. On the other hand, if they see learning as memorizing or acquiring facts, then they are likely to adopt a surface approach" (Coffield et al., 2004). Strategic learning was added later as a combination of deep and surface approach.

All in all, this grouping views approaches as options that students choose to adopt, and the strategies and the associated inventories are used as constructive diagnostic tools with the aim to improve pedagogy. Entwistle (1998) suggested that learners are in a better position to decide what they try to achieve from studying when they become more aware of their own approaches/strategies. This grouping has started to shift the emphasis from the teacher's perspective to the learner's experience.

To sum up, within the learning style theories field, researchers diverged from the notion of styles imply fixed traits that are stable over time to those who argued that learning styles are context specific and could change over various contexts. On one end of the spectrum, fixed-traits oriented theorists claimed that styles are "God given", while on the other end, the flexibly-based theorists are inclined to think that learners are free to choose their approaches and strategies for learning. It is toward the end of this spectrum that this research is associated with. In particular, after careful consideration and deliberation, Kolb's theory of experiential learning and cycle is selected as the design framework for the current study. It is a wildly accepted holistic model of the learning process and it provides flexibility for students to choose their preferred learning style as a starting point in the cycle. This iterative process adapts well into an online learning design, especially one that targets self-paced learning – it provides a structure for the learners while maintaining its flexibility as a Learner-Directed Model. Mayes and deFreitas (2004) have even classified it as an individual constructivist theory based on the idea that Kolb's cycle features a number of components that reflect solo learning activities. The next section will elaborate on the Experiential Learning Theory and its applications.

2.4.2 Experiential Learning Theory (ELT)

Section 2.3.1.4 touched briefly on David Kolb's Experiential Learning Theory (ELT) as an example of a flexible stable learning preference; this sub-section aims to provide a more in-depth description and critical analysis on the theory itself and how it relates to the current research.

Developed in the early 1970's by David Kolb, ELT provides a holistic learning theory for understanding adult learners' learning process, and it emphasises experience as the central focus in learning. ELT suggests that learning requires polar opposite abilities; thus it creates conflict and learners are forced to choose which set of abilities to use in a certain learning situation in order to resolve the conflict. For example, it is not possible to drive a car and analyse a driver's manual at the same time, we need to choose which approach to take; as a result, over time, we develop a preferred way of choosing (Kolb, Boyatzis, & Mainemelis, 2000).

In his research, Kolb observed that some students have a definite preference for certain learning activities (Kolb, 1984). For example, one student might prefer reading lecture notes whilst another student might prefer working on an interactive simulation. "From this emerged the idea of an inventory that would identify these preferences by capturing individual learning differences" (Kolb & Kolb, 2005). However, others have challenged the use of a learning style inventory by how stable and contextually depend it is (Cornwell & Manfredo, 1994; Cornwell, Manfredo, & Dunlap, 1991; Willcoxson & Prosser, 1996).

Kolb sees learning as "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience" (Kolb & Kolb, 2005). For learning to be effective, Kolb suggested that learners need to develop abilities in two sets of dialectically related modes of grasping and transforming experience: Concrete Experience (CE) and Abstract Conceptualization (AC) for grasping experience; Active Experimentation (AE) and Reflective Observation (RO) for transforming experience. As a result, in 1971, the Learning Style Inventory (LSI) was designed to help learners assess their individual learning style and to place them in one of the poles of each mode (Kolb, 1976).

Figure 2.3 below shows how a learner can progress through the experiential learning cycle: experience is translated through reflection into concepts, which are in turn used as guides for active experimentation and the choice of new experience. Kolb stated that a learner can begin the learning cycle at any one of the four modes, but that learning should be carried on as a continuous spiral. As a result, knowledge is constructed through the creative tension among the four modes and learners will be exposed to all aspects of learning: experiencing, reflecting, thinking and acting.

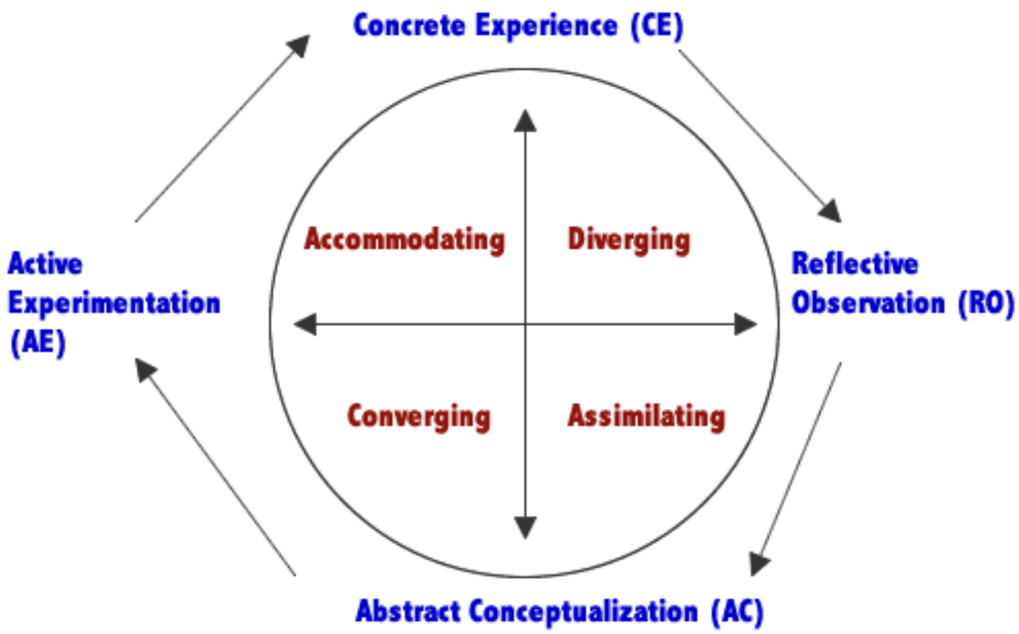

Figure 2.3: Kolb's Experiential Learning Cycle

Furthermore, there are four dominant learning styles that are associated with these modes (Kolb 1976, 2000). The four learning styles are shown in Table 2.2.

Table 2:2: *Kolb and Fry on Learning Styles (Kolb et al., 2000; Tennant, 1997)*		
Learning style	**Description**	**Preferred learning modes**
Converging (AC and AE focus)	Strong in practical applications of concepts and theories Good at problem solving, decision making and practical application of ideas	Simulations Laboratory assignments Experiment with new ideas Practical applications
Diverging (CE and RO focus)	Interested in observation and collection of a wide range of information Imaginative and aware of meanings and values Interested in people and are socially inclined	Discussion with others Social learning Debates
Assimilating (AC and RO focus)	Interested in presentation and creation of theoretical models Concern with ideas and abstract concepts	Reading Watching or listening to lectures Having time to think things through
Accommodating (CE and AE focus)	Interested in hands-on experiences Act on “gut” feelings Rely on others for information	Learn from other people Expert system

Overall, Kolb's contribution to the learning style theory is that it moves from teacher-focused to learner-centred. The learning orientations Kolb proposed provide a framework for learning design, and it promotes holistic learning in the context of a self-paced online learning environment.

Two practical suggestions came out of ELT. First, teachers and learners should "explicitly share their respective theories of learning, a process which would help personalization and adaptation of learning" (Coffield et al., 2004). The second suggestion is that "there is a need to individualise instruction and Kolb believes that information technology will provide the breakthrough" in this area (Coffield et al., 2004).

A number of criticisms have been made of the ELT. Various scholars (Jarvis, 1987; Jeffs & Smith, 1999; Tennant, 1997) have argued that ELT takes on too linear of an approach; it is overly simplistic; any of the four stages Kolb identified could occur simultaneously; and the empirical support for the inventory is weak. One of the most important criticisms is that depending on the learner, and/or the activities they are engaged in, some stages of the process can be bypassed, or repeated several times in any sequence (Wheeler, 2012).

In order to overcome the above criticisms in using Kolb's model for the current study, my research model is redesigned as an iterative process where learners can bypass or repeat any or all of the stages. It is grounded in individualised instruction that support solo domain-related online learning activities without prescribing any particular styles of learners. Learning inventory will not be used for the current study.

Effective learning design needs to involve the appropriate use of cognitive as well as meta-cognitive strategies (Brokowski et al., 1987; Garner, 1990). This research will look at how one can incorporate contextually supported meta-cognitive strategies into a learner-directed learning environment. The next section will cover the topic of meta-cognition and in particular, self-regulated learning (SRL) theory in relation to online learning.

2.5 Meta-Cognition

As mentioned in Chapter 1, meta-cognition is defined as “cognition about cognition” or “knowing about knowing” (Flavell, 1979; Metcalfe & Shimamura, 1994). It is also known as “a higher order thinking that involves active control over the thinking processes engaged in learning” (Lai, 2011; Livingston, 1997) Meta-cognitive strategy/regulation concerns the abilities of learners to monitor their own learning, setting goals, planning, as well as evaluating the outcomes of these strategies/regulations. Meta-cognitive activities help facilitate the ability of the learner to regulate cognition, and it makes students think about learning more explicitly. Similarly, self-regulated learning (SRL) refers to the setting of one’s goals in relation to learning and ensuring that the goals set are met (Boekaerts & Corno, 2005; Butler & Winne, 1995; Perry, 2006; Winne & Perry, 2000; Zimmerman, 1990). There is conceptual overlap between meta-cognition and SRL such that individuals make efforts to monitor their thoughts and actions and to act accordingly to gain some control over them. However, there is a cognitive orientation for meta-cognition, while self-regulation is as much concerned with learner’s action and behaviours than the thinking behind it (Dinsmore, Alexander, & Loughlin, 2008). Furthermore, SRL deals mainly with person-environment interaction and it has an exclusive focus on academic learning (Dinsmore, Alexander, & Loughlin, 2008). For this research, SRL is considered as a subset of the education theory family with its focus on the learners and the learning process. Since this research is interested in the person-environment interaction in academic learning, Section 2.5.1 will look at SRL in more detail.

2.5.1 Self-Regulated Learning (SRL) Theory

Self-Regulated Learning (SRL) theory fits well with a learner-directed e-learning approach because in an individualised learning environment, learners are often left to their own devices, and a flexible e-learning system can help make learners be more aware of their own thinking, monitoring, planning, evaluating personal progress against a standard, and motivating them to learn (Boekaerts & Corno, 2005; Butler & Winne, 1995; Perry, 2006; Winne & Perry, 2000; Zimmerman, 1990). When learners adapt their approaches to learning, learning is said to be self-regulated (Winne, 1997). SRL "emphasises autonomy and control by the individual who monitors, directs, and regulates actions toward goals of information acquisition, expanding expertise, and self-improvement" (Paris & Paris, 2001).

SRL theory states that learners not only need to regulate their performance, but also how they learn. Literature shows that self-regulation can positively affect learners' achievement (Azevedo, 2005). SRL is "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behaviour" (Pintrich, 2000). It is a deliberate, judgmental, and adaptive process (Zimmerman, 1990) where feedback is an "inherent catalyst" (Butler & Winne, 1995). In addition, Hadwin, Wozney, and Ponton (2005) revealed that "ordinary" collaboration (as found in traditional online forums and chats) is insufficient to transform learners' everyday "reflection" into productive "regulation".

According to Paris and Byrnes (1989), self-regulated learners have the following characteristics; they:

> "…seek challenges and overcome obstacles sometimes with persistence and sometimes with inventive problem solving. They set realistic goals and utilise a battery of resources. They approach academic tasks with confidence and purpose. The combination of positive expectations, motivation, and diverse strategies for problem solving are virtues of self-regulated learners".

What sets self-regulated learners apart is their awareness of when they know a skill or fact and when they do not, at a meta knowledge level - i.e. based on what they know or do not know, they plan, set goals, organise, self-monitor, and self-evaluate throughout their studies (Zimmerman, 1990). In addition, they are able to evaluate and trade-off between small-scale tactics and overall strategies, and be able to predict how each can support their learning progress towards the goals they pre-selected (Winne, 1995)

Zimmerman (1990) wrote that there are three features of most definitions of SRL:

1. Learners' use of self-regulated strategies – learners are aware of "strategic relations between regulatory process or responses and learning outcomes" (Zimmerman, 1990); and they are able to deploy these strategies to achieve their pre-selected goals.

2. Learners' responsiveness to self-oriented "feedback" loop (Carver & Scheier, 1981; Zimmerman, 1989) - it is a cyclic process where learners' self-monitor the effectiveness of their learning strategies. The process could include self-recording, self-instruction, and self-reinforcement. They then react to this feedback and depend on it for attaining their goals.

3. Learning and motivation are seen as interdependent process - self-regulated learners proactively seek ways to learn, and initiate opportunities for feedback, and refine strategies that can set higher goals.

To operationalise SRL, Winne & Hadwin's SRL model (2008) puts forward four phases of self-regulated studying. The flow of the four phases presents the functional architecture of Winne's SRL model. The four phases are task perception, goal setting and planning, enacting, and adaptation, and they are "flexibly sequenced phases of recursive cognition" (Winne & Hadwin, 2008). The four phases are described as follows:

1. In Phase 1, the student gathers the task at hand and constructs the definition of the task. This can be represented as a schema (containing slots for both learning tasks and meta-cognitive traits), where the slots of the schema are filled by students' perceptions of task- and meta-cognitive- conditions. This stage involves identifying the student's motivational states, self-efficacy, and information about the environment around him/her.

2. In Phase 2, the student frames goals and plans – goals set by the instructor (normally, learning objectives) as well as goals of the student's own (standards); plans are set forth by the learner to address goals, and they consist of study tactic or study strategy. The goals that are set depend on how the student perceives the task at hand.

3. In Phase 3, plans are enacted and studying begins in order to approach the goals. If the student meta-cognitively monitors products that plans create, this generates evaluations (feedback) that describe how well the learner's interim learning products match the expected standards.

4. In Phase 4, the student 'adapts' plans based on the differences observed in Phase 3. The student evaluates her performance and determines how to modify her strategies accordingly so as to better align with the goals. The student may change her goals or plan; she may also choose not to attempt that particular task again.

Despite the benefits of self-regulation, there are many reasons why learners choose not to self-regulate their own learning. For example, some learners might feel that planning, evaluating, monitoring and evaluating their learning process takes too much time and they are not willing to invest the resources in that particular context (Boekaerts, 1999). Boekaerts (1999) noted that SRL has a bidirectional relationship with learning environments. She asserted that learning environments could be used to promote self-regulatory skills and act as facilitators for learning new self-regulation strategies. I would like to extend this line of argument to online learning environments where a system can be designed to introduce, facilitate, scaffold, and provide options for self-regulation process and strategies in an unobtrusive way. Indeed, Winne (1995) suggested that self-regulation is common, and that learners should develop an effective means to self-direct their learning, so it is recommended that “the classical topic of instructional design could be revitalised as a scientific approach to accommodating and changing learners’ knowledge” (Winne, 1995). It is with this foundation that this research model design is based on: the learner-directed flexible system wherein students are presented options and self-regulated strategies to select and engage in.

In addition to SRL, contemporary research has extended the learning process through co-regulated learning (CoRL) – the interplay between learners and agents – both human tutors and pedagogical agents (Dinsmore et al., 2008; Harley, Taub, Bouchet, & Azevedo, 2012). It is out of the realm of the current research to investigate CoRL; however, there is value in considering CoRL as part of the future research plan. One of the recent advances in Anthropomorphic Pedagogical Agent (Fakinlede, Kumar, & Wen, 2013) allows a computational system to co-construct a view of shared cognition arising out of conversations among humans and among humans and software agents, which can then be used as a reference point for co-regulation.

As this thesis is about the learner-directed learning, it is important to settle the differences between learner-directed learning (LDL) and SRL in my own terms. While LDL is grounded on SRL theory, and it has a meta-cognitive focus, self-regulation requires an explicit impetus that guides or informs one to modify and evaluate one's own cognitive or meta-cognitive study habit. Thus, one could manipulate the explicit impetus to various degrees of self-regulation. More importantly, one could specifically target a particular impetus to trigger a particular aspect of regulation. On the contrary, learner-direction requires an implicit impetus. Meaning, one doesn't have to externalise the reasoning behind a particular study habit. In the current study, I took the view that in order to manipulate learner-direction (while grounded in SRL theory), design for the user and learner experience should adhere to a variety of open options that the student can choose from. Therefore, the impetus is not externally manipulatable but is implicitly built-in to the design of the online course. The next and final section will introduce user experience, user-centred design and learner experience as part of the larger context of this research.

2.6 User Experience (UX)

The term user experience (UX) came from the tradition of web site design and interaction design. Over the last decade and a half, it has increasingly become an accepted standard in understanding and evaluating how users feel about a product or a system (Garrett, 2003; Kuniavsky, 2003; Shedroff, 2001). There are many definitions for user experience. According to Law, et al (2009), UX can be defined as “something individual (instead of social) that emerges from interacting with a product, system, service or an object.” To further clarify what that “something” is, ISO 9241-210 (2010) stated that It is a person’s perception and responses that result in interacting with a product/system. In a way, UX is a rather subjective domain since each person’s experience will be different based on his/her goals, context, and perceptions. But measuring UX does not have to be based only on the totality of the effects felt by the users (Hartson & Pyla, 2012). While there are certain degrees of self-reporting/self-impression on evaluating UX, there are aspects of performance-related usability issues that can be objectified, such as the number of seconds a user takes to select the right navigation button, or with a given scale, how clear a certain instruction provided is in explaining a procedure. There are also external behaviours one can measure, such as increased in productivity or decreased in time spent on a procedure.

To confine the definition within the e-learning context, this research views UX as experiences that are being measured against a product or service based on: ease of use, looks and feel, controllability, and system performance. UX caters to the positive as well as the negative emotional and utilitarian experiences involved when interacting with a product or service. To extend the definition of UX further, this research would add the aspect of UX that focus on learners exclusively. The next section will review the difference between learner experience and user experience in finer detail.

2.6.1 Learner Experience (LX) vs. User Experience (UX)

Learner experience (LX), a term coined by this author, is defined as a learner's perception, responses, and attitudes that emerges from interacting with a learning system. It is about engaging learners in an "active cognitive process such as creating, problem-solving, reasoning, decision-making, and evaluation. In addition, students are intrinsically motivated to learn due to the meaningful nature of the learning environment and activities" (Kearsley & Shneiderman, 1999). Unless a complete record of the engagement of a learner experience within the scope of each activity is obtained, one could only hope for an approximation of issues faced by the learner during the process of learning. Online learning environments, when carefully designed, lend themselves to observation of what learners do when they engage in a learning activity.

Within the instructional design community, what is known as "design science" is defined as principles about laying out and implementing interventions. It is used to aid students in learning more about learning strategies, to extend to their sense of personal worth and to help with academic success (Pressley & El-Dinary, 1993; Zimmerman, 1990). Yet, in creating e-learning, Smulders (2003) asserted that one rarely makes the distinction between designing for users and designing for learners. In its simplest form, the difference between designing the user experience and learner experience can be viewed as the issue of form versus content. To further elaborate on Smulders' (2003) idea of the dual role of the learner-user, I composed a comparison table of user experience and learner experience as a reference (see Table 2.3). The left-hand column contains attributes that course designers would focus on in designing the user experience while the right-hand column contains attributes to consider in designing the learner experience.

Table 2.3: *User Experience and Learner Experience Comparison Table*

User experience (UX)	**Learner experience (LX)**
Ease of use - make tasks simple by providing signposts and cues. The aim is to get the users where they need to go and to what they need to do with as little delay as possible	**Challenge the learners –** do not always make tasks easy or obvious. The aim is to encourage learners to develop their own understanding of problems and concepts
Intuitive – tasks are obvious; users know where to go and what to do. The aim is to reduce uncertainty and ambiguity	**Explorative –** tasks are not always clear so as to encourage learners to discover. The aim is to increase self-reliance
Focus on surface learning	**Focus on deep learning**
Error-prevention - provide constraints on data input, etc. The aim is to reduce user frustration	**Reflection –** provide points to ponder and to pause and think. The aim is to promote inquisitive thinking
Have empathy – to be able to understand the users' perspectives and feelings. The aim is to create products/services that would be in alignment with the users' needs and using familiar terms and languages of the target audience	**Contradict ideas –** provide contradiction and debates, not always in agreement with the learners. The aim is to promote critical analysis of information

2.6.2 Designing with LX and UX

Designing superior online learning experiences requires a delicate balance of UX and LX. In the design of this research model, careful consideration has been taken in the blending of both design elements. To summarise, the current Learner-Directed Model plans to apply the following UX and LX principles:

- Intuitive and easy-to-use interface - the interface will be placed in an unobtrusive manner and be made optional; the main content interface will make use of the familiar metaphors with primary colours and self-explanatory labels
- Exploratory design - provides limited choices that do not overwhelm users and makes the system easy to use and yet offers some flexibility in what learners choose to study
- Contradict and challenge the learners – the learning activities provided will challenge the learners to learn in different styles/formats
- Support both surface and deep learning – the content is designed for both breadth and depth. Learners have the freedom to skip around or to explore each area in-depth
- Provide context – the associated supported study skills are available in context as each study skill is designed according to the learning activity provided
- Have empathy – the content is aimed at an introductory level written in plain English. It is written with the assumption that learners do not have prior domain-related knowledge and experience

All in all, the design approach for the Learner-Directed Model for this research will incorporate some of the concepts and ideas reviewed in this chapter. Concepts connecting to instructional design models that support learner control; education theories that cater to individual learning preferences and foster a solo-constructivist approach that develop autonomous learners, meta-cognitive activities associated with self-regulated and learner-directed learning, and consideration of both UX and LX.

2.7 Summary

This chapter has covered current literature in relation to the present study in five areas: instructional design models; education theories; learning style theories; meta-cognition; and user experience. In the first area, instructional design models were described, with attention paid to the type of instructional design models that have learner-control and learner-direction elements. Types of models that this current research is closely aligned with were identified, and examined the current gaps exist between these models and what this research aims to achieve. The second area covered education theories, their progression and the types of education theories that provide a foundation for this research. In order for a learner-directed learning to occur, learners need to take an active part in knowing what to select and construct the knowledge that align with their prior experiences. Third area took a look at various learning style theories and their classifications with highlights to the most influential theories based on a classification framework from Coffield et al (2004). It became obvious that learning style theories have evolved from being perceived as a fixed trait to a more flexible strategy. I positioned this research as to where I saw my work fit within this spectrum. The fourth area is on meta-cognition, and in particular, this review looked at self-regulated learning (SRL) as compared to learner-directed learning (LDL). Finally, the last area studied user experience (UX) as it relates to online learning design and how it differentiated from learner experience (LX). Detailed descriptions and analysis were given, and what emerged is that there is a need to provide an alternative learning design method to facilitate holistic learning; to support learning preferences; and to augment learner-control and self-regulation processes in new learning environments. The next chapter will look at an alternative view of providing learner control and learner-directed learning in the lens of student modelling. Review of popular user and student models will be detailed as well as the debate on adaptive versus adaptable approach in catering learner-directed learning.

Chapter 3: Learning Systems and Student Modelling

"Set out from any point. They are all alike. They all lead to a point of departure." – Antonio Porchia

3.1 Introduction

In Chapter 2, a comprehensive literature review provided a foundation on which this research is based, namely, instructional design models, educational theories, learning styles theories, meta-cognition, and user experience (UX). The literature review and discussion indicated that there are a number of imminent opportunities to develop an alternative model that is learner-directed. Another angle in exploring the notion of learner control and provision of learner-directed e-learning environment is through the lens of adaptive systems and student modeling. This chapter will survey the world of adaptive e-learning systems, associated technologies and approaches, as well as student modeling as points of inspiration and departure for the current research study.

The objective of this research is to understand how a learning system can attend to the individual needs of the learners. Often, this is the domain of the adaptive systems. An adaptive system is a system that could adapt itself or other systems to various circumstances (Fröschl, 2005). It is a system that makes use of relevant representations of user characteristics, and makes appropriate adjustments based on the users' goals/needs/preferences. In order to capture this information, adaptive systems often employ a user model. A User model is a representation of a user that captures a user's goal, tasks, knowledge, background, experiences, interests, traits, and context of the work (Nurmi & Laine, 2007). An adaptive learning system is a branch of adaptive systems, and in the context of e-learning, it specialises in the adaptation of educational content, assessments, and presentation to support and enhance learning. In support of the current study, the goal is to create an instructional sound and flexible environment that caters learning for students with different levels of cognitive abilities, prior knowledge, preferences, demographics, technical skills, and other abilities (a student model).

This chapter will begin with a summary of current adaptive learning systems relevant to the context of the present research study in Section 3.2. Then, Section 3.3 will describe the characteristics of user models and student models. Different types of student models and their usage in adaptive learning systems will be introduced. Section 3.4 will depict some of the common approaches for student modeling, with the emphasis on the ones that promise a finer level of learner control. Then, in Section 3.5, adaptive versus adaptable approaches will be compared and discussed with the focus on how the current research integrates concepts from these approaches/concepts for learner control. Finally, this chapter will conclude with Section 3.6 with a summary of this chapter.

3.2 Summary of Current Adaptive Learning Systems

An adaptive system may be based on the users' goals, skills, attributes, and preferences. This section describes the type of adaptive learning systems currently in use, their classifications and the challenges in implementing them. The selection of the adaptive learning systems is also based on the ones that make use of a user model in its formulation.

In general, theoretical models of adaptive learning can be classified into four theoretical approaches: the macro-adaptive approach, the aptitude-treatment interaction approach, the micro-adaptive approach and the constructivistic-collaborative approach (Mödritscher, García, & Gütl, 2004). Macro-adaptive approach is the oldest approach and it attempts to personalise instruction at a macro-level based on a few main components such as learning objectives, levels of detail and delivery system (Park & Lee, 2003). Students typically have little or no control/input over this adaptive approach. Aptitude-treatment interaction approach adapts instructional strategies to students' aptitudes. Aptitudes such as learning styles, cognitive styles, and prior knowledge can be adapted. This approach offers some control to learners over the learning process as learners can control the styles of the instruction or the wayfinding ability in navigating through a course. Micro-adaptive approach adapts based on observing the tasks students perform. Finally, constructivistic-collaborative approach integrates collaborative technology as part of the learning activities. The constructivistic-collaborative approach is student-centred as it places the control of learning into the hands of learners (Marzano, 1992), and it is similar to a learner-directed approach based on active learner control. In this approach, learners play an active role in the learning process by constructing their own knowledge through experiences in a context in which the target domain is integrated with both subject-specific tasks and meta-cognition-specific tasks (Akhras & Self, 2000). The collaborative aspect is realised through the provision of activities and supports including a collaborative learning skill coach, an instructional planner, a student or group model, a learning companion, and a personal learning assistant (Mödritscher et al., 2004).

The second classification is grouped by the adaptive learning systems developed with the theoretical models described above. Macro-adaptive instructional systems, intelligent tutoring systems, adaptive hypermedia systems, and adaptive educational hypermedia systems are presented below.

3.2.1 Macro-Adaptive Instructional Systems

At the macro level, students were grouped or tracked by grades from ability tests. In the early 1900s, macro-adaptive instructional systems were developed to tailor instructions to the learner's abilities. Students were divided by grades of ability tests. According to Park & Lee (2003), examples of such a system are the Burke Plan, Dalton Plan, Winnetka, and Keller Plan. The main adaptive feature in these plans is that students were able to study learning material at their own pace (Park & Lee, 2003).

3.2.2 Intelligent Tutoring Systems (ITS)

Intelligent tutoring system (ITS) is a computer system that aims to provide system-to-student instruction automatically and cost effectively (Shute & Psotka, 1996). The system interacts with learners, assesses, diagnoses problems, and provides assistance as needed. An important feature of ITS is the ability to go beyond learning simulation by providing contextual hints and individualised guidance when a learner requests it (Ong & Ramachandran, 2003). In other words, the system is deployed as a way to reduce the need for human instructor interaction with learners. It is especially useful when there are large groups of students to be tutored, or when a specific topic needs repeated tutoring effort. However, it is immensely expensive to develop ITS and it involves a substantial amount of complex programming. ITS uses micro-adaptive approach combining the aptitude-treatment interaction approach to adapt at task level. It consists of four components: the domain model, the student model, the tutoring model, and the user interface model (Freedman, 2000; Nkambou, Mizoguchi, & Bourdeau, 2010; Nwana, 1990). Artificial intelligence techniques and research in cognitive psychology further develop ITS to more accurately represent the teaching and learning process.

3.2.3 Adaptive Hypermedia Systems (AHS)

Adaptive hypermedia system (AHS) is a hypertext and hypermedia system that builds and applies user models to adapt various visible aspects of the system to an individual user (Brusilovsky, 1996). Hypermedia applications such as websites with an unlimited number of links and content could potentially cause information overload and orientation problems (Nielsen & LyngbÊk, 1990). Adaptive hypermedia thus attempts to overcome this problem by adapting a selection of links or content most appropriate to the current user. Moreover, adaptive hypermedia can also offer the most appropriate links or content for the context of the current user, for the device the current user is accessing the information from. AHS's user model can be initialised by a user in completing a questionnaire, or more commonly, by observing the browsing behaviour of a particular user to build a user model automatically. The user model is then applied to classify and manipulate link anchors to guide users to pages that are closely matched to their goals and needs (De Bra, Brusilovsky, & Houben, 1999). AHS provides two types of adaptation: at content-level, and at link-level (Brusilovsky, 2001). Adaptive presentation will arrange presentations in different ways/orders with different content. Adaptive navigation is provided by an adaptive navigation support group. It is used for adapting navigation (links) in different ways - for example, to hide, record, delete, recommend, rank, and push links (Kinshuk & Lin, 2003). AHS has been used in formal learning systems, informal learning resources, e-commerce sites, online help systems, and other applications.

3.2.4 Adaptive Educational Hypermedia Systems (AEHS)

Adaptive educational hypermedia system (AEHS) is a subtype of AHS. The focus of user modelling in AEHS is on domain knowledge of the learner (Brusilovsky, 1996). It tailors what the learner sees to that of the learner's goals, abilities, needs, interests and knowledge of the subject, by providing hyperlinks that are most relevant to the learner. In recent years, the popularity of e-learning and the advent of learning management systems promote a greater use of AEHS. Since learning management systems are commonly built with a one-size-fits-all-learners approach, AEHS attempts to provide an alternative approach that caters to the individual learner's needs. The purpose of this adaptation is to maximise learner satisfaction, learning speed, and assessment results (Souhaib, Mohamed, Eddine, & Ahmed, 2010).

3.2.5 Challenges and Limitations

Challenges and limitations in developing and implementing adaptive systems are manifold. First and foremost, adaptive systems are costly. Content component building in ITS, for example, took 300 hours of development time for the custom content in order to encode an hour of online instruction time (Murray, 1999). The high cost of development makes it difficult to justify the commercial value of such systems (Polson & Richardson, 1988); therefore, developers and instructional designers need to thoughtfully evaluate the context and circumstances in order to decide on what to adapt. Pedagogically speaking, there are also limitations in using adaptive systems. For ITS, the system may restrict the user from certain tasks or advise to do certain tasks as recommended by pedagogical strategies whether or not they match with a user's preferences (Oppermann, Rashev, & Kinshuk, 1997). Usually, users are not allowed to act against the tasks (such as to reject, skip, contradict, or seek alternatives), and there is a danger in creating a learned helplessness situation. Another challenge for ITS is that the system fails to develop deep learning in students. When students can receive continuing hints and support, some students become overly reliant to the system and they tend to "bottom out" the hints without developing self-directed and reflective skills in learning. Tutoring systems are unable to detect shallow learning and therefore, the learning for some users is not optimal (Koedinger & Alven, 2007). For AHS and AEHS, if prerequisite relationships are omitted or are just wrong, the user may be directed to pages that cannot be understood by her because of necessary prior knowledge in this domain. Another drawback is that the same page might look different if this page is visited again. When the document is adapted to a developing user model, each time a user visits a particular page again, it may look different. This can potentially cause confusion and loss of orientation for the user (De Bra, 2000).

In terms of measuring the effectiveness of adaptive systems, there is little empirical evidence that they work (Park & Lee, 2003). Adaptive systems all vary greatly in design, focus, techniques, and implementation. In an educational context, tutors, course designers, learners all interact and shape the system in different ways, which makes it difficult to evaluate and to provide a standard measurement across systems. Among studies that attempt to evaluate adaptive systems, one recent study found that there was no statistical difference in effect size between expert one-on-one human tutors and step-based ITS (VanLehn, 2011). However, there is some recognition of adaptive systems' abilities to provide immediate feedback, individualised tasks, on-demand hints, and just-in-time content support (Koedinger & Alven, 2007; VanLehn, 2011). Another issue relating to evaluating adaptive system is the tendency to measure its effectiveness against a static system. Comparison between adaptive and non-adaptive systems is not appropriate, as De Bra (2000) stated that it is like “comparing a motorcycle to a bicycle”. More comparative studies are needed between different adaptive techniques and their effectiveness on learner control and learner experience overall.

The next section will take a closer look at user and student modelling, what they are, and how they are used in adaptive systems, especially within an adaptive learning system context and the challenges in implementing them.

3.3 User and Student Modeling

User modelling can be defined as a model of users residing inside a system or computational environment (Fischer, 2001). An adaptive system adapts based on the users’ goals and preferences. The properties of the users are stored in a user model. Thus, a user model represents the system’s beliefs about the user (Koch, 2000). Broadly speaking, user modelling is a technique employed to provide users with options with respect to performing tasks and interacting with systems differentially. The common variables to model include the users’ personalities, abilities, prior knowledge, preferences, performances and intentions (Barker & Adisen, 2005). User modelling attempted to address the issue of designing a system for millions of users at design time while making it work as if it were designed for each individual user at run time (Fischer, 2001) – to say the “right” thing at the “right” time” in the “right way”.

Koch (2000) listed seven purposes of a user model. The purposes are to:

1. Assist a user during learning of a given topic
2. Offer information adjusted to the user
3. Adapt the interface to the user
4. Help a user to find information
5. Give the user feedback about his knowledge

6. Support collaborative work
7. Give assistance in the use of the system

All in all, the aim for user modeling is to “reduce information overload by making information relevant to the task-at-hand to the assumed background knowledge of the users” (Fischer, 2001).

A student model is a type of user model that is intended for use in an educational teaching and learning context. In e-learning, a user model is used for augmenting the learning process, thus the model is called a student or a learner model. A student model is used to modify the interaction between the e-learning system and the learner so as to suit the needs/goals/wants of each individual learner. Learner models can be divided into these components: a profile, a cognitive overlay model, and course overlay model (Castillo et al, 2005). Learner profile stores demographic and personal information such as name, age, gender, preferred learning styles, etc. Cognitive overlay model stores the system’s beliefs about the learner knowledge. Course overlay component supplies information about the learner’s interactions with the system.

Ragnemalm (1996) distinguishes between student models that contain the students' actual domain knowledge to those that contain students’ characteristics. A wide range of modeling approaches is available to the software developer according to Ragnemalm. Student models therefore may hold information that relates to the knowledge a user has in a particular domain, their personalities, preferences, individual skills, learning or cognitive styles and in fact any information about the user that may be useful in configuring a computer application for individual use. The first type of models (models that contains actual domain knowledge) is sometimes referred to as overlay models as they compare the “knowledge” of the learner with that of the expert model, embedded in the system, based upon performance. A delivery model is then used to deliver aspects of the domain, the intention of which is to reduce the difference between the student model and the expert model.

Models based on student characteristics on the other hand, are often referred to as psychological models (Ayala, 2009). They may hold general information about the characteristics or “global descriptors” of a student such as language skills, intelligence, motivation, learning style or preference, in fact any characteristic of a learner that might prove useful to the system in order to configure the presentation or management of learning. It is especially applicable in large-scale e-learning courses such as Massive Open Online Courses (MOOC) when the enrollment numbers often reach hundreds and thousands of students from all parts of the world.

Brusilovsky has suggested that some features of psychological student models must be provided by the user as they are too difficult to deduce from interaction alone (Brusilovsky, 1996). Such models are referred to as being collaborative or cooperative. Also, many psychological characteristics of a user such as intelligence or learning style cannot easily be implied from user interaction alone. Collaboration is often based upon the user's input and may take place at one or more of the three main stages in the development and application of user modelling: data collection, application, and presentation stage (Vassileva, 1996).

The challenges in building and implementing a useful student model lie in the fact that “the typical user of a system does not exist; there are many different kinds of users, and the requirements of an individual user usually change with experience (Mackay, 1991). To extend this line of thought, the user’s learning needs and goals could also be shaped by the environment, the devices (smart phones, tablets, laptop computers, or interactive kiosks), and time. In addition, simple classifications based on stereotypes (Rich, 1989) such as novice, intermediate, or expert users are not sufficient for complex systems such as an e-learning system (Fischer, 2001).

For collaborative or cooperative models, it is challenging to collaborate with users unless the systems have some ways to find out what the user really wants and does. Traditionally, the ways to find out about that are by:

- Asking the users explicitly (Nakakoji, 1993) – to make use of input fields, and to choose options in settings, etc. However, asking users explicitly interrupts the workflow and it takes time and effort to the point that it might potentially put users off from interaction. Also, many times, input forms and settings are poorly and ambiguously (intentionally or otherwise) designed. This could lead to users' misunderstanding and frustration. Besides, the questions presented to the users don't always remain relevant, as users' needs, wants, and knowledge change over time.

- Being inferred from user actions (Fischer, Lemke, Mastaglio, & Morch, 1991; Mastaglio, 1990) – by observing behaviours and movements in the system. The limitation with this method is that the system doesn't always get it right and the users' intentions are not always clear. This could run the risk of infuriating users by suggesting the wrong action – Microsoft's Office Assistant "Clippy", for example, was voted as the most hated mascot ever (Schestowitz, 2010).

- Communicates information about external events to the system (Bolt, 1984; Harper, Lamming, & Newman, 1992) – again, the issue with selecting information about external events need to be relevant and timely, as well as having a clear idea of what the users' intentions are.

This section described the types of user/learner models available, the components within these models, and challenges in building and implementing a useful student model. In the following section, three examples of student modelling applications in adaptive learning systems are depicted.

3.4 Student Modeling Applications in Adaptive Learning Systems

This section will present some examples on the use of student modeling application in adaptive learning systems, how they support learner-directed learning, and inspire the current study. The three student model applications covered are cooperative psychological student model in multimedia application, psychological student model based on verbal and visual skills, and a flexible class of learner-adapted systems. These three applications are selected because of the flexible, learner-centric approach and the way they support learner control in their operations.

3.4.1 Cooperative Psychological Student Model in Multimedia Application

This study investigated the use of a co-operative student model of learner characteristic that was used to optimise the presentation of learning for individuals on multimedia delivered courses (Barker, Jones, Britton, & Messer, 2002). A multimedia learning application was developed that presented information differentially based upon the individual characteristics of learners, held in the student model. Barker and colleagues (2002) established a psychological student model that was comprised of descriptors related to language skills, cognitive level – measured by a computer-delivered Cognitive Style Analysis (CSA) test developed by Riding (1991), support level (scaffolding), task level – the level at which tasks were set for learners and question difficulty level by using Bloom's taxonomy of learning levels (Bloom, 1956). This model was implemented in an educational multimedia application to deliver and assess basic skills in UK Higher Education Colleges. It was found that a cooperative approach was valued highly by teachers. The learning application itself was developed to run over a PC network and a simple database application was employed to hold the values of the student model for learners. Learners were required to log in, so that they might use the application that configured presentation of the multimedia material individually, based upon the values held in the student model. It was also possible to collect user data unobtrusively and securely at any time from the file server.

Barker and colleagues have shown that it is possible to improve performance in multimedia applications for some learners by configuring presentation according to the language skills of learners and their individual cognitive styles (Barker et al., 1999; Barker et al., 2000). They found that differentiation was only effective when it was provided for those who needed it the most and there was some evidence that it was possible to de-motivate learners by configuring presentation of information inappropriately.

It was concluded that the characteristics of learners employed in the student model represent a balance between the need for automatic configuration of variables, as in language and cognitive style and their co-operative configuration, as in task, question and help levels. In this way, important aspects of learning that could best benefit from computer-based control were differentiated from those aspects of learning that required and benefited from human input.

The Cooperative model represents an alternative to fully automated configuration of presentation of information and it involves learner's input. In this application, students cooperate or collaborate with the system and the tutors to establish an optimum configuration of the student model. Learner's involvement in this project aligned well with the constructivist' view of the importance of learner control (Somekh, 1996), and it serves as a frame of reference for this thesis as a way to shift control from an automated system to one that directly asks for learners' feedback. Some challenges in implementing such a model are that it is rather expensive to update cooperatively, and in a timely manner. From the learners' perspective, cooperation would put additional load to the learners, and it might become a distraction from learning, sometimes to the point of annoyance. There is also the issue of inferring too much from too little information (Henderson & Kyng, 1995) when learners do not adequately inform the system (implicitly or explicitly) and thus allowing the system to make assumptions such as the polarised nature of cognitive theory where students are being classified into one cognitive style over another.

Next application is a student modeling approach that will support learners in interacting with complex learning applications and web 2.0 technologies by adapting content based on Riding's CSA test of cognitive styles. This work suggests the need to accommodate multiple cognitive styles in interacting with complex systems such as a university level e-learning system and how we can best support students in providing a flexible learning experience online.

3.4.2 Psychological Student Model Based on Verbal and Visual Skills

In this study, Adisen & Barker (2007) presented a psychological student model based on the verbal and visual skills of learners. The skills required to interact with complex computer-based and online applications are often very different from the traditional working and learning skills that served computer users in the past. A new set of visual and verbal skills are important in organizing, processing, and communicating information while interacting with increasingly complex computer applications. New skills include the ability to navigate through virtual worlds, to perform complex tasks by locating specific information in a meaningful way that is presented in multi-media formats (Adisen & Barker, 2007). According to Schnotz (2002), text and graphics are complementary sources of information insofar as they contribute in different facets in the construction of a domain based mental model. A student model was established to accommodate different levels of visual and verbal abilities. Based on previous experiences in modeling and a survey of relevant literature (Adisen & Barker, 2007; Adisen, Barker, & Britton, 2004), a set of visual and verbal skills were identified as likely to be important in performing tasks and interacting with complex computer applications. Twelve important visual skills such as “remember an image and compare with the one seen earlier”, and 11 important verbal skills such as “answer a question related to a passage that is present on the screen” were selected to develop a student model and that tests to evaluate the learners’ performances on those skills were recorded. These test scores were measured against Riding’s CSA test scores along the Verbaliser/Imager and Wholist/Analytic dimensions (Riding, 1991) to detect any correlation. The results have indicated that the Verbaliser/Image dimension was not a useful measure of the visual and verbal skills required to interact with complex computer systems. There was some evidence that the Wholist/Analytic dimension was related to the performance of verbal and visual skills; however, many skills that were expected to perform better by a specific group (such as visual skills by imagers) were not found in this study.

The findings of this study suggested that when tasks get difficult and complex and have real contexts, it is not possible to relate real-world tasks to a single cognitive style dimension alone (Adisen & Barker, 2007). There is a need to support multiple cognitive styles and flexible learning preferences in learning tasks, especially when these tasks involved analysis and interpretation of information in various formats such as pictorial, textual, and audio formats.

The following section describes the next progression in learner-adapted systems that give learner control and responsibilities over the learning process, especially in interacting with the learner model. A flexible learner-adapted system was proposed that offers the learners a choice of learning tools and other on-demand elements.

3.4.3 A Flexible Class of Learner-Adapted Systems

Development work on student modeling and adaptive systems have begun to shift their focus to support greater learner control over the learning process. Learner-control-related tasks include exploring, designing, constructing, making sense and using adaptive systems as tools in a learner-centric way (Kay, 2001). To cater to this kind of support, Kay (2001) proposed a high level architectural view of a flexible learner-adapted system (Figure 3.1).

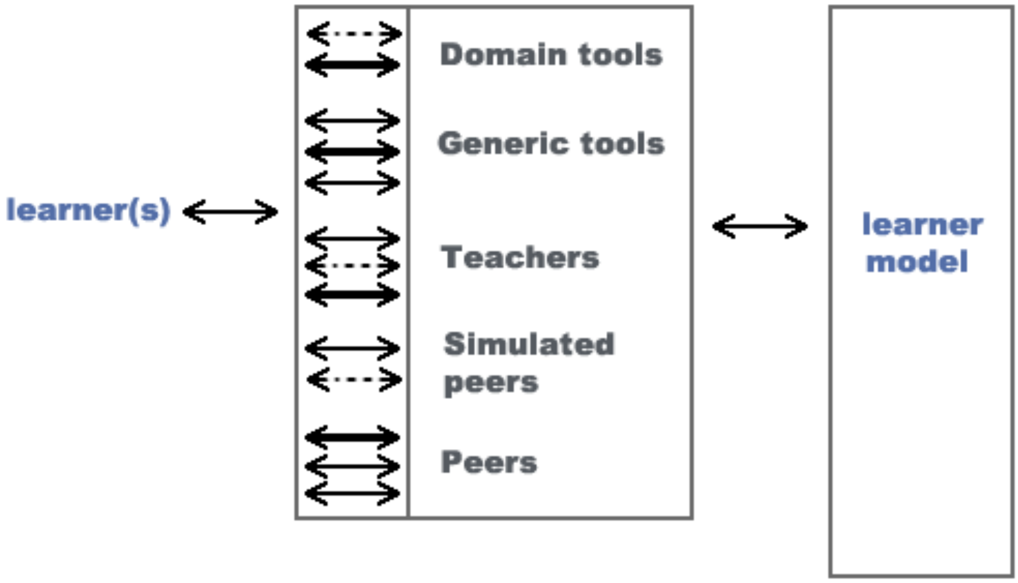

Figure 3.1: A high level view of a flexible learner-adapted system (Kay, 2001)

This system provides up to five types of tools: domain tools, generic tools, teachers, simulated peers, and peers. The way this system provides learner control is through the options of tools that students can pick and choose as they see fit. In Figure 3.1, learners interact with the system in bidirectional ways, and the tools are the ones available at the interface with the thickness of the lines indicating how one learner interacts with some tools more than others. The learner model on the right sits as a separate entity, and is potentially available to all five types of tools. Domain tools could include a simulation environment, or drill-and-practise tasks; generic tools could include text editors, spreadsheets, graphing tools, etc. They have the potential to provide contextual study-skill support and can be designed as a source of user modeling information. Teachers are used as tools in a way that multiple teachers will be available for the learners to choose from, and the learners can decide which teacher(s) they will work with. This also gives learners' control of teaching strategies (Major, 1995). The use of animated teaching agents (Johnson, Rickel, & Lester, 2000) fits in well with this tool to engage and motivate learners. Simulated peers, also known as learning companions, collaborate with the learners as a dyad, to learn together from a teacher, and/or for the learners to teach the companion (Chan, 1996; Chan & Baskin, 1990). The learning companions can make good use of the student model also. Finally, peers are other students who can communicate with the learner via the system interface. The computer has the potential to provide support for learners working in peer groups. Support such as recording group tasks, allocating tasks to different members of the groups, etc. could serve as a source of user modeling information. Kay (2001) stated that although the learning support for a particular domain may involve many of these tools, there may be common elements across them.

This is a promising approach for designing a learner-control adaptive system that potentially supports complex learning activities and one that's designed with positive learner experience in mind. Furthermore, the generic tools that support learning activities could be useful across disciplines. Kay (2001) claimed that the learner model continues to have a central role toward individualised learning support tools enable learner control. In the next section, the comparison between adaptive versus adaptable approach in relation to learner control will be presented. This thesis argues that a non-modeling approach serves as a viable option in designing online learning that provide a finer, more natural, and purposeful learner control experience at multiple levels.

3.5 Adaptive vs. Adaptable Approaches in Supporting Learner Control

On one hand, learners always have control over any learning situation, albeit a negative control by turning the system off or walking away from learning altogether. On the other hand, learners might not want control all the time, especially when they are new to the subject matter and are not confident that they make optimal choices without some guidance or error-prevention mechanism. Sometimes, there comes a point when too many choices become overwhelming and actually reduce the learner's level of control (Schwartz, 2004). Too little choice may result in boredom and activities that actively discourage the learner. Too much choice may lead to uncertainty, confusion and fear, again affecting motivation. Achieving the right balance will vary from circumstance to circumstance and learner to learner. Intentional choices about what to do next on a learning trajectory are sometimes made by the learner, sometimes by some other, such as an instructor, the author of a book, the director of a video or any number of other decision-making roles. For learners to be in control, it is important that they are the ones choosing whether and when to choose, and whether and when to let the others make those choices for them (Lee & Dron, 2008).

There are many ways that learners can be given control within an educational transaction. A common approach to giving learner control is through dialogue (Lee & Dron, 2008). Dialogue allows learners to ask questions, express misconceptions, request changes in pace or content, provide formative evaluations, and so on: essentially, to influence what a teacher does. A step away from this is to allow the teacher's role in the dialogue to be taken by a machine. For example, a well-programmed search engine may provide answers to a request for more clarity or more detail, or a multiple-choice quiz may give feedback to the learner on what is going well and what is not. At the far end of the dialogue spectrum are systems that do not explicitly interact with learners at all: books, static websites, videos and so on. Although they may involve in an internal didactic conversation, guided somewhat by the authors and creators (Holmberg, 1986). It is this end of the spectrum that concerns this thesis. It is a hypothesis of this thesis that having an optimal level of learner control is essential in creating a positive learner-directed learning experience. It is possible to design an online learning system to implicitly interact with learners and support learner control in an unobtrusive way – a learner-directed learning (LDL) with an implicit impetus.

In adaptive systems, there are growing trends in shifting the focus from an adaptive system that build a clever teacher to one that allow learners to explore, design, construct, make sense and use adaptive systems as tools (Kay, 2001). This shift of focus inspired the current research in looking at providing learner control and learner direction with an alternative approach using a flexible student model. While there are many useful features in user modelling and adaptive systems that cater to learner control, the applications are still limited as mentioned in Section 3.3.5 and in the examples showcased in Section 3.5. To summarise, some of the challenges and limitations are that it is costly to develop and to update the models; many models make assumptions about the learners and tend to prescribe solutions that are "off-target", thus, put off learners from interacting with the systems; and that models work well in simple systems but not as sophisticated in complex systems with diverse learners and changing context. Helpful hints and support offered by the system at the right time might be useful; however, push systems such as Microsoft's "Tip of the Day" would not work as it is out of context for the learners and learners might not find it helpful when the tips appear to be random and even thoughtless.

In the world of computer adaptation, Oppermann et al (1997) proposed that there are two kinds of systems: adaptable systems and adaptive systems. Adaptable systems are the ones that users can change properties/behaviours of the system to suit their needs. Adaptable system is viewed as another form of cooperative systems (Barker et al., 2002). Adaptive systems are the ones that automatically change to tailor to the needs of the users based on preset assumptions. The spectrum of adaptation in computer systems is illustrated in Figure 3.2 below.

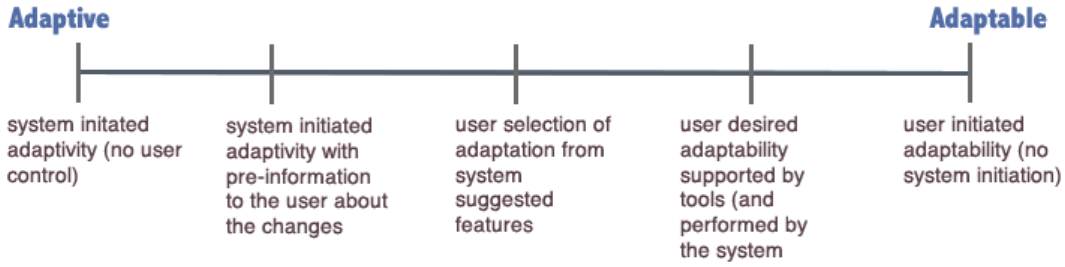

Figure 3.2: Spectrum of adaptation in computer systems (Oppermann et al., 1997)

Based on this classification in Figure 3.2, the current research believes in the type of adaptation needed for learning system is on the far right-hand side of the spectrum. A system that is adaptable in a sense that learners are being presented the complete set of learning options available, and can choose whether and when to choose, and whether and when to let others (systems and/or human) make those choices – there will be no system initiation. So the questions remain, as course designers and educators, how can we design courses that will achieve the balance of giving just the right amount of choices to learners? Which aspect of pace, content and media can we modify in order to give control? What kind of interaction design principles could be applied for online courses to create such a system? In the next chapter, the above questions will be addressed as part of the discovery of an alternative design approach for creating a Learner-Directed Model that caters to the optimal balance of learner control.

3.6 Summary

In summary, this chapter encapsulated the types of adaptive learning systems as related to the current research; outlined the characteristics of user models and student models; depicted different types of student models and their usage in adaptive learning systems; and showcased some common approaches for student modeling as examples of different types of learner control support. It also compared the differences between adaptive and adaptable approaches in designing a learning system that would support a finer and more balanced learner control. In the next chapter, an approach to the design of a Learner-Directed Model, along with the different components that make up the model will be presented as an alternative to the modeling approach in providing learner control and learner direction to support a positive learner experience.

Chapter 4: Learner-Directed Model Design

"Design is not the narrow application of formal skills, it is a way of thinking." – Chris Pullman

4.1 Introduction

Chapter 3 reviewed and discussed various types of adaptive technologies and user modelling, their characteristics and relationships to learner control and learner-directed learning, as well as their limitations and challenges in implementation. There has been a growing interest in catering to learner-directed learning for lifelong learners and to develop meta-cognitive skills such as setting learning goals, knowing what material to select, assessing learning process, developing troubleshooting skills, and revising learning goals according to progress. Constructivists also emphasise with the learners' role in taking an active part to construct their own understanding of the subject matter, and to incorporate prior knowledge and experience to the new information (Duffy & Cunningham, 1996). In this chapter, an alternative approach in the design and development of a Learner-Directed Model will be discussed and presented as an alternative to adaptive system modelling in supporting learner control. As stated in previous chapters, for a learner to be in control, it is important that he or she is the one choosing whether and when to choose, and whether and when to let others (human or systems) make those choices.

Anderson (2006) extends Paulsen's Laws of Cooperative Freedom that described a learner's freedom to negotiate the time, the pace, the content and the media of education with the freedom to choose the type of relationship with other learners and the teacher. It is also a long-touted benefit of online learning that the learner can usually choose the place in which he or she learns (Creed, 1996). If we are to give control to the learner, each of these freedoms should be addressed. Because this thesis' interest is in the interaction and instructional design for online resources, it is assumed that time and place are already under the control of the learner. Although we may be designing learning activities that involve other peers and/or instructors, it is not the concern of this thesis to consider Anderson's freedom of relationship. This leaves the current research with the freedoms of pace, content and media. In this chapter, I propose a new design approach for a Learner-Directed Model that caters to learner control with the consideration of freedoms of pace, content, and media. Section 4.2 describes the background and the characteristics of such a model. Section 4.3 depicts a new kind of self-regulated learning called self-directed regulated learning (SDRL), as an extension of the self-regulated learning theory and a subset for learner-directed learning. In Section 4.4, the model's functional, design, and content specifications will be outlined. Section 4.5 presents the details of the design components that make up the model including domain knowledge learning as well as meta-cognitive skills' interface. Finally, this chapter concludes in Section 4.6 with a summary.

4.2 Background and Characteristics of a Learner-Directed Model

For learners to be in control, it is important that they are the ones choosing whether and when to choose, and whether and when to let the others make those choices for them (Lee & Dron, 2008). The initial development of the current research focused on creating an interaction design framework for designing online courses that give learner control. For the most part, production e-learning environments are built on the one-design-fits-all principle. The problem of this principle is that there is no one design that satisfies all learners as learners are diverse and they all learn differently. Through interaction design, my original idea was to shift this mindset by suggesting and indicating various learning options and alternatives as learners work their way through the virtual landscape (Lee & Dron, 2008).

Building on the notion of providing interaction design control options, this research investigated different approaches to student modelling and the development of a student model suitable for use in a web based adaptive educational system (Barker & Lee, 2010). Previous work has shown that co-operative student models rely on far fewer assumptions and enable rich and complex dialogue between learners, computers and teachers (Barker et al., 2002). To extend this work, a series of scenarios were developed relating to the functions and properties of such co-operative models within a variety of contexts, for example students working co-operatively with teachers, students working in groups with other learners and teachers working with groups of learners. From there, it emerged a new student modelling approach for use in these circumstances with the support of two learning theories – Experiential Learning Theory (ELT) and Self-Regulated Learning (SRL) theory as the underlining instructional design principle for this approach (Lee, Barker, & Kumar, 2011, 2012).

The concept behind a flexible Learner-Directed Model for this research is grounded on learner control and learner experience. The model needs to support the following:

- Learners initiation and direction
- Learners will have full control of the learning process – pace, media, content
- Meta-cognitive learning as well as domain learning
- An adaptable system approach
- A non-linear model, iterative design
- Consistent with how people naturally learn
- Cater to different learning styles/preferences
- Provide the right amount of choices
- Grounded in established education theories and instructional design theories, in particular theories that are learner-centric

In Chapter 2, Kolb's Experiential Learning Theory (ELT) (Kolb, 1984) was covered extensively, and that included the experiential learning cycle with four stages of learning: concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE). The core of the theory is that learning is a holistic cognitive process and is grounded on real-world experience via the dialectic exchange between the learner and the environment. Learners progress through a learning cycle that takes them from the act of experiencing and observing knowledge to reflecting upon those actions, then it leads to the formation of concepts, and hands-on application of knowledge. It is an ongoing process of learning. Figure 4.1 below illustrates the learning cycle and its iterative process.

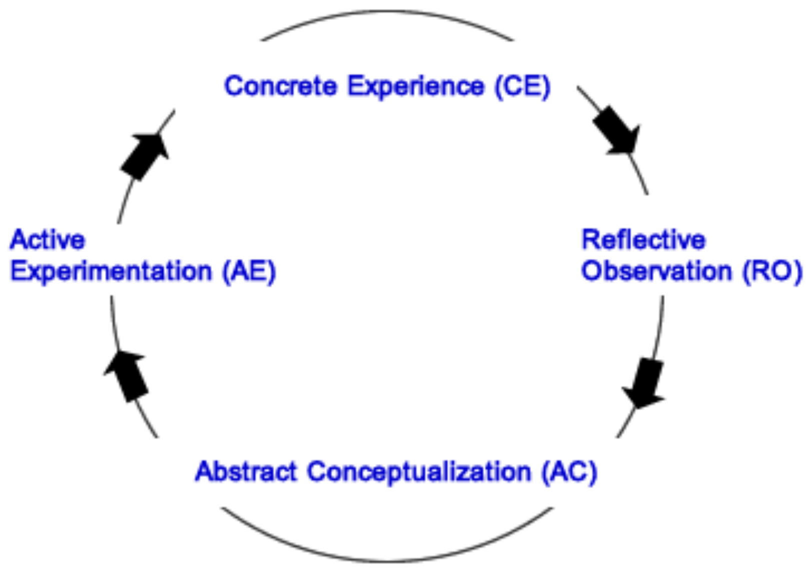

Figure 4.1: Kolb’s learning cycle stages

As a constructivist theory of learning, ELT fulfils many of the criteria for building a leaner-directed learning model. It is a learner-centred and multilinear model as it caters to different learning styles; it is consistent with how people learn, grow, and develop (Kolb et al., 2000). The cyclical process allows flexibility and continuous reflection in an authentic context. It attempts to explain why learners approach learning experiences in such different manners but are still able to flourish. More importantly, this is an inclusive model of adult learning that intends to explain the complexities of and differences between adult learners within a single framework (Oxendine, Robinson, & Willson, 2004). A useful application of ELT is in the field of e-learning. It was found that many online courses did not allow for concrete experience and active experimentation due to the fact that the learning processes were based on more traditional learning methods and not capitalizing on the self-directed nature of the learners (Friedman et al., 2002). As a starting point, this research will employ the ELT stages of learning cycle in creating a learning design framework for presenting the domain knowledge, namely, introductory computer programming in Java.

To support meta-cognitive learning for the current study, another theory comes into play. Chapter 2 touched on meta-cognitive theory and self-regulation. As you recall, the difference between meta-cognition and self-regulation is that there is a cognitive orientation for meta-cognition, while self-regulation is as much concerned with learner's action and behaviours than the thinking behind it (Dinsmore et al., 2008). Self-regulated learning (SRL) theory states that learners not only need to regulate their performance, but also how they learn. SRL deals mainly with person-environment interaction and it has an exclusive focus on academic learning (Dinsmore et al., 2008). Using SRL as a complementary theory for the design of a Learner-Directed Model fits well with the requirements for the current model. It supports learner control, promotes autonomous learning, and enhances the overall learner experience. The type of self-regulated learning approach this study will use for the design of meta-cognitive activity support is called Self-Directed Regulated Learning (SDRL), a term coined by the author. The next section will provide more details on SDRL and how this approach fits in with this research design.

4.3 Self-Directed Regulated Learning (SDRL)

At one end of the spectrum, self-reflection could be as simple as a thinking process made self aware, the intangible 'ah ha' moment of a conceptual breakthrough; at the other end, self-regulation could be more tangible as a system or a tutor can observe what students do after they self-reflect. For example, in debugging a piece of programming code, a student can self-reflect on errors identified by the compiler at the end of each compile of the programme being developed. The system can track/record the number of errors and warnings faced by the student at the end of each compile. The system can also classify the types of errors encountered by a single student over multiple sessions of programme development. Looking at this list of errors is an act of self-reflection. However, self-regulation takes it one step further. Students may try to identify most common errors and warnings they faced, take notes on how they resolved these common errors and warnings, and refer to these notes when they encounter these common errors and warnings when writing another programme. This "proactive self-reflection" is what I identified as self-directed regulated learning (SDRL) because at this stage, this research does not plan on tracking the end results of using the study skill tools, it is the provision of these “how to” study skill guides and tools embedded as options for students to assist them in becoming better self-regulated, self-reflected learners that this research is interested in.

The difference between SDRL and SRL is that SDRL aims at 'regulation" in a more implicit manner than SRL. That is, in SRL, regulation is more explicit, whereby one can directly and independently measure the degree of regulation being imparted by the system as well as measure the degree of regulation being absorbed or applied by a student. In SDRL, regulation is being implicit in the design and interactions, measurements related to regulation are inherently intertwined with other components of the system, and hence it is hard to measure the degree of regulation in a direct and independent manner.

The next section aims to provide an overview of the requirement specifications for the Learner-Directed Model in four areas: technical requirement, functional requirement, interaction design requirement, and content requirement. The requirement specifications aim to serve as a guideline for others who wish to replicate a similar model in their own settings.

4.4 Requirement Specifications

In Section 4.2, it outlines the characteristics of the Learner-Directed Model and what it needs to support learner control and learner experience in e-learning. Based on that list, this section will expand on the specifications in four areas: technical, functional, interaction design, and content requirements.

4.4.1 Technical Requirements

The model needs to be developed within the confines of a Learning Management System (LMS). Moodle is the LMS that is currently used for Athabasca University, Canada, the institution in which this research was conducted. Therefore, students who access the Learner-Directed Model need to be able to negotiate the Moodle interface, going through the single log-in process through the university portal in order to launch the online learning material contained within the model. The model also needs to be mobile friendly and cross-platform compatible for both PC and Macintosh computers as students access their learning material from a distance and with different computer system configuration, and with different internet connection speed.

4.4.2 Functional Requirements

In terms of functional requirements, the model needs to provide learners with the abilities to:

- Start and end anytime
- Skip the entire section
- Pick one or multiple learning activities to study
- Pick none of the learning activities
- Access the meta-cognitive skill supplement section at any time
- Pick one or multiple meta-cognitive skills
- Pick none of the meta-cognitive skills

It also needs to have the following functionalities to:

- Track learner’s progress by recording the time spent on the model
- Track learner’s competency at the domain level by providing a pre-test and post-test
- Provide a survey for learners to self-report on their experience using the model

The main focus for functional requirements is that the system should allow maximum flexibility for users to interact. The system should not initiate or suggest any learning paths. All the learning options are available for learners to choose or not to choose.

4.4.3 Interaction Design Requirements

Interaction design defines the interplay of the software with users' behaviours, responses, and environment (Cooper, 2007). The following principles of interaction design are extracted from Tognazzini (2003) and are used as interaction design requirements for the Learner-Directed Model.

Appropriate use of visual elements – Use engaging visual elements when possible. The model should have visual elements that attract learners to explore more. The aesthetic-usability effect describes people's perception on more-aesthetic designs as easier to use than less-aesthetic designs – whether they are or not (Kurosu & Kashimura, 1995). Furthermore, aesthetic designs have claimed to be more effective at fostering positive attitudes and to make people more tolerant of design problems. It is especially important in stressful environment when there is an increase in fatigue and reduction in cognitive performance (Norman, 2002). The Learner-Directed Model strives for aesthetic design that looks easy to use and thus help foster positive attitudes toward learning and system acceptance.

Consistency – Principle of consistency states that systems are more usable and learnable when similar parts are presented in similar ways (Lidwell, Holden, & Butler, 2003). Lidwell, Holden, & Bulter (2003) stated that there are four kinds of consistency: aesthetic, functional, internal, and external. Aesthetic consistency is the consistency of style and appearance. The Learner-Directed Model interpreted this as having a recognizable quadrant-based interface that consistently appearing across all the pages.

Functional consistency means consistency of meaning and action. It improves usability and learnability because people can learn to expect the action follow the interaction (such as a click of “home” button always take the users to the home page). The Learner-Directed Model makes use of consistent “key study skills” red button located on the upper-right-hand corner of all the learning activities pages. The quadrant design also consistently connects learners to the different types of activities by using different colours and labels.

Internal consistency indicates consistency with other elements in the system. In the case of the Learner-Directed Model, it means the look-and-feel of the pages, amount of content, and the presentation of material for each quadrant and for each learning concept is consistent with each other.

External consistency suggests that there needs to be consistency with other elements in the environment (i.e. independent systems observe common design standards). The Learner-Directed Model interpreted that as the need for consistency amount other Moodle courses offered at Athabasca University. The Learner-Directed Model achieved external consistency because students have to follow similar sequence of events in order to access the module – they are required to log in to the module, read the “Read this first” document, take the pre-test, and then access the learning material for different learning concepts.

Explorable Interfaces – design that encourages learners to explore should keep human errors in mind. Lidwell, Holden, & Bulter (2003) explain that forgiveness in design helps prevent errors and minimises the negative impacts; this in turn will foster a willingness to learn and use the design. The Learner-Directed Model encourages exploration by always having a way out/back to the home page or to start over again. It also indicates to the users where they are and where they need to go by highlighting the section they are currently in and by having an interface that would allow users to skip around to different learning activities.

Scaffolding – Scaffolding is the support given during the learning process that tailored to the needs of the student with the intention of helping students to achieve their learning goals. These supports gradually change as learners become more competent in their tasks (Wood, Bruner, & Ross, 1976). The idea behind scaffolding is to facilitate incremental mastery of concept, and that students can in time learn to internalise the information and become self-regulated, self-directed learners. The scaffolding support in the Learner-Directed Model is built-in to the key study skills. Each key study skill is associated with a different learning activity, and as a learner progress through the learning activities for each concept, each key study skill becomes more advanced and complex.

Learnability – Good design relies to some extent on the ability to instill a sense of instant familiarity (Meada, 2006). Design should leverage human's ability to relate and understand intuitively without learning a new metaphor or principle every time people use a system. The Learner-Directed Model has a very low learning curve. Users can access it the first time and understand what the site is about and know how to achieve their goals within it. For example, the model allows learners to complete their studies in the manner they choose, and the circular interface design makes it obvious for the learners to understand what their options are.

Visible navigation – According to Norman (1990), the principle of visibility is about how people are better at recognizing solution when selecting from a set of limited options rather than recalling the solutions from memory. It makes the system more usable and allows users to control the system better. The Learner-Directed model reduces navigation to a minimum and to make sure that the labeling use clear and natural language. The quadrant design also limits the options to four learning activities, so as to prevent information overload.

4.4.4 Content Requirements

The model needs to contain domain-knowledge learning material in introductory Java computer programming. Specifically, one unit of Java programming content needs to be redeveloped to fit with the model interface and instructional design framework. The amount of content should be designed for about 45 minutes – 1 hour of instruction time for self-paced study. Content should also be designed in a way that learners can start and stop at any given time. The type of content should target introductory computer programming course in plain English for university-level study. Supplementary meta-cognitive learning content should also be provided.

4.5 Design Components Breakdown

4.5.1 The Golden Circle

Golden Circle, inspired by the concept of golden ratio, is a model to help people understand why we do what we do (Sinek, 2009). It begins with the question "Why" in mind. To give clarity of purpose on why I am creating this model, I would like to use the Golden Circle. It is an explanation that starts from the inside out. Essentially, the Golden Circle makes up of three parts – Why, How, and What (see Figure 4.2).

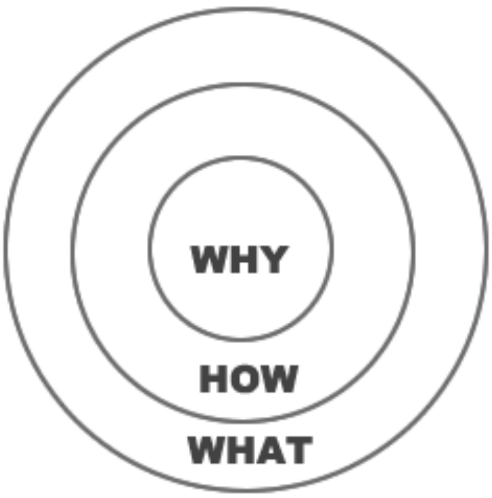

Figure 4.2: Sinek's (2009) Golden Circle

The breakdown of the three parts could be explained as:

WHAT - What are you trying to do? This is to describe the product or system or service one is trying to build/provide.

HOW - How can you do that? What tools/techniques do you need in order to achieve what you do?

WHY - Why are you doing it? What is your purpose, cause or belief?

To adapt that to my purpose on designing a Learner-Directed Model, the three parts in the Golden Circle can be explained as:

WHAT – To learn computer programming online

HOW – Using two theories for the design of the interface/Instructional design: Experiential Learning Theory (ELT) and Self-Directed Regulated Learning (SDRL)

WHY – To provide learner control and enhance the overall learner experience (LX)

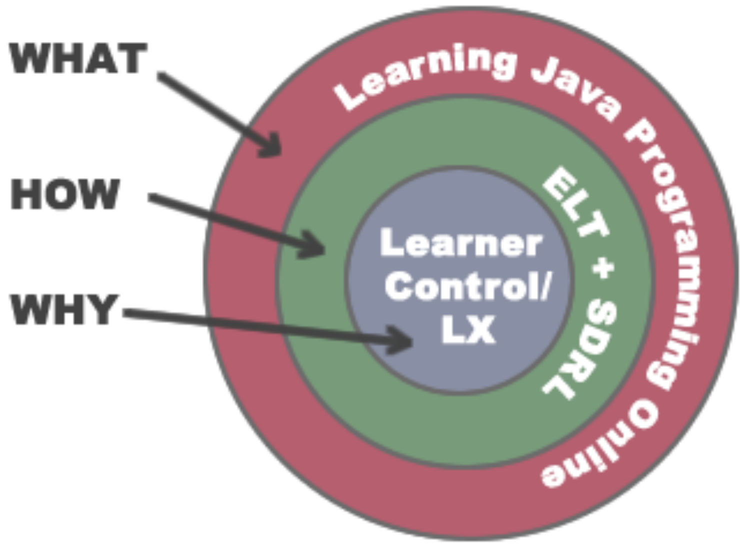

Figure 4.3: The Golden Circle adapted for the purpose of the current study.

In the following three sections, more details will be provided on the *What*, *How*, and *Why* as the reasons for the creation of a Learner-Directed Model.

4.5.2 WHAT – Learning Computer Programming Online

One unit (Unit 3 – Control Structure) of an introductory to programming course material was being redesigned to fit with the Learner-Directed Model. The content was based on COMP268 - *Introduction to Java Programming* course currently offered by the School of Computing and Information Systems (SCIS) at Athabasca University in Canada (http://www.athabascau.ca/syllabi/comp/comp268.php).

Introduction to Java Programming course was chosen as the domain due to the fact that this course has one of the highest attrition rates within the school. Common complaints among students are that the course does not engage them and there is a lack of motivation as a result. In addition, the complexity of learning computer programming further discourages students from completing their online study. Dijkstra (1988) stated that computer programming is a "radical novelty" and that a traditional learning system no longer works. Thus, it needs a different design approach.

After the redesign, the module used in this research study composed of five learning concepts. The five learning concepts are:

1. Overview of Intro to Programming
2. If-Else Statement
3. Loops
4. Break, Continue, and Return Statement
5. Switch, and Try-Catch-Finally Statement

4.5.3 HOW – Using ELT and SDRL as Design Framework

The ELT learning cycle was mapped on top of a circular wheel interface with four quadrants representing the four learning stages. Each stage was linked to a learning mode based on Kolb's experiential learning cycle: concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE). The four learning modes corresponding to Kolb's four stages are: watching, discussing, conceptualizing, and trying out.

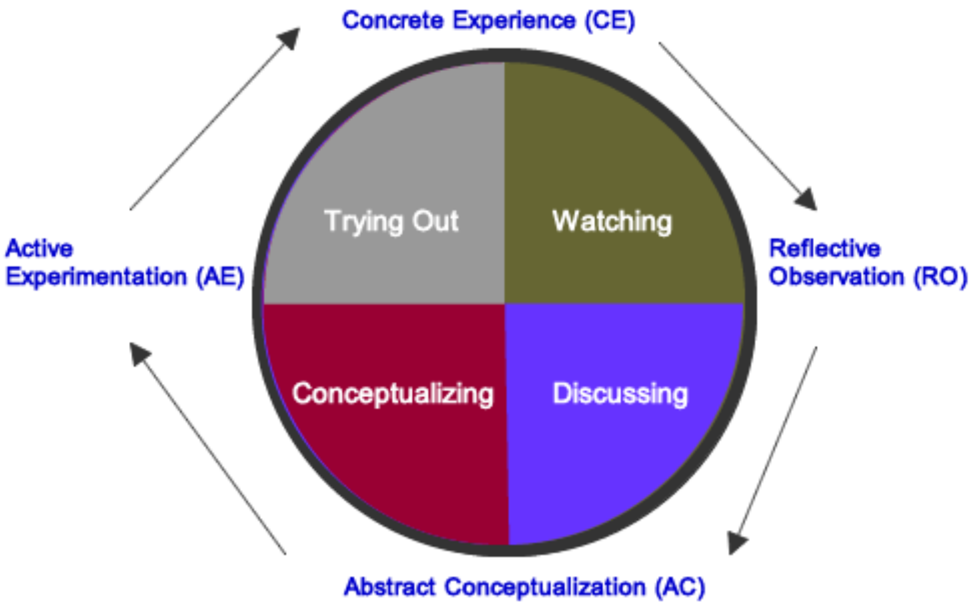

Figure 4.4: The four learning modes correspond to the four stages of the ELT cycle

The four learning modes are adapted from the learning activities that support different aspects of learning cycle put together by Mobbs (2005). Table 4.1 below displays the list of such learning activities.

Table 4.1: *A List of Learning Activities That Support Different Aspects of the ELT Cycle (Mobbs, 2005)*

Concrete Experience	**Reflective Observation**	**Abstract Conceptualization**	**Active Experimentation**
readings examples problem sets trigger films simulations/games	logs journals discussion brainstorming	lecture projects analogies model building	projects fieldwork laboratory case study simulations

While this is a useful and extensive list, it is not practical to incorporate all the learning activities into the current model. From this list, the four main types of activities, one representative from each aspect of the learning cycle was selected:

- Concrete Experience - Watching (viewing tutorial videos)
- Reflective Observation – Discussing (posting to discussion forums)
- Abstract Conceptualization – Conceptualizing (concept mapping and mental model building)
- Active Experimentation – Trying Out (writing codes in Java)

As Kolb stated that learning can begin at any stage in the cycle, similarly, this learning design follows the idea that learners have different ways of learning, and they have an option to choose which way is best for them and where the starting point and end point are, and when they are ready to leave the learning material. This corresponds well with Anderson's (2006) notion of creating online learning that caters to the freedom of pace, content, and media.

The five learning concepts all start with the same interface that present the four modes of learning. Instead of requiring the participants to fill out a "learning style inventory" prior to learning so as to classify them into different learning styles, the course material will provide maximum flexibility and is designed in cyclical format; therefore, it allows the learners to select whichever learning mode(s) they prefer. A pre-test is given at the beginning of the course to assess their prior knowledge in computer programming, as well as to gauge their prior competency in study skills. Figure 4.5 indicates what learners will see when they enter the course home page and select "Learning Concept 1".

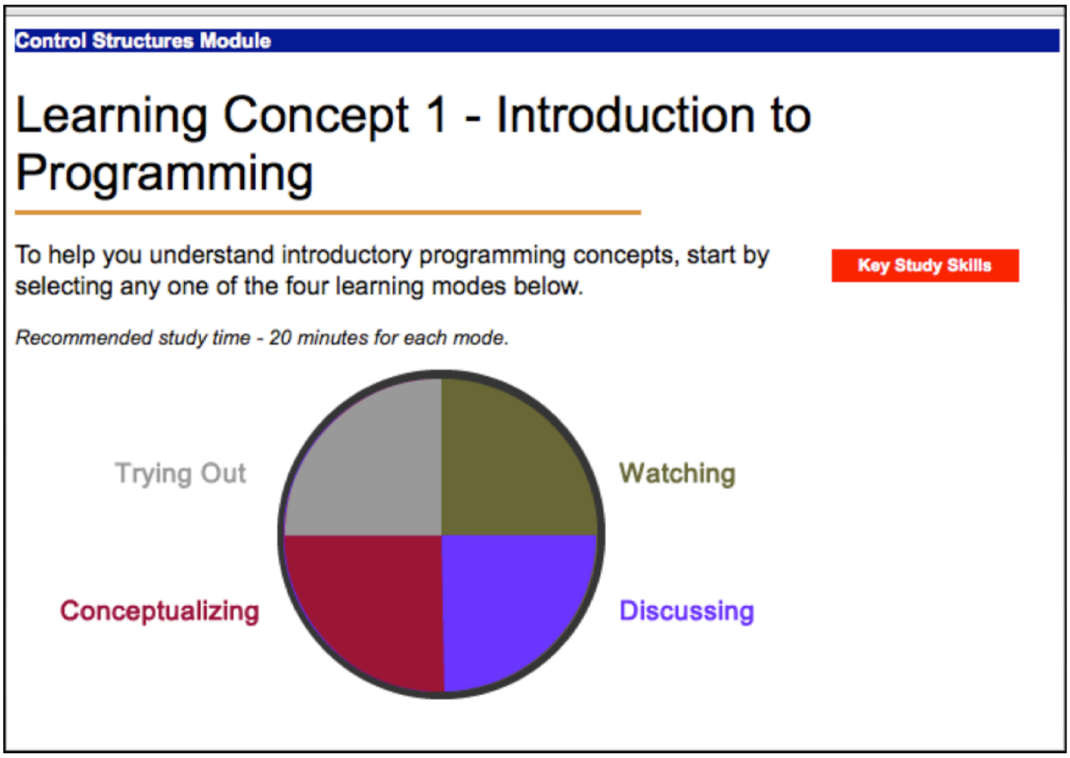

Figure 4.5: Experimental Group home page for Learning Concept 1 – Introduction to Programming

For learners who are interested in learning by observation, they can select the "watching" mode, which will provide a series of tutorial videos on how to write and edit a basic programme in Java (Figure 4.6). For others who prefer to engage in the reflective process in the form of discussion forum posting can select the "discussing" mode. It will take the learners to the page with learning activities that are designed for social interaction, dialogues and reflections (Figure 4.7).

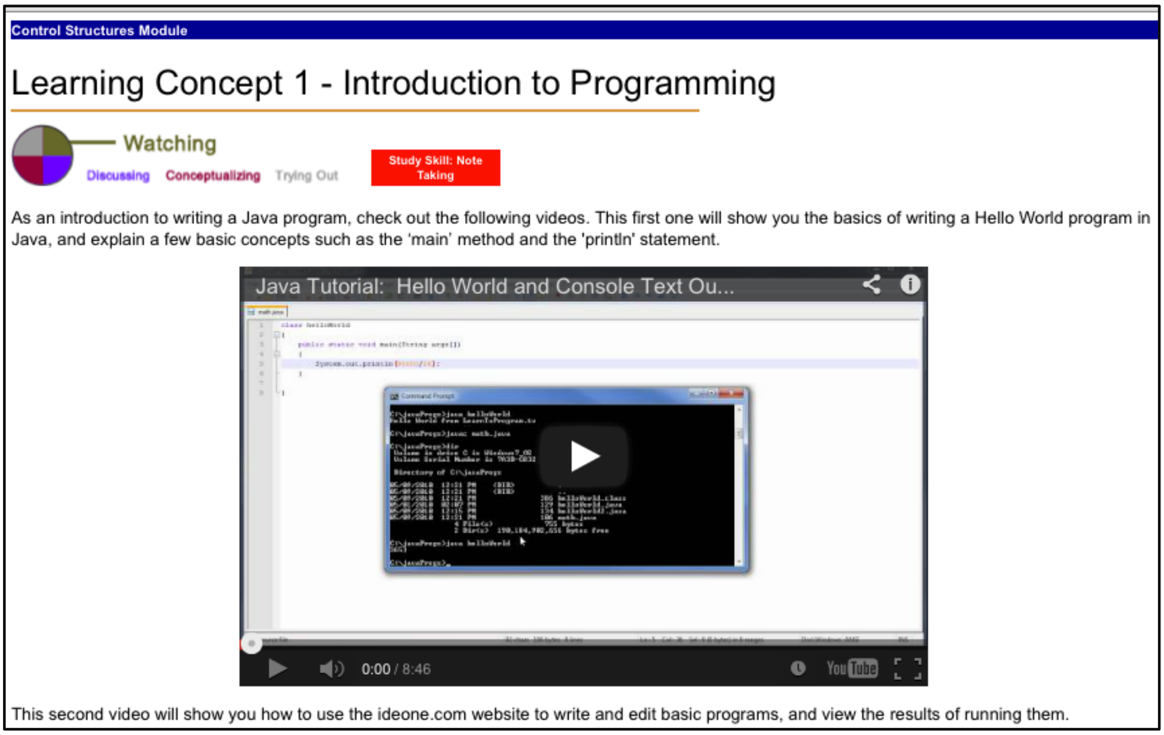

Figure 4.6: Tutorial videos on how to write and edit a basic programme under the “Watching” learning activity

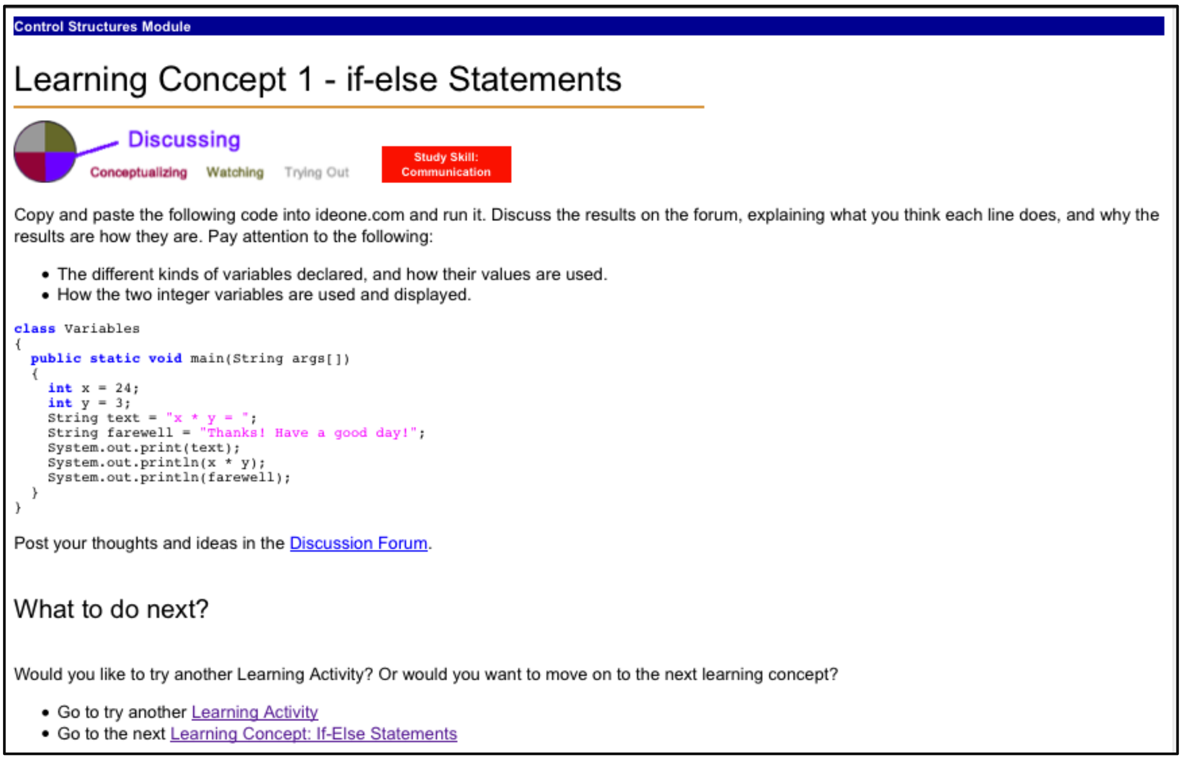

Figure 4.7: Learning activity in the form of discussion forum posting to encourage reflective thinking and social interaction

According to ELT, learners can begin at any stage of the learning cycle, but it is most beneficial for acquiring new knowledge if they would go through them all eventually to fully understand and apply this new knowledge. This interface design encourages the learner to explore and access more than one learning activity, but they might or might not choose to go through them all; the decision is theirs to make. If at the end of any chosen learning activity, the learners feel that they have a good grasp of the material, they can opt to skip the rest of the cycle and go to the next topic. A post-test is available at the end of the module for learners to self-assess their knowledge both at the domain and meta-cognitive level. In other words, learners can test how well they have learned a certain programming concept in Java as well as whether the associated key study skills are helpful to them in regulating their own learning and deploying them as learning strategies. The post-test for the domain-knowledge portion asked programming related questions and is objective in nature; the meta-cognitive skill portion of the test is in the form of self-reporting and is subjective in nature. Altogether, it provides a high-level view of competency on both domain and meta-cognitive levels of learning.

As supplementary learning material, a Self-Directed Regulated Learning (SDRL) theory based interface titled “Key Study Skills” is available on the upper right-hand corner of the webpage to assist with learning about meta-cognitive knowledge. As mentioned in Chapter 1, learning computer programming doesn’t rely on a single skill; learners can benefit from mastering a set of meta-cognitive skills to optimise learning (Azevedo & Cromley, 2004; Winne, 1995). The way to provide study skill in this research is a “built-in” approach (Wingate, 2006). As opposed to the “bolt-on” approach (Bennett et al., 2000) where study skill support is treated as an external element independent of the subject matter; this approach integrates study skills in a contextually appropriate manner.

Topical study skills for studying introductory computer programming has been selected in these four areas: note taking, communications, conceptualizing, and problem solving skills. Twenty related study skills - five successive skills (to scaffold) for each of the four learning modes - have been developed. Each study skill is paired with a tool for learners to try out and practise these skills. For example, within the "Watching" activity, the key study to emphases is "note taking". Learners can choose to access this supplementary material at any given time during their study. The design consideration is that the key study skills appear as an unobtrusive interface that sits on the upper-right-hand-corner of the main content. Learners can choose to engage and learn how the "note taking" skill helps with the "watching" activity (i.e. how to take better notes while watching a tutorial video online and what are the appropriate tools to use for note taking), or they can just ignore it and carry on with watching the tutorial video on its own. Figure 4.8 shows that the Note Taking skill is being presented with Evernote, and note-taking software. The rest of the study skills are paired with the following: communications – Moodle discussion forum; conceptualizing – FreeMap (mind mapping tool); and problem solving – BlueJ (an integrated development environment tool).

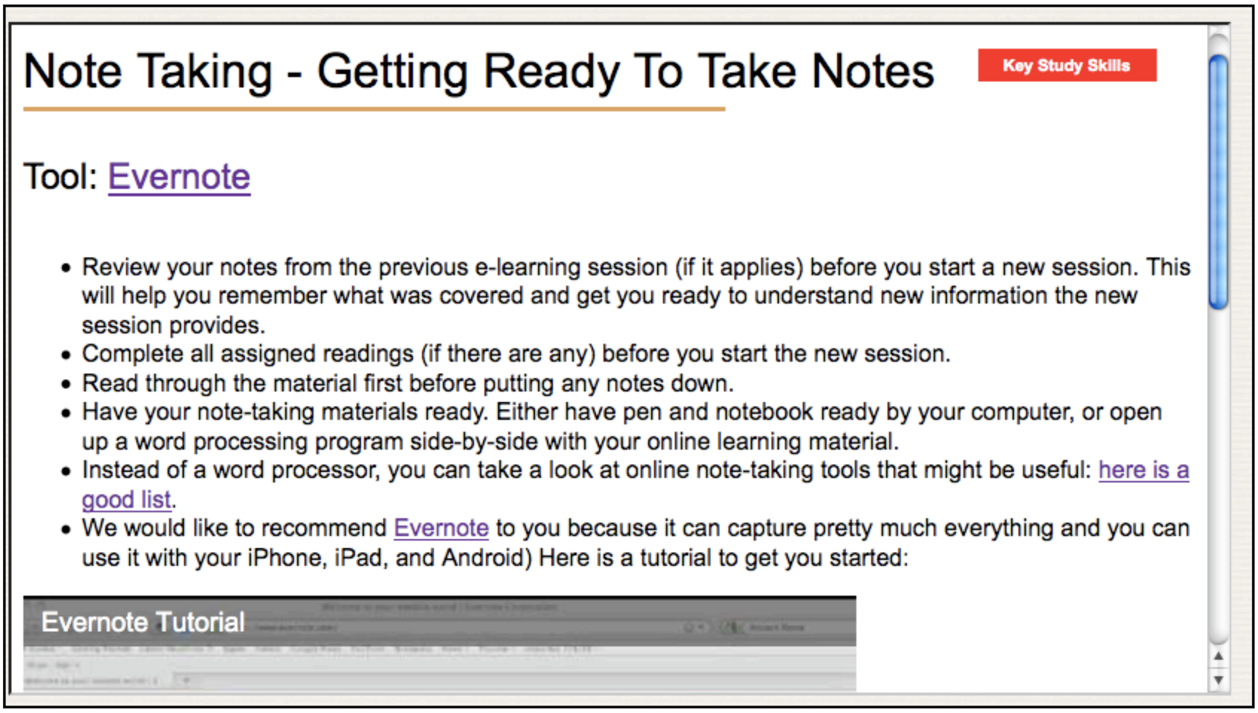

Figure 4.8: One of the key study skills – Note Taking

Twenty study skills --five successive skills for each of the four learning modes-- have been developed, as listed below. The skills are successive in a sense that the topics will scaffold as the learners become more competent in each study skill.

Watching Mode

Corresponding Skill: Note Taking

(Tool: Evernote http://www.evernote.com/)

The five note taking skills are:

- Getting ready to take notes
- How to take notes
- How to organise your notes
- How to take notes online/with media
- How to review/use your notes

Reflecting Mode

Corresponding Skill: Communications

(Tool: Moodle discussion forum)

The five communication skills are:

- What is netiquette
- How to ask the right questions
- How to write a good discussion post
- How to reflect on what you wrote
- How to reflect on your debugging history

Conceptualizing Mode

Corresponding Skill: Formulating Ideas

(Tool: Freemind http://freemind.sourceforge.net/wiki/index.php/Main_Page)

The five formulating idea skills are:

- When to get help and how to evaluate information sources
- What are the different types of search strategies
- How to use mind mapping to conceptualise

- How to create good mind maps
- How to use mind maps to solve problems

Trying Out Mode

Corresponding Skill: Debugging

(Tool: IDE tool BlueJ http://bluej.org/download/download.html)

The five debugging skills are:

- How to debug (in general)
- How to debug (in BlueJ)
- How to create and maintain your own debugging history
- How to refer back to your debugging history
- How to group/classify your bugs

As previously mentioned, the aim of this research is to design a flexible and Learner-Directed Model. Thus, the study skills stated above accommodate the four phases of self-regulation as proposed by Winne & Hadwin (2008). For example, in choosing study skill note taking, learners can follow the four phases as stated below:

1. Phase 1 - Gather the tasks at hand and define the task by reading the "Getting Ready to Take Note" section to identify the information and environment they need to take effective notes.
2. Phase 2 – Frames goals and sets a plan by reading the "How to Take Notes" section. The study skill will provide suggestions and aids on how to set goals and strategies in note taking online. There are also additional readings on "How to Take Notes Online with Media". "How to Organise Your Notes" provides additional strategy in approaching note taking as a skill.
3. Phase 3 – Enacting the plan by taking notes themselves. The study skill guides will help by providing a tool, in this instance, Evernote, with tutorial on how to use it.

4. Phase 4 – Adapt and adjust the plan based on observation on Phase 3. Depending on the experience in Phase 3, students can then use the "How to Review/Use Your Notes" to reflect on what they need to improve on and what worked in note taking.

Overall, the study skill material is perceived as supplementary learning support and is embedded as part of the course interface. It is not obtrusive nor a requirement for students to access them.

4.5.4 WHY – Learner-Control and Learner-Experience (LX)

Within the instructional design community, what is known as "design science" is defined as principles about laying out and implementing interventions. In the education world, it is used to aid students on learning more about learning strategies, to extend to their sense of personal worth and to help with academic success (Pressley & El-Dinary, 1993; Zimmerman, 1990). To take this concept a step further, this research is concerned with creating and supporting an overall positive learner experience by giving learner control over pace, content, and media. Designing superior online learning experiences requires a delicate balance of user experience (UX) and learner experience (LX). In the design of this Learner-Directed Model, careful considerations are taken in the blending of both design elements. To summarise, this Learner-Directed Model makes use of the following design principles:

- Provide limited choices so as not to overwhelm users and make the system easy to use and yet offer some flexibility in what learners choose to study
- Unobtrusive and intuitive interface - the study skills interface is out of the way and optional; the main content interface makes use of the familiar quadrant with primary colours and self-explanatory labels
- Support both surface and deep learning – the content is designed for both breadth and depth. Learners have the freedom to skip around or to explore each area in-depth

- Provide context – the study skills are available in context as each study skill is designed according to the learning activity provided

4.6 Summary

In this chapter, an alternative approach in the design and development of a Learner-Directed Model was presented as an alternative to the user modeling approach in supporting learner control. Background and the characteristics of the current model as well as a new kind of self-regulated learning called self-directed regulated learning (SDRL) were discussed. The design components of Learner-Directed Model were elaborated with respect to Sinek's (2009) Golden Circle. The model's functional, design, content specifications, and the details of the design components that make up the model including domain knowledge learning as well as meta-cognitive skills' interface were covered. In the next chapter, it will report the experimental design methodology and process using this Learner-Directed Model.

Chapter 5: Experimental Design and Study

"All life is an experiment. The more experiments you make the better." – Ralph Waldo Emerson

5.1 Introduction

Previous chapter detailed an alternative approach in the design and development of a Learner-Directed Model in supporting learner control with the consideration of freedoms of pace, content, and media. The model's functional, design, content specifications, and the details of the design components that make up the model including domain knowledge learning as well as meta-cognitive skills' interface were covered. This chapter reports on a research study in which student volunteers were involved in studying a segment of an e-learning module designed using this Learner-Directed Model.

In this research study, an ex-post facto experiment was set up with 35 voluntary participants randomly assigned to either one of the two e-learning modules with identical subject content but different learning design models: a Learner-Directed Model (Experimental Group), and a linear model (Control Group). Content material was adapted from *Introduction to Java Programming* (COMP 268). The experiment was carried out over a period of six months at Athabasca University, Canada's Open University. Participants went through pre and post tests, accessed and interacted with learning materials and tools, and finished the experiment with an end-of-the-module survey. Participants' pre and post test scores, activities, and survey results within the e-learning module were traced and recorded for the duration of their interaction with the system.

Historically, *Introduction to Java Programming* (COMP 268) has been running for over 10 years at Athabasca University, as part of a requirement for Bachelor of Science (BSC) degree in Computing and Information System. It is also available as an elective for students from other studies who are interested in learning about computer programming. Its current version is #11, and it gets revised at least every two years - a standard practise at Athabasca University. The course is developed by a course development team consists of a course professor, tutors, a subject matter expert (usually the author or co-author with the course professor), an instructional designer, an editor, a graphic designer and a copyright specialist. The course team works collaboratively to create and revise the course. The usual turn-around time for revising a course is between six to nine months. This course, similar to most undergraduate courses at Athabasca, is a monthly continuously enrollment course whereas students can start at the beginning of the month throughout the year for duration of six months. Based on the conversation with the current course professor, the drop-out rate on a monthly basis is up to 50%. For every 24 students enrolled, a tutor will be assigned to provide personal attention and feedback to the students. Similar to many e-learning courses offered by the University, material in this module is presented in a linear, textual format with heavy reference to the textbook and limited user interaction.

In this chapter, details of the experimental design and methodology are being documented as follows: Section 5.2 explains the method of this study including the background information, choice and rationale of the methodology used. It also describes the participants' profiles, the recruitment process, and the experimental procedure. Section 5.3 covers various measurement matrix and related steps. Finally, the chapter concludes with a summary of the experimental design and methodology along with supplementary material associated with the research design presented in various appendices.

5.2 Method

This study involved 35 undergraduate student volunteers from Athabasca University to study and evaluate one unit of adapted content material from *Introduction to Java Programming* (COMP 268). The volunteers were assigned to either an Experimental Group or a Control Group during this six-month period. Participants agreed to the consent form were invited to log into

Moodle, an open-source learning management system (LMS) commonly used in higher education institutions and is currently the main e-learning delivery platform for Athabasca University. Since Athabasca University students are already familiar with Moodle, no orientation was provided on using and navigating Moodle. Learner-directed model-based design module with meta-cognitive learning support in the form of study skills (as discussed in Chapter 4, Section 4.5.3.) was being presented to an Experimental Group of 18, while static and linear content without meta-cognitive learning support was being presented to a Control Group of 17. Six participants were selected randomly from the two groups (three from each group) for the follow-up semi-structured interviews to collect qualitative feedback about the study. An amount of $35 Canadian dollars (CAD) was offered to each participant as compensation for taking part in the study. In addition, the six participants who took part in the follow-up interviews were compensated with $40 CAD.

5.2.1 Choice of Methodology

This section describes the rationale behind choosing a mixed method approach as the over-arching methodology for the current research (Creswell, 2009). Mixed method was used because it is a comprehensive approach to examine the research questions. According to Brannen (2005), mixed methods research means adopting a research strategy employing more than one type of research methods. The blending of both quantitative and qualitative methods allow this study to explore the research questions in-depth and contextually from multiple points of view (Johnson & Onwuegbuzie, 2004). In order to measure the effectiveness of a learner-directed system in terms of student performance, collection of quantitative data in terms of test scores and Likert scale survey questions is more efficient. For a contextual understanding of learners' attitude, qualitative method in terms of open-ended questions, and follow-up interviews provide a more detailed and natural response from the subjects. Thus, the two methods used in the current study are: ex post facto experimental design for the quantitative method; the open-ended questions part of the survey and follow-up interviews as the qualitative method.

Triangulation is a technique that facilitates validation of data through cross verification from more than two sources. In particular, it refers to the application and combination of several research methods in the study of the same phenomenon (Bogdan & Biklen, 2006). The advantages of using triangulation is that it explains more fully the complexity of human behaviour by studying it from more than one viewpoint (Cohen, Manion, & Morrison, 2007), and it gives a more detailed and balanced picture of the situation (Altrichter et al., 2008). In the current study, triangulation is undertaken to draw on multiple viewpoints on the effectiveness of a Learner-Directed Model, and to look at a more balanced and detailed picture of the learner experience.

Ex post facto experimental design approach is the most suitable research method for collecting quantitative data when true experimental research is not possible. The ex post facto design is a variation of the "after-only with control group" experimental design. The chief difference is that both the Experimental and Control Groups are selected after the experimental variable is introduced rather than before (Green & Tull, 1993). It is particularly appropriate when simple cause-and-effect relationships are being explored (Cohen, Manion, & Morrison, 2011). Ex post facto research design involves assignment of subjects to Experimental Group and Control Group, and subjecting the Experimental Group to experimental treatment. In this research, participants are chosen on a voluntary first-come-first-serve basis rather than being randomly selected. It is not possible to randomly select participants as the research is constrained by the availability of students at a given time, within a given university, studying a given subject. However, once the participants agree to sign the consent form to take part in the study, there is a random division and assignment of participants to the two different e-learning modules. This random assignment allowed this researcher to compare the performance and the learner experience between the groups. The

Experimental Group is subjected to an experimental treatment - a different design and presentation of the learning material along with the additional supplementary study skill content.

The use of pretest-posttest control-group design is to confirm that the two groups that are randomly assigned to the study are comparable, and the observed differences in outcomes are not impacted by extraneous factors or pre-existing conditions. Even though randomization is used, the presence of a pre-test help measure whether the two groups were initially the same in terms of their prior subject –level knowledge and meta-level knowledge.

The recruitment of volunteers and the splitting of the Experimental Group and Control Group are considered to be ethically sound. Student participation of this research study was on a voluntary basis. Students were made aware that their participation and learning outcomes (including test scores) did not have influence on their academic records at the university. The participants were then randomly assigned to either the Experimental or the Control Group. By randomizing the placement, it ensures that the group attributes to the different modules would be roughly equivalent and any difference between the two groups would be due to chance.

In addition, every effort was made to minimise the risk of unfair advantage of one group over the other by ensuring the content was the same for both Control Group and Experimental Group. The instructional and interaction design of both modules took into the consideration of presenting content in a different yet compatible way for both groups. The design of both modules and the related ethical considerations were presented to two ethics committees at University of Hertfordshire and Athabasca University respectively, and they agreed that any risk was minimised. Consequently, ethics approvals were granted (Appendix 2 and 3).

The disadvantage of having volunteers as participants is that research studies might attract certain types of students – more motivated, curious, or self-regulated/self-aware. They might also be academically stronger than their non-volunteering peers as they are willing to make that extra effort to participate in this research study. However, it was not the intention of this research to compare the two groups to the actual student body enrolled in Introduction to Java Programming (COMP 268). It is the between-group comparison this research is interested in.

5.2.2 Participants' Profiles and Recruitment Procedure

Thirty-five students from Athabasca University volunteered to participate in the study. Students were recruited from those who enrolled at the University during the experimental period. It was made explicitly clear to the students that this experiment is on a voluntary basis, and their grades are not affected whether they choose to participate or not. At the time of the experiment, all participants were registered with the University at the undergraduate level, and their age ranged from 19-49. Table 5.1 summarises the participants' demographic information for both Experimental and Control Groups:

Table 5.1: *Demographic information for Experimental and Control Groups*

	Experimental Group	**Control Group**
Total number of participants	18	17
Age range	19-49	20-42
Gender	M=11, F=7	M=11, F=6

Participant recruitment messages were posted in two University Facebook pages The two Facebook pages are the Official University Facebook page: https://www.facebook.com/Athabasca.University (with 2557 likes), and the University Students Facebook page:
https://www.facebook.com/athabascauniversitystudents (with 302 likes).

Recruitment messages were posted for duration of two weeks and 35 students responded to them. Recruitment messages were also posted in all introductory level computer science courses' announcement pages in Moodle with the instructors' permission. The participants are adult learners from all academic disciplines as introductory level computer science courses are open to all learners regardless of their majors. The content was adapted from a 200 level (200 level is an introductory level at Athabasca University) *Introduction to Java Programming* (COMP 268). As this is an accredited online University in Canada where the majority of the courses employ some degrees of multi-media technology, it was expected that all participants have at least a basic level of academic and technical ability to comprehend the content as well as navigating the course. Moodle is the main platform for online course delivery at Athabasca since 2007, and students have had Moodle training as part of their orientation. Therefore, it was assumed that participants could access Moodle and find their way around the module with little problem. In addition, on the course home page itself, it stated that the prerequisite of the course is: "You are expected to have a basic knowledge of computers in general and to be able to set up and use Java or other programming language(s) in a relevant programming environment. You are expected to be a proficient user of the Internet and to be able to use word processors, text editors and file manipulation tools (including zip compression) effectively. You should have completed high school algebra."

Students who volunteer to be participants had been presented an online debriefing at the beginning of the experiment along with a consent form. Ethics approval had been sought prior to the start of the experiment from both University of Hertfordshire in the UK and Athabasca University in Canada. For details of the ethics approval forms, see Appendix 2 and 3.

5.3 Procedure

Once the recruitment messages were posted, students interested in participating were directed to a "recruitment website" for an outline of this research. At this time, students who wanted to participate were directed to the next page that shows the online Participant Information Sheet (PIS). A button labelled “I have read” would appear and it requires the participants to acknowledge that they have read the information sheet. Then the participants were shown the Participant Consent Form (PCF) in a separate page. Two buttons appeared at the bottom of this page – “I have read and I agree to participate” and “I have read and I do not agree to participate”. The responses of participants were electronically recorded along with their names and email IDs. Clicking on the “I have read and I agree to participate” button would constitute consent. See Appendix 4 for the PIS and Appendix 5 for the PCF.

5.3.1 Experimental Group Setup

Students who were assigned to the Experimental Group were directed to the Learner-Directed Model site called “Control Structures (Experimental)” while the Control Group students would study the linear-model site called “Control Structures (Control)”. Both sites resided on a secure server at the iCore Lab, a research facility for computer science studies at Athabasca University. For both the Control and the Experimental Groups, participant could only access the material after taking the pre-test. Figure 5.1 shows the home page for the Experimental Group.

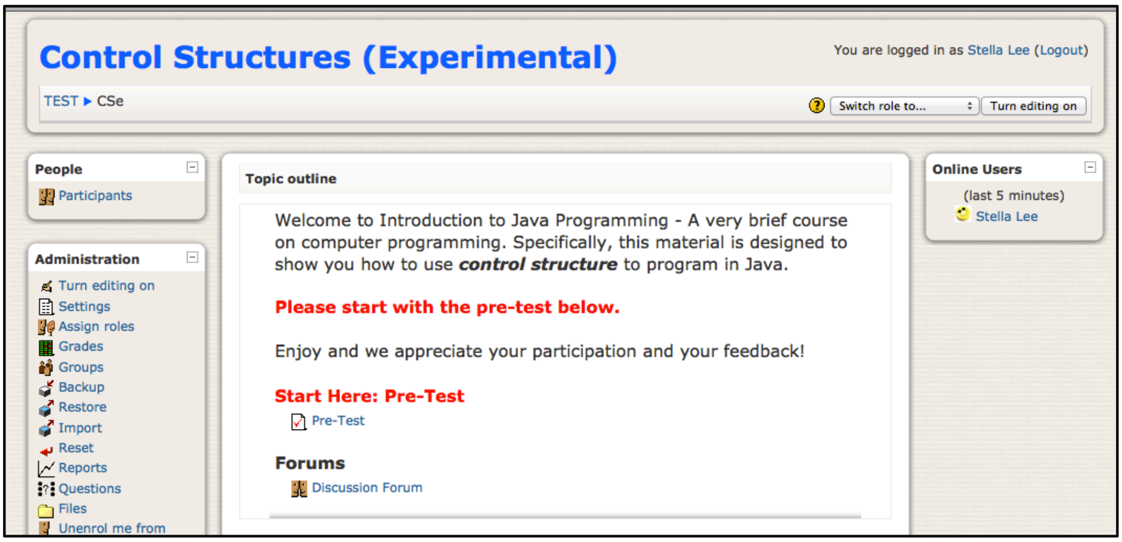

Figure 5.1: Experimental Group home page

Once participants access the home page, they must start with the pre-test. (Figure 5.2)

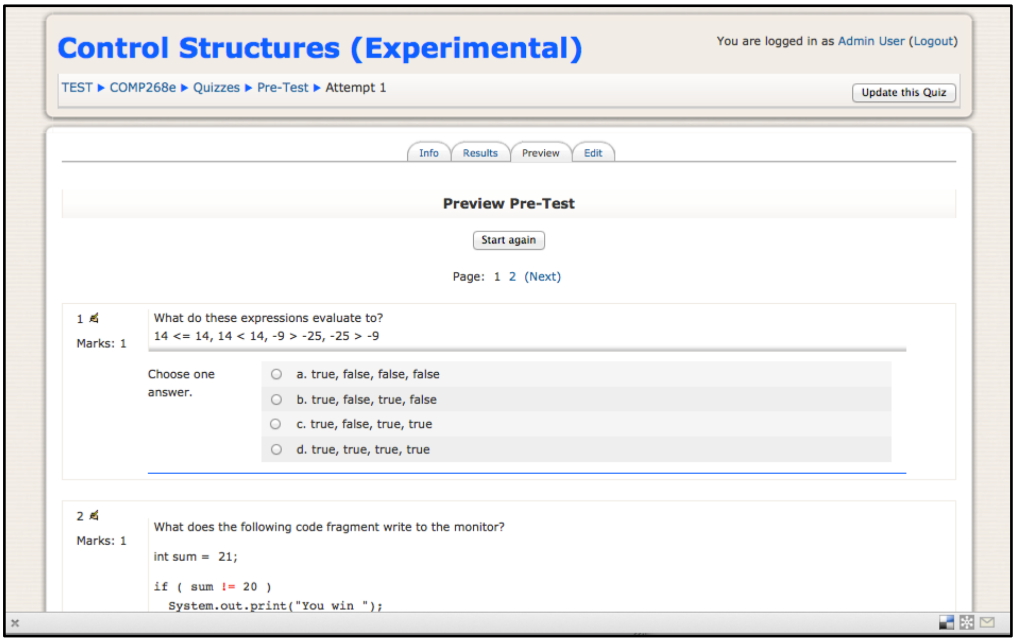

Figure 5.2: Experimental Group pre-test page

The pre-test was a timed test that consists of 30 items in two parts: 20 questions for domain-knowledge and 10 statements for meta-knowledge. Domain-knowledge questions test participants, their prior knowledge in computer programming and are objective in nature. The meta-knowledge questions asked students to self-report on how well they knew a certain study skill set and were subjective in nature. Students had a maximum of 30 minutes to complete the pre-test. For a sample of the pre-test questions for domain-knowledge, see Appendix 4. For the pre-test questions for meta-knowledge, see Appendix 5.

Once the students completed the pre-test, they were presented with an instruction on how to navigate the module (Figure 5.3) and a list of five learning concepts (Figure 5.4).

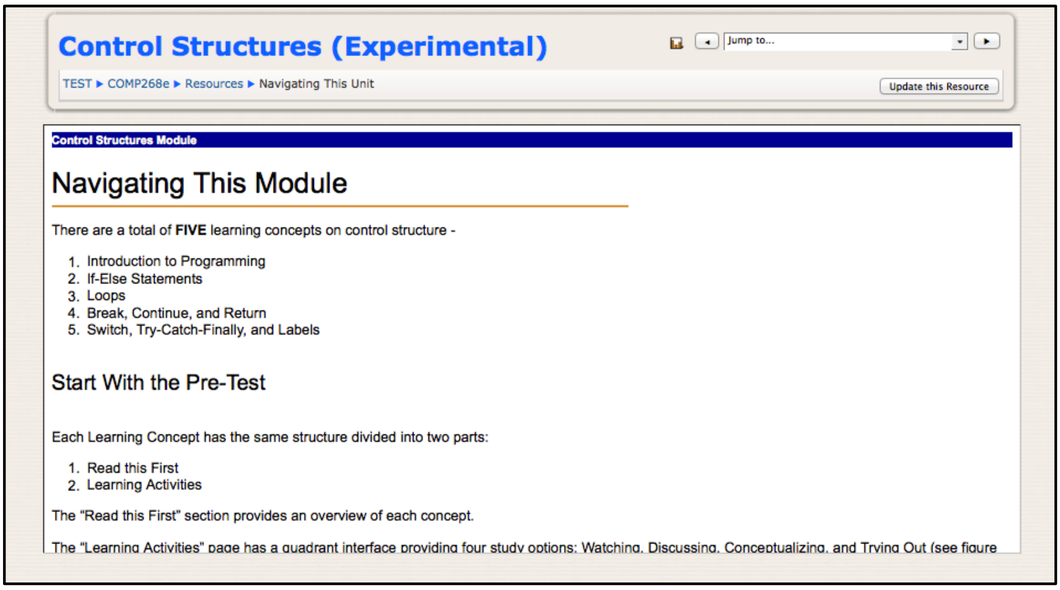

Figure 5.3: Instruction on how to navigate the module

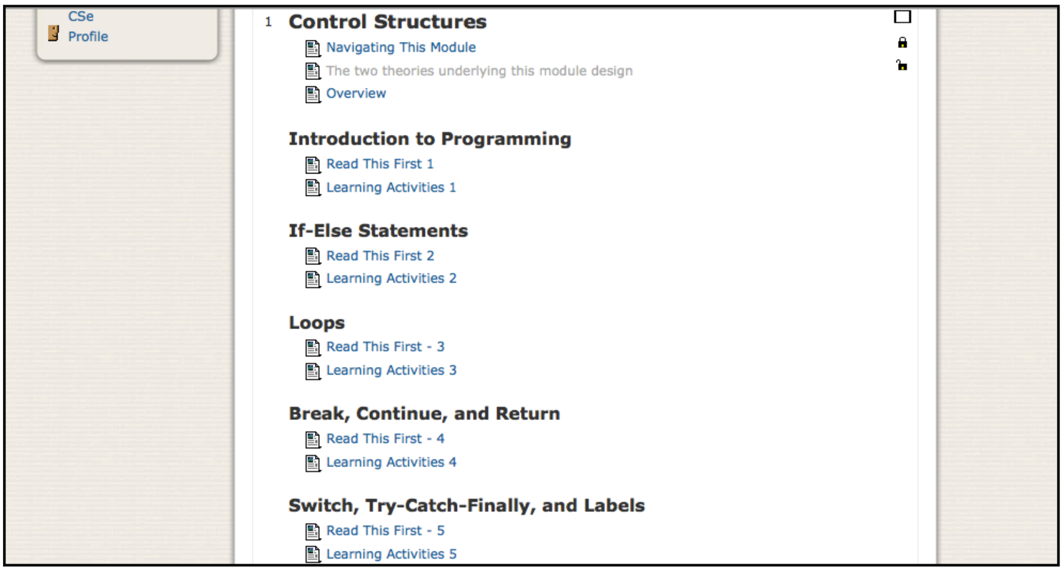

Figure 5.4: Experimental Group listing of Learning concepts

The five learning concepts on Control Structure were designed based on the original material extracted from COMP268 – Introduction to Java Programming in Unit 3, with modification to make it contextually appropriate for this experiment (i.e. so the material makes sense as a stand-alone module without having to study Unit 1 or 4).

Each learning concept has two parts – Read This First, and Learning Activities. The "read this first" is a textual overview of the concept, and the material is derived directly from the course COMP 268. The aim of the Read This First section is to provide a theoretical overview of the concept before students select their learning activities (Figure 5.5).

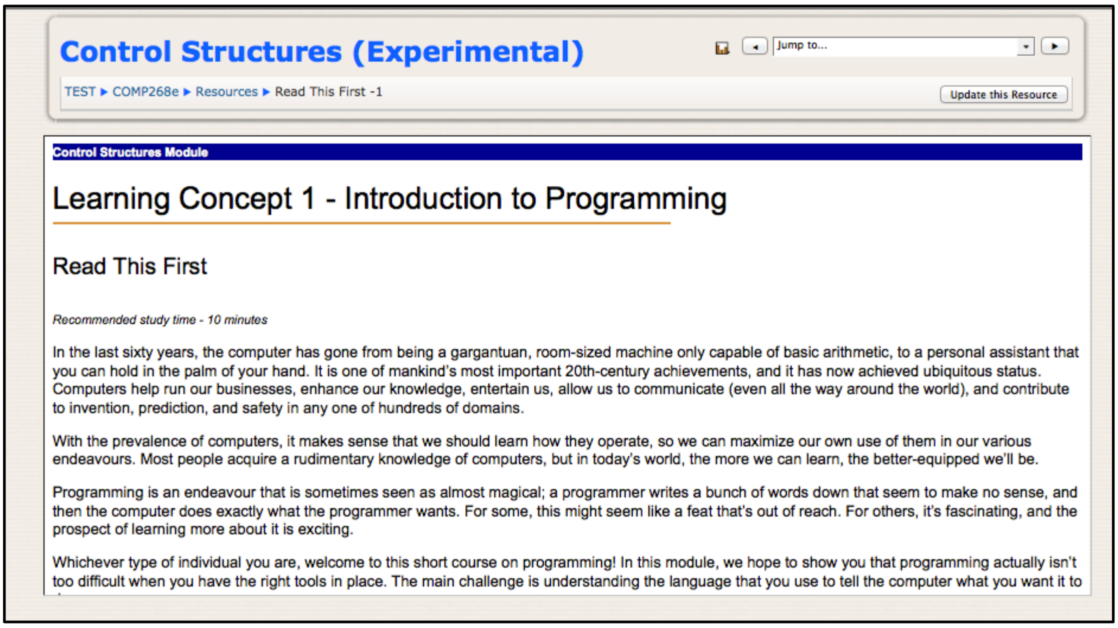

Figure 5.5: Read This First section of Learning Concept 1.

When students clicked on the Learning Activities, they were taken to the next screen that presented them with a flexible learning interface in the shape of a circle with four quadrants (Figure 5.6).

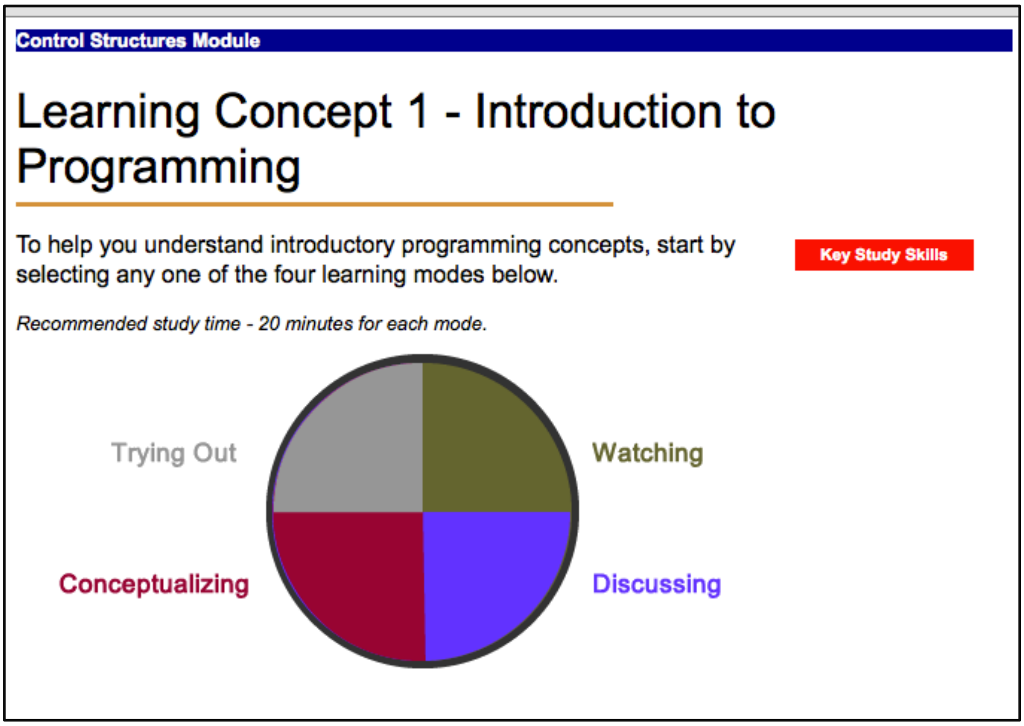

Figure 5.6: Experimental Group Interface for Learning Concept 1

At this stage, students were presented with different options for their learning activities: watching, discussing, conceptualizing, and trying out. Alternatively, they could skip ahead to another learning concept or go directly to the post-test if they were confident of passing this module without going through any learning material at all.

To further illustrate how the quadrant design work, I will focus on how students can use one section of this circle under the third Learning Concept – Loops. Figure 5.7 displays the home page of Learning Concept 3 – Loops.

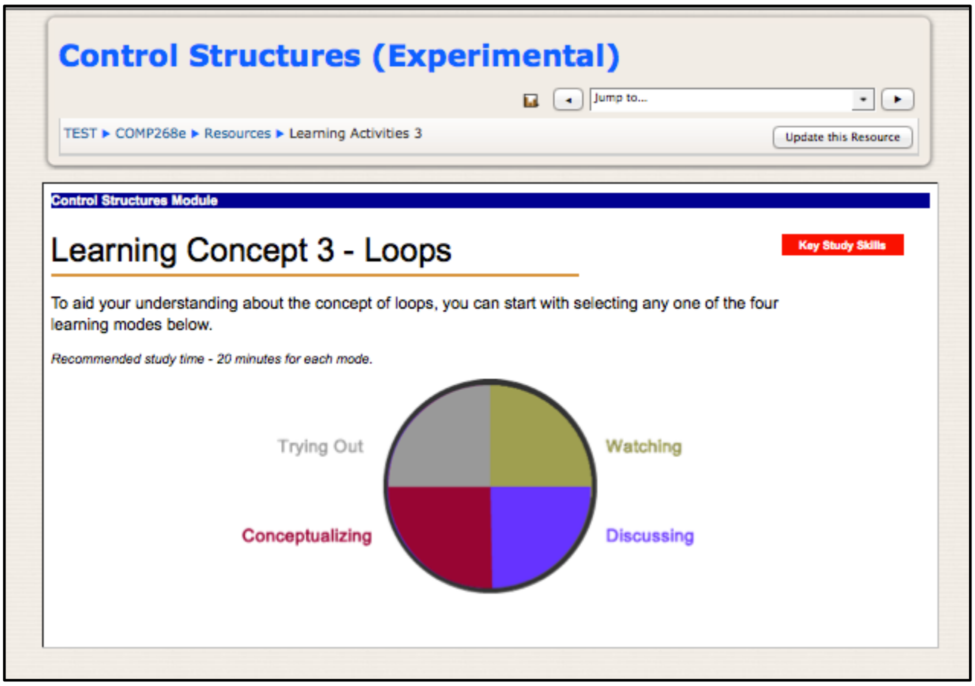

Figure 5.7: Home page of Learning Concept 3 – Loops

If students prefer to learn by watching some tutorials on video about how to write loops, they can select the “Watching” option on the upper right of the quadrant, and it will present a page with a series of video tutorials on different types of loops – while loops, for loops, and do-while loops (Figure 5.8).

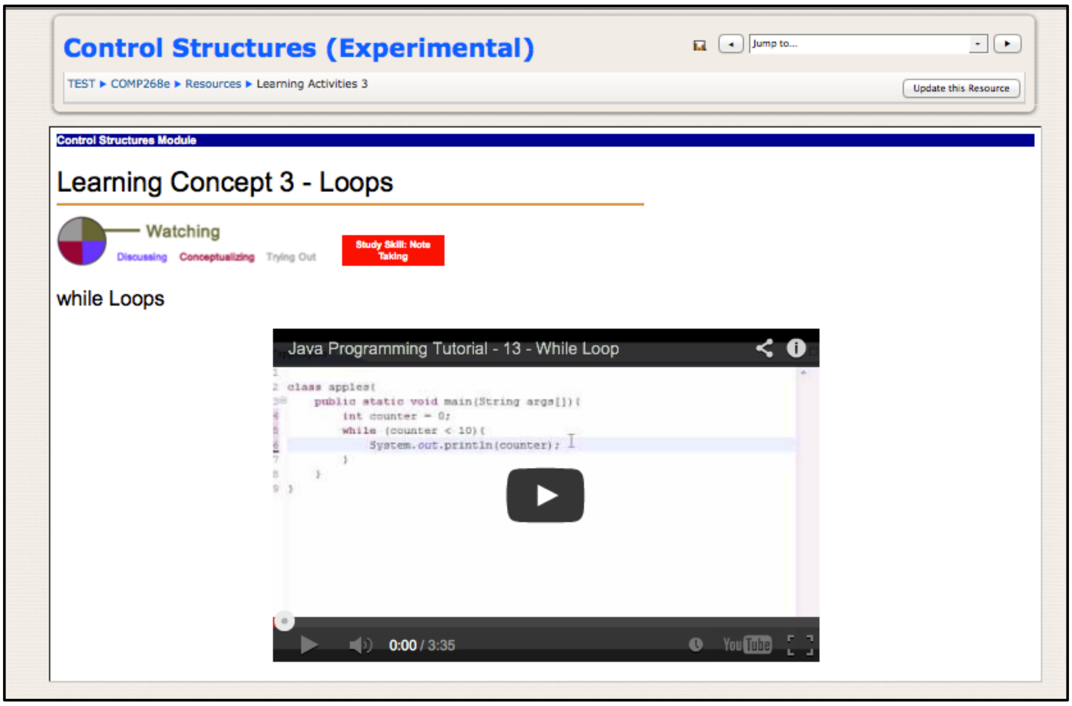

Figure 5.8: Video tutorial on how to write loops.

Notice that the circular interface is still available on the upper left corner and it indicates to learners where they are in terms of the learning activities. From there, they are free to jump around and select a different learning activity such as Discussing, Conceptualizing and Trying Out. Additionally, there was a red, rectangular button labelled “Key Study Skills”. They could access a key study skill page by clicking on the button (Figure 5.9). The key study skill page corresponds with the type of learning activity you choose. In this example, the student is going through a Watching activity; therefore, the key study skill for that is on how to take notes, with a special emphasis on how to take notes for video tutorial. As elaborated in Chapter 4, there were a total of four topical study skills: note taking, communications, conceptualizing, and problem solving skills. A total of twenty related study skills - five successive skills for each of the four learning modes - have been developed. Different learning activities were associated with different key study skills.

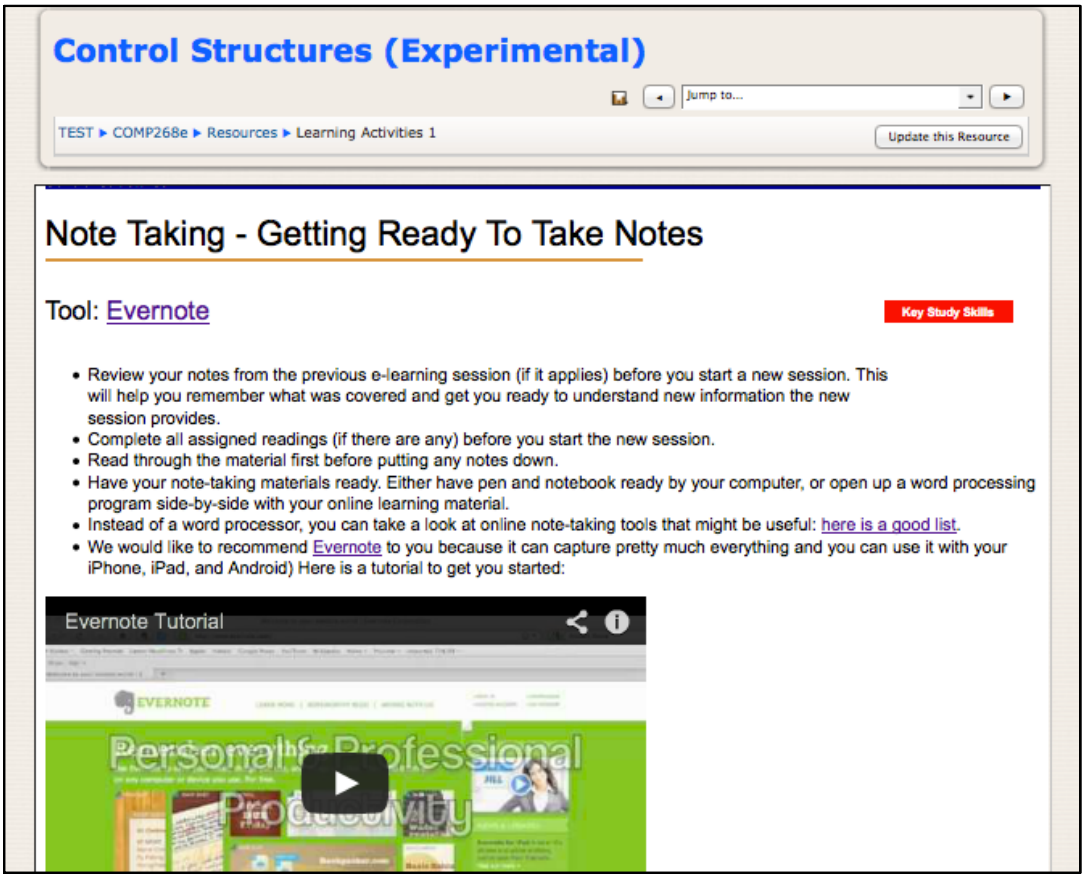

Figure 5.9: Key Study Skill page on note taking

All learning concepts, key study skills and associated activities were made available as options for participants to pick and choose as they saw fit. They were neither obligated nor forced to follow a certain learning path, in any sequence. It was anticipated that each participant would most likely finish studying the material in about 1 to 2 hours' time; depending on how many learning activities they choose to do. The only requirement for completing this module for the Experimental Group is to take the pre-test, post-test, and the survey at the end.

The learning activities were structured around Kolb's learning cycle in four stages (Kolb, 1984). Kolb refers to these four stages as: *concrete experience* (CE), *reflective observation* (RO), *abstract conceptualization* (AC) and *active experimentation* (AE). The different stages of the cycle are associated with distinct learning styles. Kolb (1984) suggests that students develop a preference for learning in a particular way. The preferred style reflects a tendency rather than an absolute and students may adopt different learning orientations in different situations, but they tend to favour some learning behaviours in preference to others. The four styles are diverging, assimilating, converging, and accommodating (Figure 5.10). These four styles are associated with how learners prefer to learn and solve problems (Healey & Jenkins, 2000; McCarthy, 1987):

1. *Divergers* - view situations from many perspectives and prefer brainstorming, they have high interest in people and process information reflectively
2. *Assimilators* - use inductive reasoning and prefer theoretical models, they prefer to perceive information abstractly and are detailed oriented.
3. *Convergers* – good at practical applications, and like to integrate theory and practise, and are skill oriented
4. *Accommodators* – prefer to experiment and interested in action and results, they like new things, and are interested in self-discovery

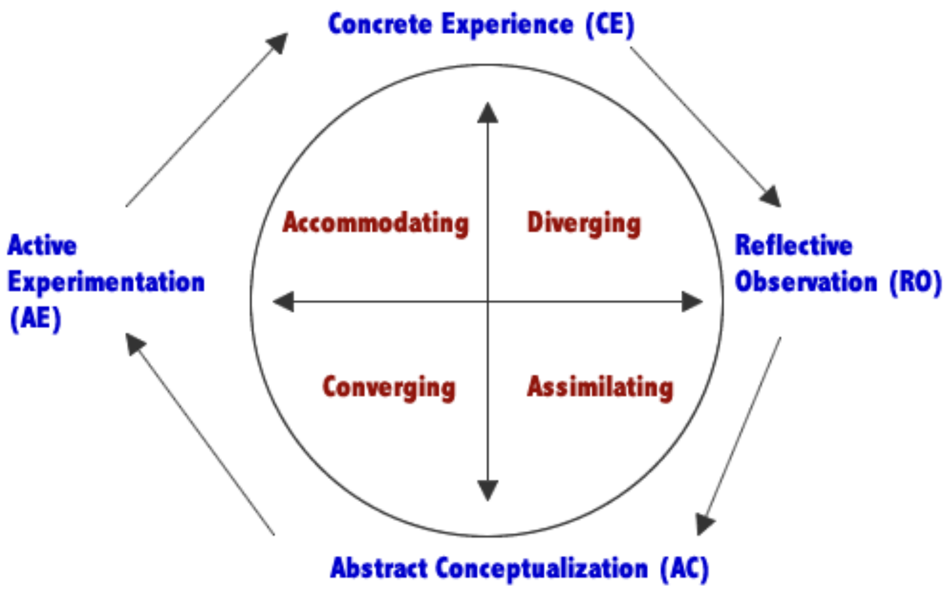

Figure 5.10: The four stages of the learning cycle and the associated learning styles

The learning activities created for this study were based on the work of Mobbs (2005), and University of Leicester Graduate School (2014). The activities that correspond with the four stages are listed in Table 5.2.

Table 5.2: *The Four Stages of the Experiential Learning Cycle And the Suggested Learning Activities (Mobbs, 2005; University of Leicester, 2014)*		
Stage	**Description**	**Suggested Learning Activities**
Concrete experience	Apply previous experience to current learning by reading, observing or watching	readings examples problem sets trigger films simulations/games
Reflective observation	Lots of questions are asked and communication channels are opened to others members of the team. Learners need to verbalise and discuss with others	logs journals discussion brainstorming
Abstract conceptualization	Making sense of what happened and understand the relationship between them	lecture projects analogies model building
Active experimentation	Learners need to consider how they are going to put what they have learned into practise	projects fieldwork laboratory case study simulations

From each stage, one suggested learning activity was selected for the design of this study. The activities are:

- Concrete Experience - Watching (viewing tutorial videos)
- Reflective Observation – Discussing (posting to discussion forums)

- Abstract Conceptualization – Conceptualizing (concept mapping and mental model building)
- Active Experimentation – Trying Out (writing codes in Java)

These extra activities accommodate the four orientations as Kolb stated, for example, for divergers, these learners like to see things from others' perspectives and to seek out others opinions and input. The two activities - watching tutorial videos and discussion forum postings are designed to cater to the diverging orientation. For convergers, these learners prefer to integrate theory and practise, and are skill oriented; therefore, learning activities such as concept mapping, mental model building and providing practise exercise for them to try out their coding skills are appropriate for this orientation.

5.3.2 Control Group Setup

As for the Control Group, the view on the module and the interface was rather different. The design of the Control Group module mirrored the typical design of a current online offering for computer programming courses (Figure 5.11). Learning material was presented in a linear format, and students were strongly encouraged to study the entire material corresponding to each topic before moving on to the next topic. To start the module, similar to the Experimental Group, the Control Group participants needed to start with the pre-test (Figure 5.12).

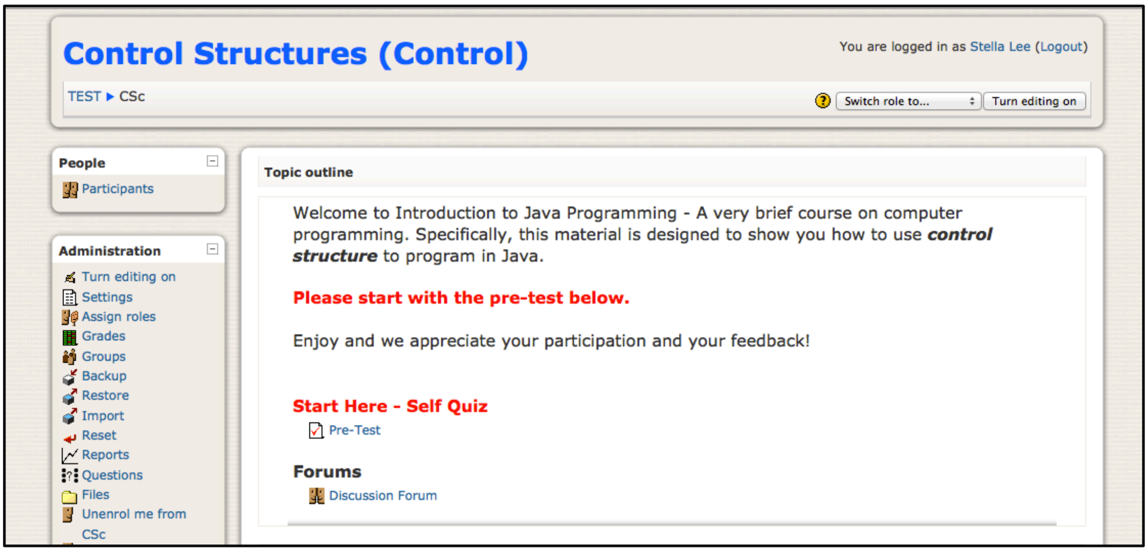

Figure 5.11: Control Group home page

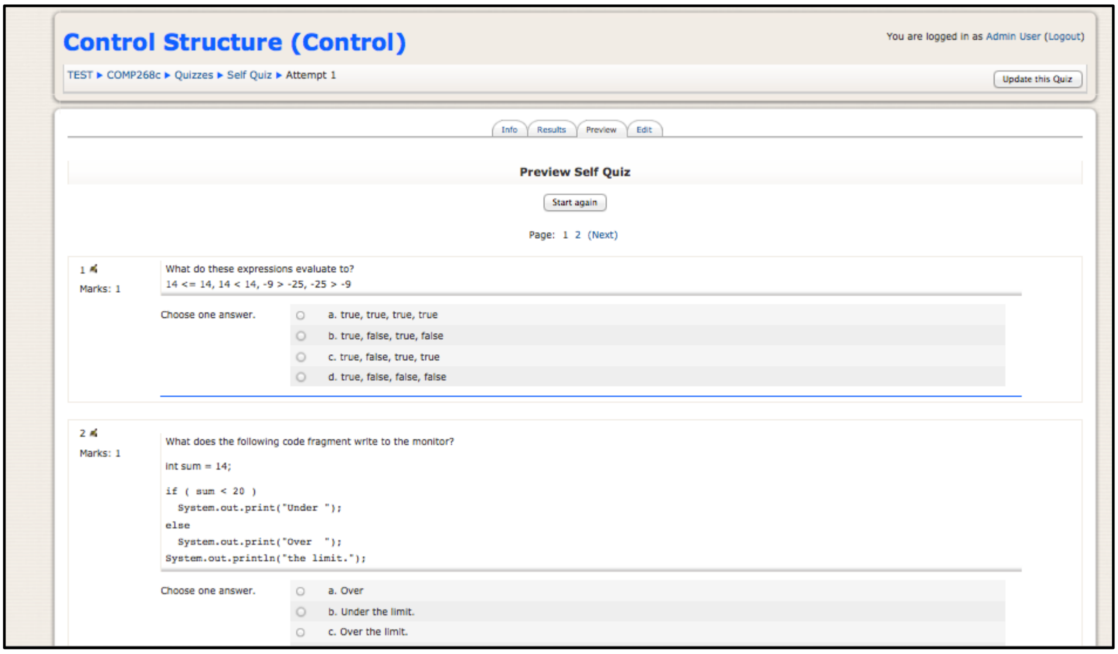

Figure 5.12: Control Group pre-test

After participants completed the pre-test, they were presented with a linear list of learning concepts; again, similar to the Experimental Group, the home page displays a list of learning concepts. However, the similarity ended there once the participants accessed the learning concepts.

Unlike the Experimental Group, the Control Group did not have a flexible circular interface in quadrants. Instead, a linear presentation of content was made available for learners to access (Figure 5.13). Five learning concepts were provided, the same learning content as the Experimental Group.

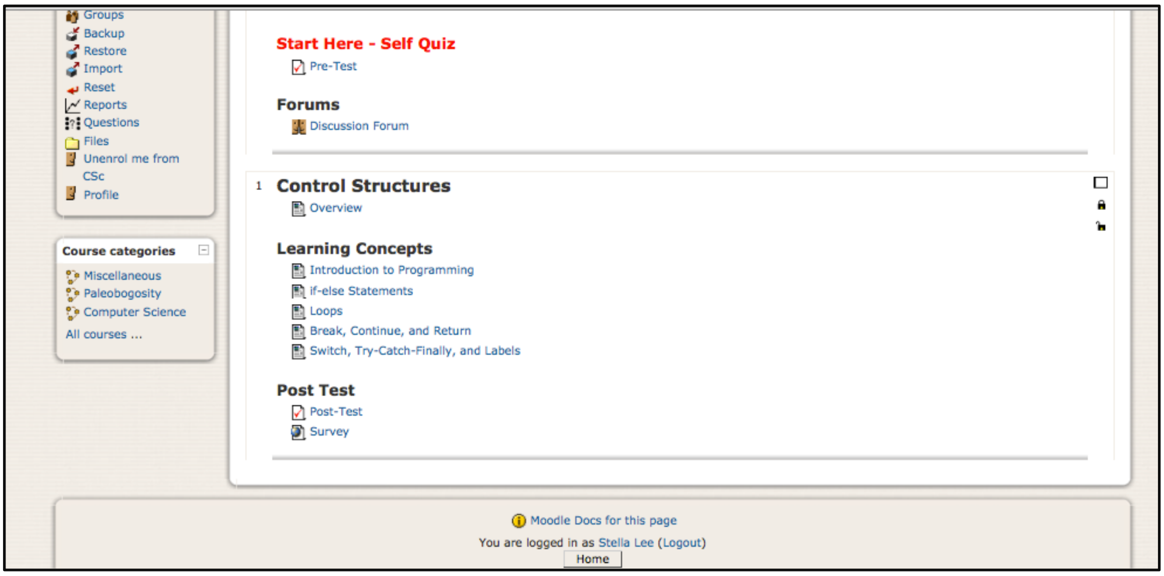

Figure 5.13: Control Group home page with the listing of learning concepts

However, instead of a circular interface, the link to each learning concept led to a page that looked like Figure 5.14 and 5.15.

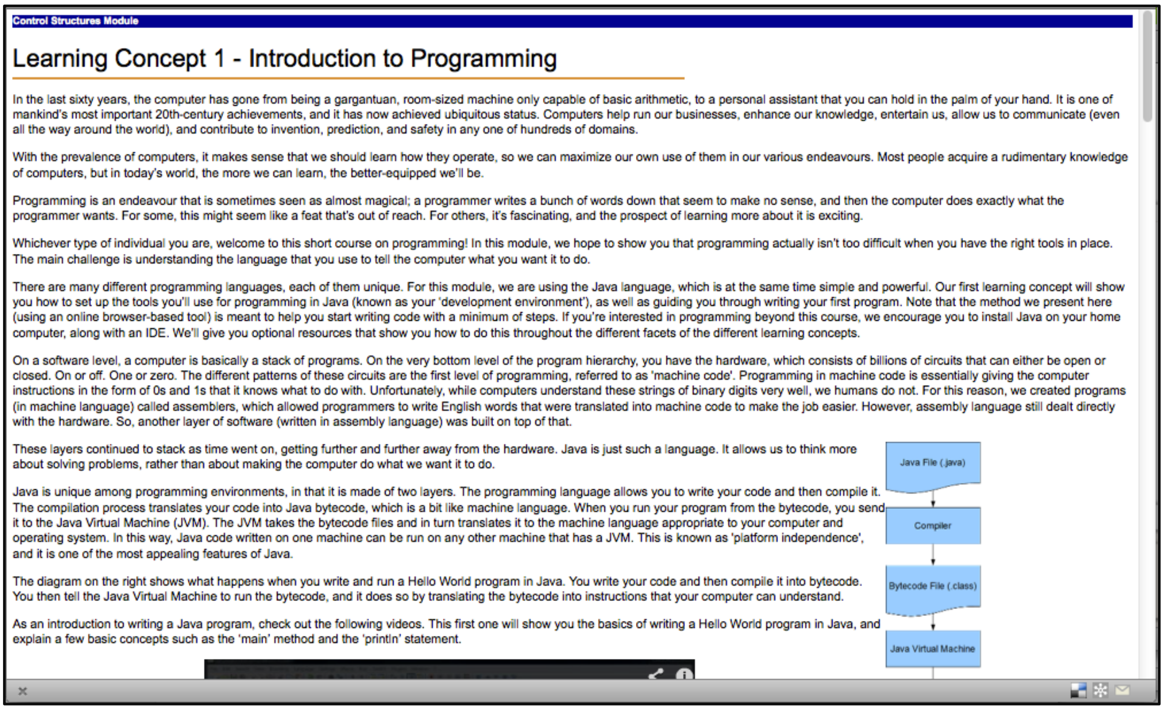

Figure 5.14: Control Group Learning Concept 1

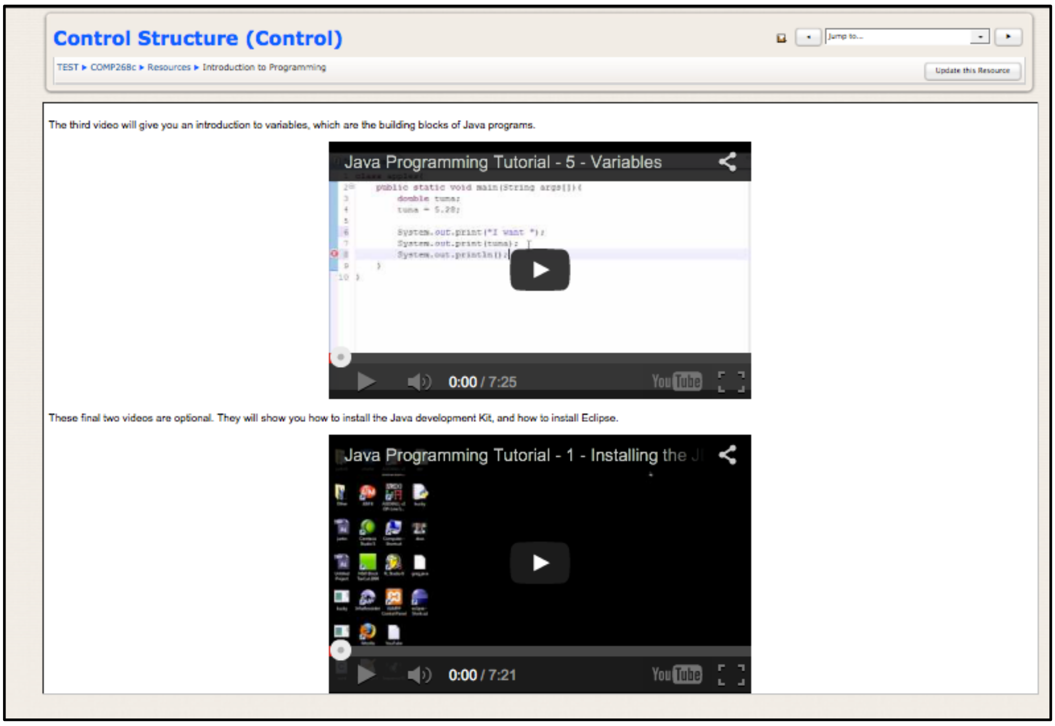

Figure 5.15: Control Group Learning Concept 1 continues on the same page

All the learning materials were presented in one linear page where students have to scroll up and down. Once the participants are done with one learning concept, it will link to the next learning concept, and this continues on until all five learning concepts are covered. Figure 5.16 and 5.17 display Learning Concept 2 – If-else Statements.

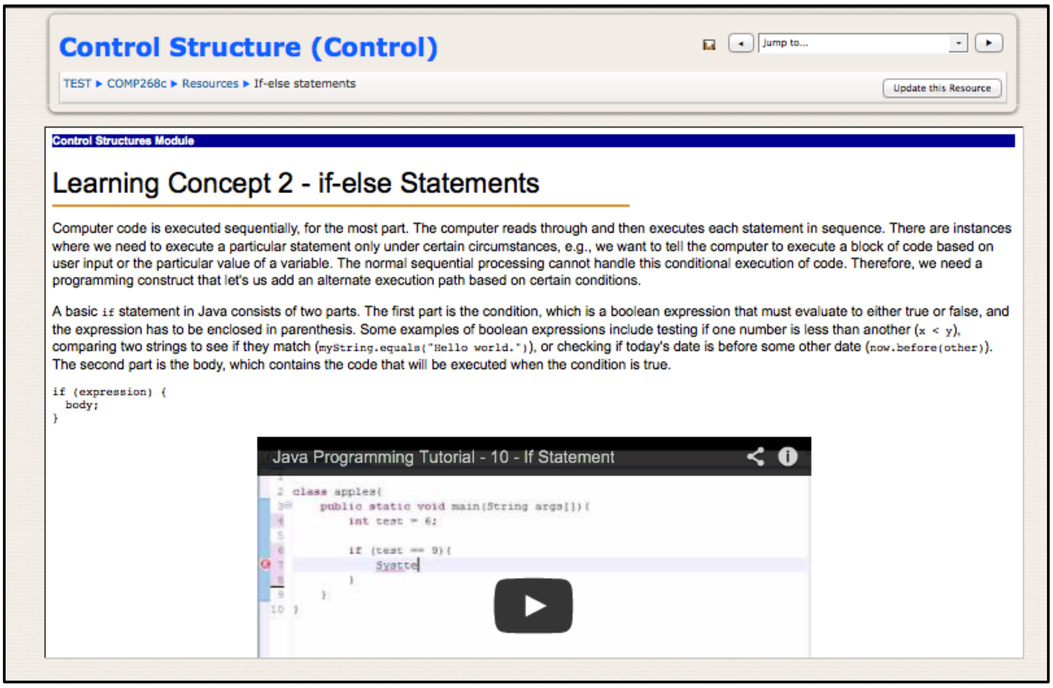

Figure 5.16: Learning Concept 2 – If-else Statements

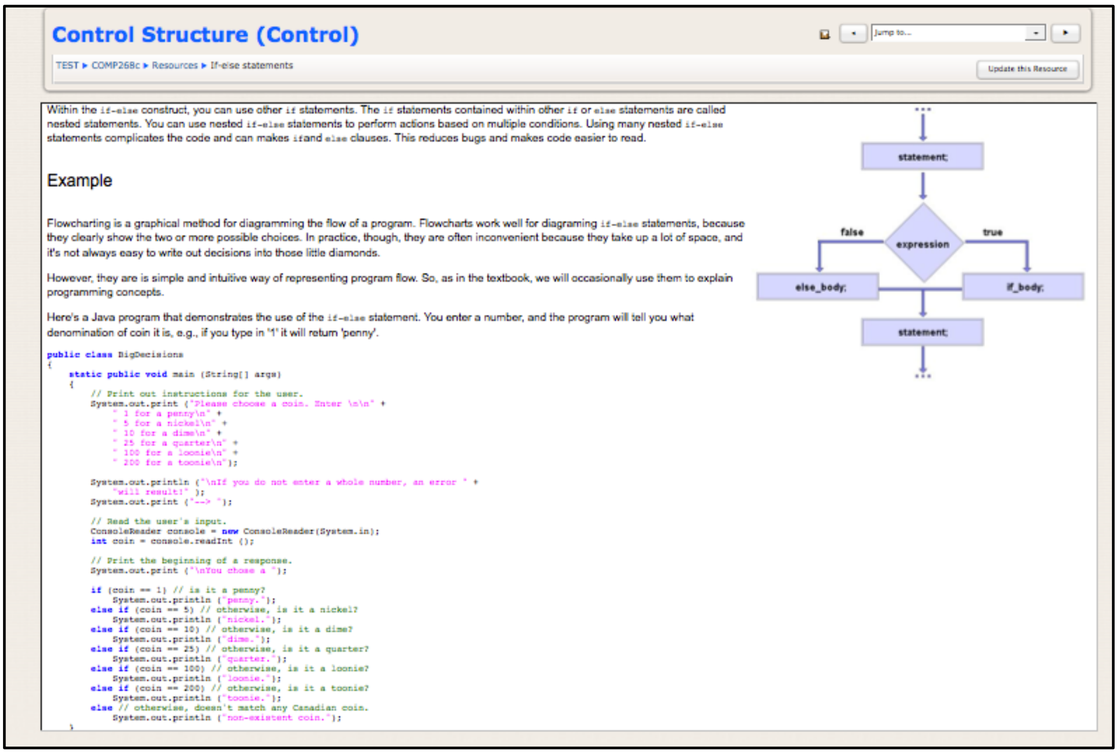

Figure 5.17: Learning Concept 2 continues on the same page

After the learners are finished with all five learning concepts, a post-test is required for them to assess their competency on this module (Figure 5.18). Even though learners are not required to go through the learning concepts in a sequential order, it wasn't made explicit to them. The learning activities are the same as the ones in the Experimental Group, but for the Control Group, learners were not made aware of the different learning preferences, thus, there were no differentiation of the Watching, Discussing, Conceptualizing, and Trying Out activities.

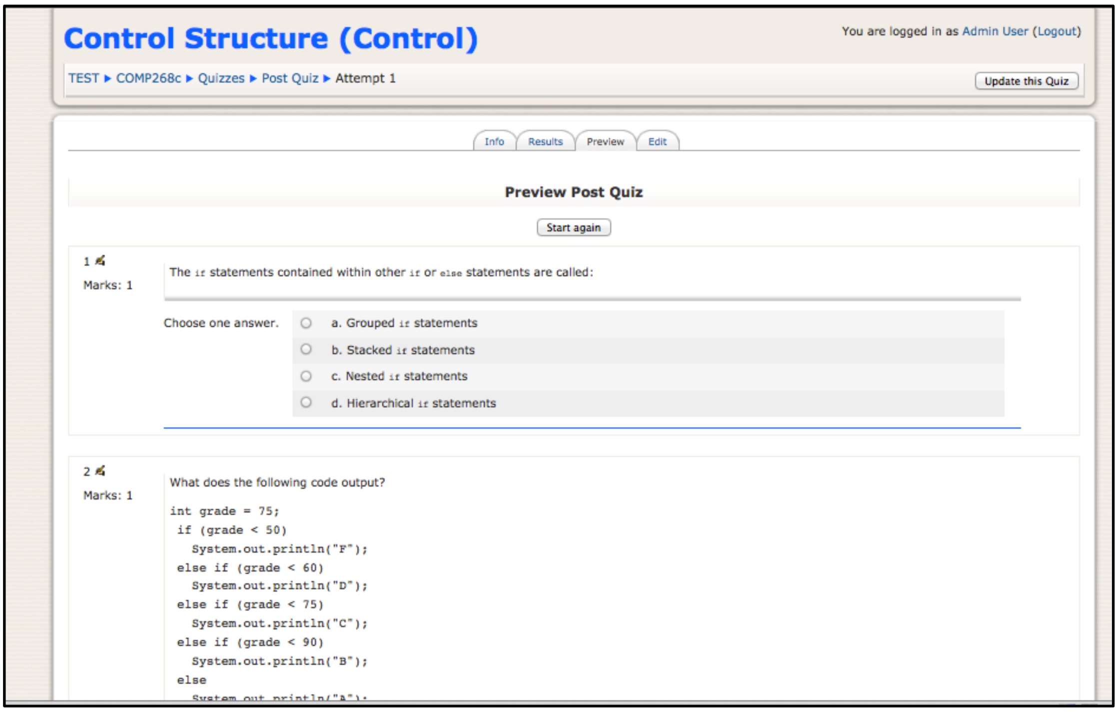

Figure 5.18: Post-test for the Control Group

The Control Group’s navigational structure and instructional design is a representation of the contemporary format of the COMP268 – Introduction to Java Programming (Figure 5.19).

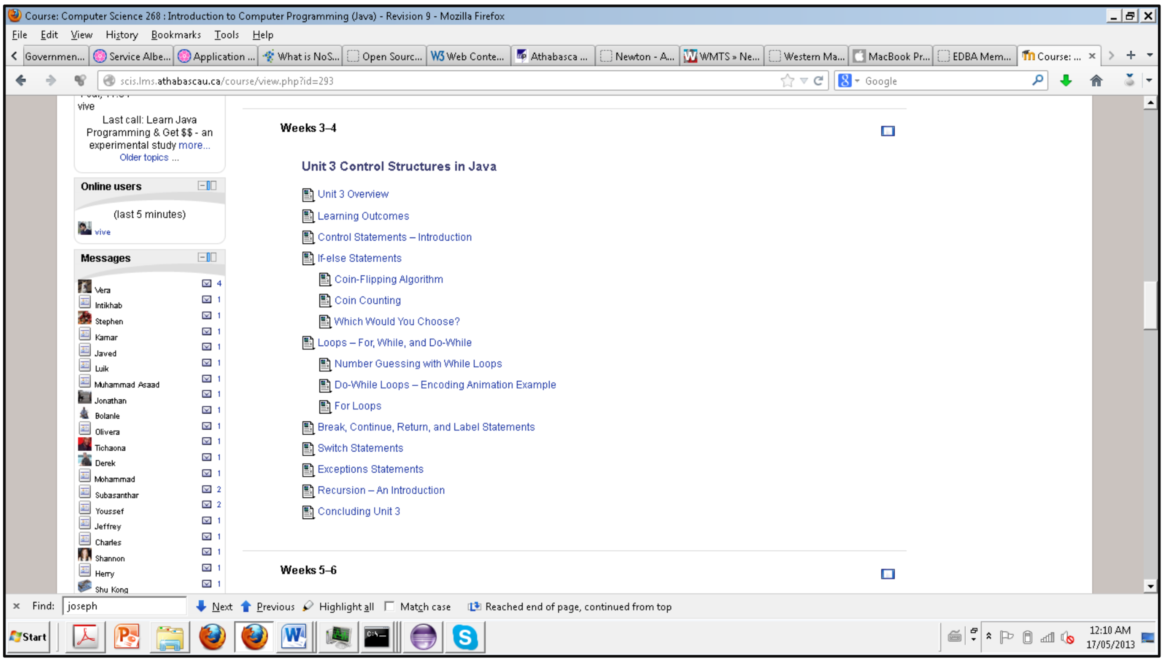

Figure 5.19: The current COMP268 course as offered by Athabasca University

At the end of the module for both the Control and the Experimental Groups, there was a survey. Each participant was required to complete the survey in order to receive a remuneration cheque for an amount of $35 CAD. The online survey was embedded in the module but hosted in Limesurvey (http://www.limesurvey.org/). The aim of the survey was to gauge the participants' learning experience in terms of system performance, usability, user satisfaction, and perceived controllability of the system.

From the pool of participants who completed the study and submitted the survey, six participants (three from each group) were randomly chosen and invited by email to take part in semi-structured follow-up interviews. Since they already consented to the study at the beginning and since the interviews were only an extension of the study, there were no separate information sheet or consent form for the interview process. The interviews were conducted electronically in Skype, a software application that allows users to make voice calls over the Internet (http://www.skype.com). Each Skype call lasted for about an hour.

The next section will detail the measurement instruments for the current study. Instruments include log file data collection, pre-test, post-test, survey, and follow-up interviews.

5.4 Measurement

Five data collection instruments were employed to measure the performances and experiences for both the Experimental and the Control Groups. They were: log file data collection, pre-test score, post-test score, survey, and follow-up interviews.

5.4.1 Log File Data Collection

The aim of the log file data collection is to track the time spent on domain area activities and the study skill activities within the Moodle website. The "reports" function in Moodle was used to identify learning activities being accessed and the students' time spent within it. Summary of the log file was generated in Excel spreadsheet format to provide information on the total time spent as well as time spent on domain area and study skill activities for both the Control Group and the Experimental Group.

5.4.2 Pre-Test

One timed (30 minutes) pre-test consisted of 30 items in two parts: 20 questions for domain-knowledge and 10 statements for meta-knowledge were provided as the starting point of the module for both groups. In this test, two types of data were examined:

1. Test scores for the domain-knowledge – to gauge how much a student has already known about control structures in Java programming prior to this module. These test scores were compared to the post-test domain-knowledge test scores. This part of the test questions was randomised.
2. Test scores for meta-knowledge (study skills) – to gauge a student's study skill competency. This is in a form of a self-report rather than an objective measurement of specific study skills. Participants were asked to check the response which best described their level of agreement with the statements. These scores were compared to the post-test meta-knowledge scores as students reflected on whether there were any changes in their study skill knowledge during the time they studied the module. Figure 5.20 and 5.21 below display screenshots of both the questions for the domain-knowledge and meta-knowledge (study skills) for the Pre-Test.

For a sample of the Pre-test items, see Appendix 6. For the Study Skill items (same items on both Pre/Post-test), Appendix 7 provides the listing.

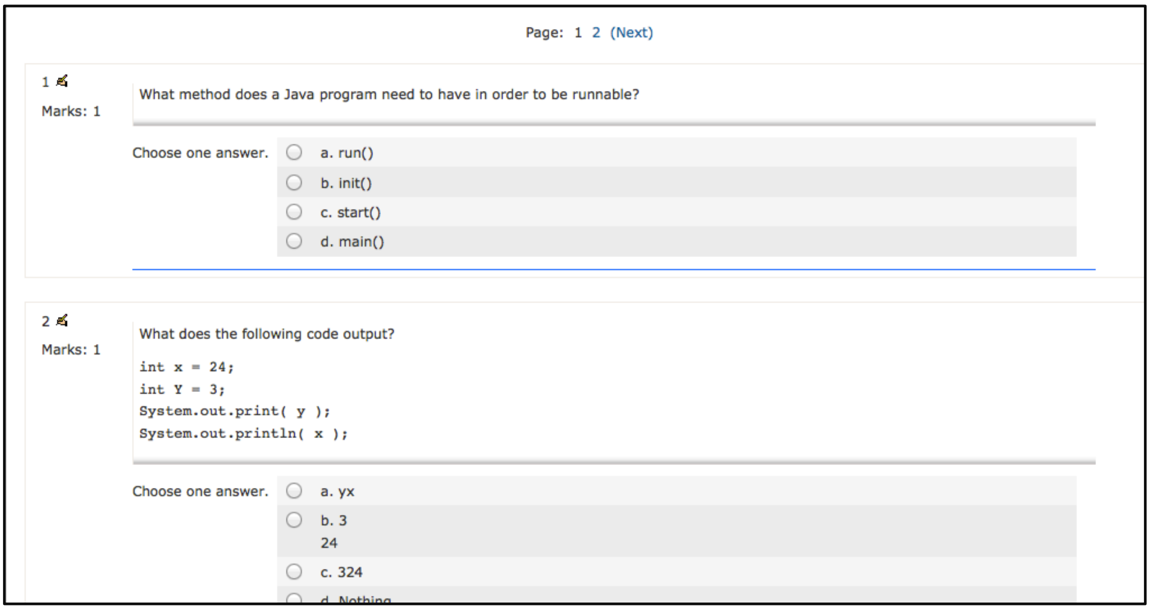

Figure 5.20: Domain-knowledge questions for the pre-test

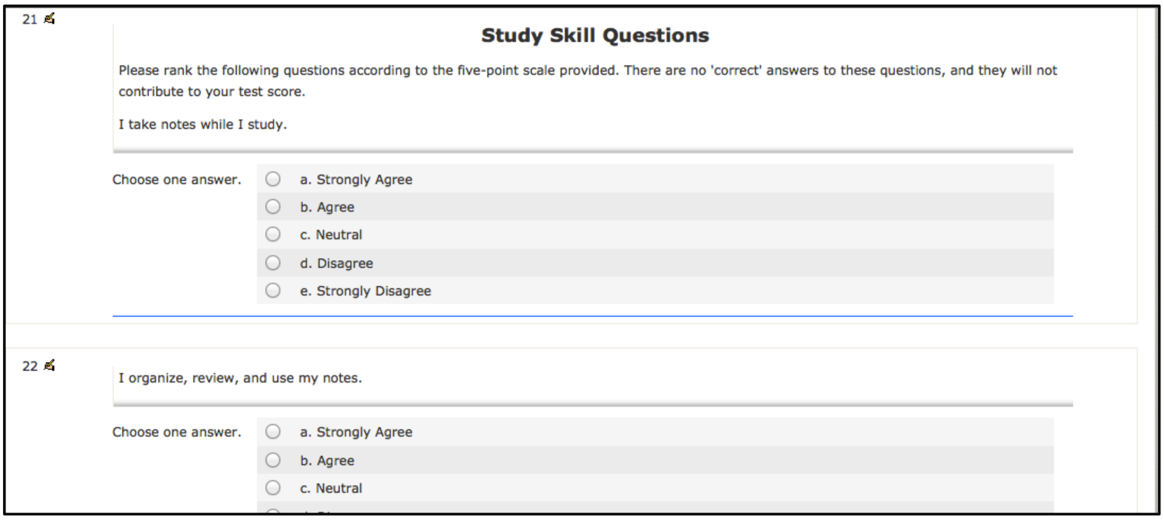

Figure 5.21: Meta-knowledge (study skills) questions for the pre-test

5.4.3 Post-Test

One timed post-test consisted of 30 questions in two parts: 20 questions for domain knowledge and 10 questions for meta-knowledge. Again, two types of data were collected:

1. Test scores for the domain-knowledge – the researcher compared this to the pre-test scores and identified whether the students had any changes in domain-knowledge.

2. Test scores for meta-knowledge (study skills) – the researcher compared this to the pre-test scores and identified whether the students had any changes in meta-knowledge.

Both the pre-test and the post-test were summative tests and self-administered by the participants. The domain-knowledge questions were aimed at a similar level as the pre-test and the meta-knowledge (study skills) questions remained unchanged. Both the pre-test and post-test questions were adapted from the formative and summative quizzes used in the current version of COMP 268 – *Introduction to Java Programming* offered at Athabasca University. One Associate Professor (Dr. Vive Kumar) in Computer Science and one post-graduate student (Clayton Clemens) from the same university and department reviewed, re-worded and validated the domain-knowledge questions one month prior to the implementation of this research study. For the meta-knowledge (study skills) questions, a review of literature referring to key study skills for online learning as well as for computer programming was conducted so as to help identify items for inclusion in the pre-test and post-test.

5.4.4 Survey

Survey is a well-established technique for generating users' opinions and product evaluations (Preece et al., 2002). One survey was employed in this research study and was hosted in Lime Survey (http://www.limesurvey.org/) with a link embedded at the end of the module. Lime Survey is a free and open source survey software tool and the data storage resides in Canada (as opposed to the US, where concern arises from the perceived privacy risk associated with the Patriot Act), thus fulfilled the ethics approval's requirement at Athabasca University in Canada.

The survey aimed to measure learners' attitudes toward study skills and tools provided in the module, their perceived ease of use and satisfaction, system usability, learner experience, and perceived controllability.

The survey was divided into seven parts:

1. User demographic questions pertaining to their age, gender, and email
2. Study skills and tools questions (there are three questions in this part that concern the Experimental Group only)
3. Perceived ease of use and user satisfaction questions
4. System usability questions
5. Learning experience questions
6. Perceived controllability questions
7. Open-ended text field questions

To ensure high construct validity, eight survey items had been adapted from Davis (1989) and Unger & Chandler (2009) for measuring perceived ease of use and user satisfaction. For system usability, six items were based on the work of Koohang & Du Plessis (2004) while three items derived from Smulders (2003) for learning experience. As for perceived controllability, four items were being reworded from Liu (2003); finally the two open-ended questions "what do you think it is the best features of the modules, and why?" and "what features of this module did you think should be improved, and why" were posted as an attempt to identify ways to improve the product and were based on the idea by Tullis & Albert (2008). Figure 5.22 and 5.23 provide a couple of snapshots of the survey layout. For a set of complete survey questions, refer to Appendix 8.

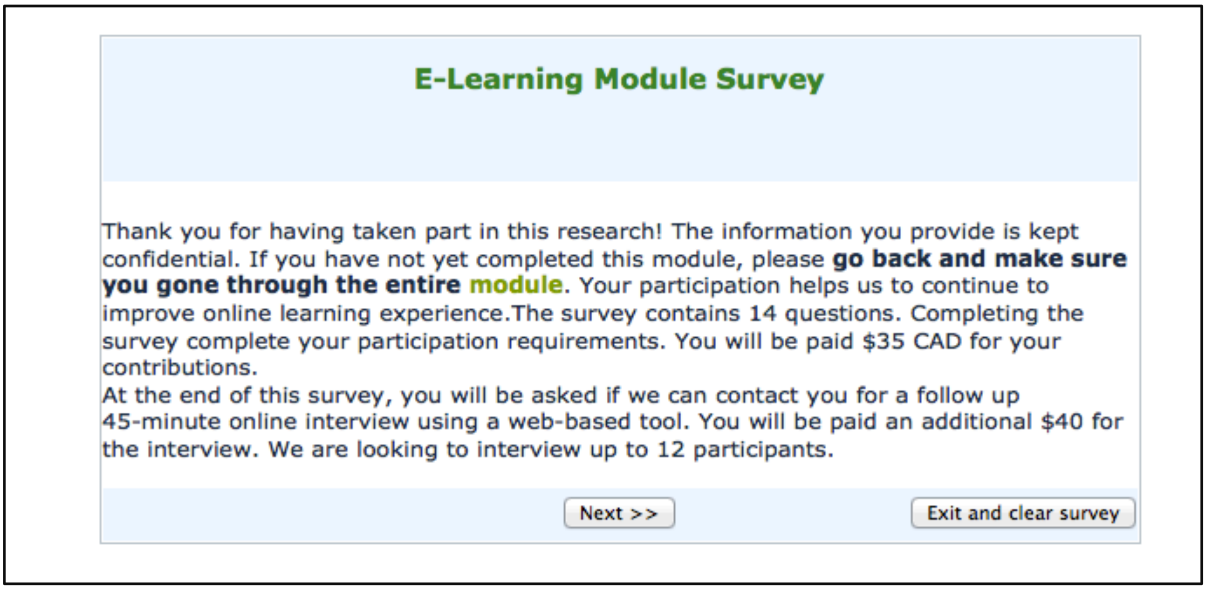

Figure 5.22: End-of-module survey homepage

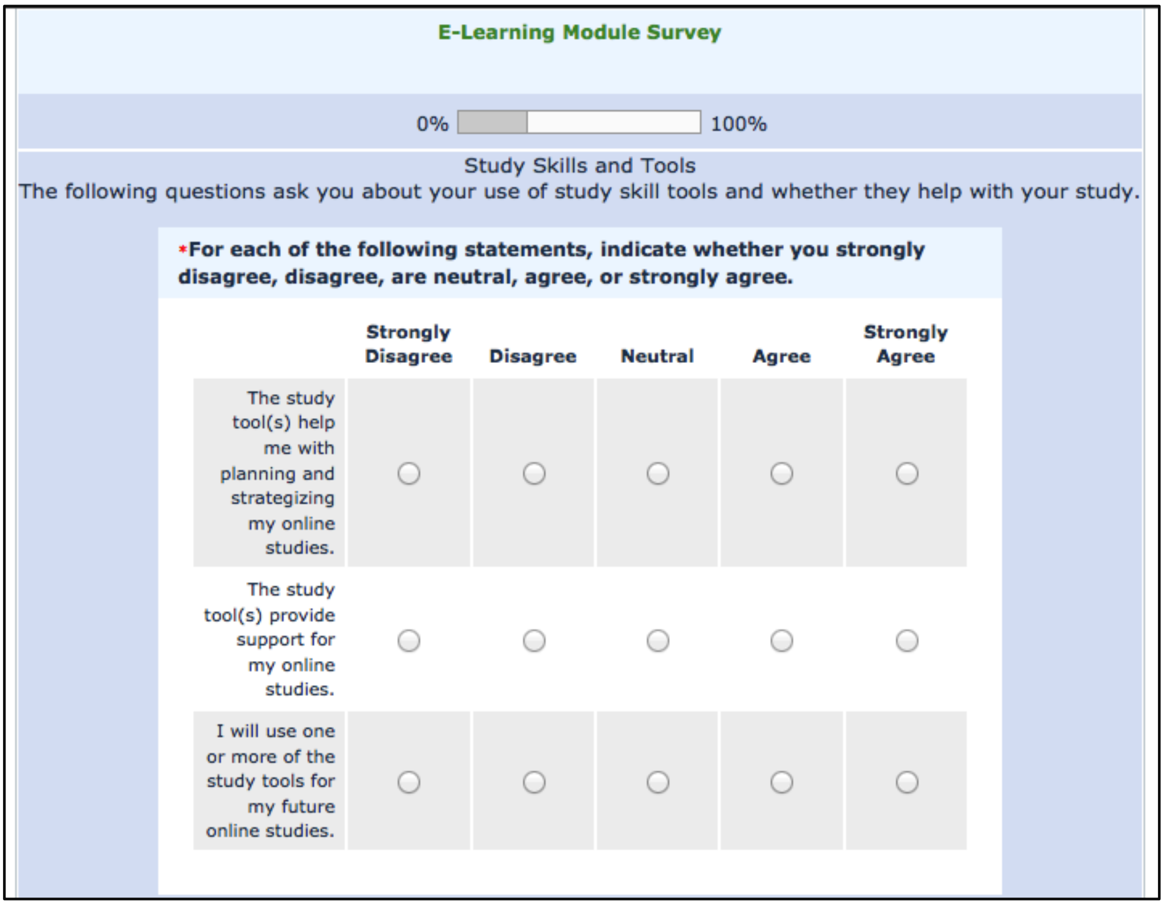

Figure 5.23: End-of-module survey question setup for Study Skills and Tools

5.4.5 Follow-up Interviews

It has been said that interviews are a “conversation with a purpose” (Khan & Cannell, 1957). For this research, interviews were used in conjunction with survey to deepen understanding of the learners’ attitudes and experiences, as well as to determine which aspect of this e-learning model needed restructuring and improvement. Six one-hour, semi-structured interviews were conducted over Skype 3-4 weeks after the end of the experiment. The interviews were conducted using voice call without the video component. Voice call was used without the video component as the audio quality tends to be better, and it works better to accommodate different connection speeds. Since the participants lived across Canada, Skype offered the most cost-effective and flexible method to accommodate the participants’ busy schedules. Participants were also offered to use telephone as an alternative method, but all six interviewing participants opted for using Skype as the means of communication. Calling a person on Skype is similar to using a speakerphone as both the interviewer and the interviewee’s voices are audible. The challenge of using Skype to conduct voice-only qualitative research interviews was that the interviewer was relying primarily on voice cues; therefore, it was critical to listen intently to build rapport (Cater, 2011).

In order to build rapport and establish a connection, the interviewer started with an icebreaker question asking either “how is the weather at your end?” or “how is your studying with Athabasca University coming along?” Following that, the participants were asked the list of questions related to the experiment (Appendix 9). Participants were asked the same set of questions in the same order, thus providing a logical order for the interviewer to follow that also helped reduce bias and variations.

The purpose of the interviews was to verify and extend information obtained from the survey, particularly in discovering more details about the learners’ attitudes and impression about the experiment. The interviews also gave learners a chance to elaborate on the survey results.

Questions were geared toward system usefulness, in both the theory-centric variation in domain level as well as the theory-centric variation in meta-cognitive activities, i.e., study skills. The interviews were recorded and transcribed. The interviewing questions were validated by an external user experience design professional in Edmonton, Canada. Her suggestions were to add "Why" in addition to "What" for question 3 and 4: "What are the things you like best about this module (and why)?" and "What are the things you like least about this module (and why)?" For question 9, the design professional recommended a slight changing in wording from "Has the overall learning experience been positive, neutral, or negative? Please explain" to "How was your overall learning experience as you used the tool? Please explain". For the recommendations for the questions by the UX professional, refer to Appendix 10.

5.5 Summary

This chapter described the experimental design and methodology used for the current study. Participants' profiles, the recruitment process, and the experimental procedure were covered in detail. This experiment demonstrated how a Learner-Directed Model could be designed and implemented in an online environment, particularly for learning introductory computer programming concepts. Qualitative and quantitative measurement matrixes were discussed at length. In the next chapter, a detailed reporting of the quantitative and qualitative results will be presented and analysed.

Chapter 6: Results

“It is a capital mistake to theorise before one has data.” –Arthur Conan Doyle

6.1 Introduction

Chapter 5 detailed the experimental design and method used for the current study; it explained the choice of methodology for this study, participants’ profiles, recruitment process, experimental procedure, and various measurement matrixes. One unit from an online course at Athabasca University, Canada, titled *Introduction to Java Programming* (COMP 268) has been redeveloped into two different formats. The two groups of the study samples (18 for the Experimental Group and 17 for the Control Group) have been subjected to data collection methods including data from a pre-test, post-test, log analysis, and a survey. Furthermore, follow-up interviews with six randomly selected participants were conducted to support the findings of the survey and to gain a more in-depth understanding of the learning experiences of the two groups. The results of these data collections and the related analysis will be reported in this chapter.

This chapter starts with the research hypothesis and questions in Section 6.2. Next, the presentation of the results is divided into two sections – quantitative findings and qualitative findings. Section 6.3 covers quantitative findings with the results for the pre-test/post test scores for domain knowledge and study skill usage, log file data, and the part of the survey that employs the Likert scale. Likert scale is a psychometric scale that uses questionnaires. The questions are formatted in which responses are scored along a range. Section 6.4 describes qualitative findings with the information gathered from the written statements part of the survey as well as the follow-up interview analysis and summary of the interview findings. Finally, the chapter concludes with a summary relating the findings to the learner control, and learner-directed learning experience.

6.2 Research Hypotheses and Questions

The hypotheses of this research are as follows:

1. Online computer systems that are designed based on learning style theories and educational theories are beneficial to learners
2. Online computer systems that employed unobtrusive learner support for meta-cognitive activities such as study skills are beneficial to learners
3. Online computer systems developed in the above ways could improve learning for students in terms of learner control, attitudes, and learner experience (LX)

Based on the above stated hypotheses, research questions were formulated. They are as follows:

1. Which learning style theory and education theory would be useful to develop an e-learning system?
2. How could an e-learning system be developed based on the learning style and education theories?
3. What is the effectiveness an e-learning system based on a model of learning style and education theories?
    a. What would the effect of such a system be on the performance of learners?
    b. What would be the attitudes and learner experience (LX) of learners using such a system?

The next two sections will aim to present the quantitative as well as qualitative findings and to find out whether they support or reject the hypotheses and answer the research questions I set out to answer.

6.3 Quantitative Findings

Participants for this research study were recruited from Athabasca University, and were enrolled in at least one of the undergraduate courses offered by the

University during the time of this research study. In order to participate in this study, they were also required to be in good academic standing (i.e. not on academic probation). There were a total of 35 students who volunteered for this research study (22 males, and 13 females), with age ranges from 19 to 49. It is worth pointing out that the original numbers of participants were significantly greater. It started with 54 students (Experimental Group N =26, Control Group N=28) and ended up with 35 students (Experimental Group N =18, Control Group N=17). This drop-out rate is consistent with the typical dropout rate for computer science courses at Athabasca. For COMP 268, the typical monthly drop-out rate could reach as high as 50%.

In this section, data collected in the experiment described in Chapter 5 are summarised in Table 6.1 and 6.2 for the Experimental and Control Groups respectively. To assess the hypotheses and the research questions stated above, statistical tests were performed on the data displaying in those tables. They contain descriptive statistics for each variable corresponding to Experimental Group (N=18) and Control Group (N=17). The tables present the arithmetic means and standard deviation. The dependent variables for both groups were:

- Pre-test score for domain knowledge
- Post-test score for domain knowledge
- Pre-test score for study skill usage
- Post-test score for study skill usage
- Survey score
- Total time spent in the module

The independent variable was the experimental condition.

Table 6.1: *Descriptive Statistics for the Experimental Group*			
	N	Mean	Standard Deviation
Pre-Test (domain knowledge)	18	15.7	2.7
Post-Test (domain knowledge)	18	15.8	2.7
Pre-Test (study skills)	18	33.9	12.9
Post-Test (study skills)	18	35.4	13.6
Time spent on study skills (minutes)	18	9.2	22.8
Time spent on domain (minutes)	18	428.9	907.1
Total time (minutes)	18	438.1	929.9

Table 6.2: *Descriptive Statistics for the Control Group*			
	N	Mean	Standard Deviation
Pre-Test (domain knowledge)	17	14	3.7
Post-Test (domain knowledge)	17	14.5	3.1
Pre-Test (study skills)	17	32.8	13.1
Post-Test (study skills)	17	36.8	3.4
Time spent on domain (minutes)	17	160	163.6

The null hypothesis employed in this research was that any difference in mean performances and attitudes between the experimental and control conditions was due to chance alone. In order to test this, an independent-sample t-test was conducted to compare domain knowledge pre-tests and post-tests, study skill usage pre-tests and post-tests and survey between the

Experimental Group and the Control Group. The results of this analysis are shown in table 6.3 below.

Table 6.3: *Independent Samples T-Test*				
	F	t	df	Sig*
Pre-test (domain knowledge)	1.57	1.54	33	0.13[2]
Post-test (domain knowledge)	0.17	1.30	33	0.10[1]
Pre-test (study skills)	0.07	0.27	33	0.79[2]
Post-test (study skills)	5.59	-0.39	33	0.35[1]
Total time spent	4.1	1.01	33	0.15[1]
Survey	0.40	2.32	33	0.02[1]
* [1] 1 tailed [2] 2 tailed				

The finding shows that there was no significant difference in performance between the Experimental Group and the Control Group over the course of this experiment ($p>0.05$). The possible reasons for this will be discussed in the final chapter of this thesis. The results of the analysis also show that there was no difference between the performance of the Experimental Group and the Control Group on pre-test and post-test for both domain knowledge and study skills ($p>0.05$). One tailed statistics was employed in post-test comparisons as it was predicted that the Experimental Group would perform better than the Control Group. This will also be discussed in the final chapter. The results of the comparison of the survey results between the Experimental and Control Group show a significant difference in their responses ($p<0.05$). The null hypothesis is therefore rejected and any differences in the means of attitude measurements are due to the effect of the experimental condition. The differences in attitude and learner experience between the experimental and control conditions will be discussed later in this chapter in section 6.4. There were no significant differences between the Experimental Group and the Control Group in terms of total time spent studying the domain material

($p>0.05$). This is interpreted that even given a flexible approach to learning where learners can skip learning material; they choose to spend a similar amount of time in studying the material.

6.3.1 Survey Results By Questions

The end-of-the-module survey has a total of 28 questions for the Control Group, with additional three questions for the Experimental Group with a total of 31 questions. The additional questions concern the use of the supplementary study skills and use of tools that were only available to the Experimental Group. It was made explicitly clear that participants are asked to express their beliefs and opinions about this module, and that their statements and opinions do not affect their grades in this module or any other courses they enrolled in at Athabasca University.

The survey was divided into seven sections as follow:

1. User demographic questions pertaining to their age, gender, and email
2. Study skills and tools questions (there are three questions in this part that concern the Experimental Group only)
3. Perceived ease of use and user satisfaction questions
4. System usability questions
5. Learning experience questions
6. Perceived controllability questions
7. Open-ended text field questions (qualitative feedback)

The user demographic questions were collected as a general data and presented in Table 6.4.

Table 6.4: *Demographic Information for the Experimental and Control Groups*

	Experimental Group	**Control Group**
Total number of participants	18	17
Age range	19-49	20-42
Mean age	29.8	27.6
Standard deviation	8.10	9.38
Gender	M=11, F=7	M=11, F=6

All data collected from the survey will be covered in this section, with the exception of item 7, the open-ended text field questions that will be described in Section 6.4.1.

For survey sections 2 – 6, participants were asked to rate each statement by selecting a number between 1 and 5. The numbers correspond to the following:
1 = Strongly Agree
2 = Agree
3 = Neutral
4 = Disagree
5 – Strongly Disagree

The results are presented below with the survey questions, mean scores for the Experimental and Control Groups, t-test results, and a brief explanation.

6.3.2 Study Skills and Tools Questions (Section 2)

This section of the survey questions concerns the use of study tools, whether the participants use them, and how helpful they are in relation to planning, strategizing, and supporting their online studies. Question was also asked about whether they plan on using study skills supported tools for future online studies.

Scale: Strongly Agree = 1, Agree = 2, Neutral = 3, Disagree = 4, Strongly Disagree = 5

The three questions from Section 2 are as follows:

1. **The study tool(s) help me with planning and strategizing my online studies.**
   Experimental Group mean score = 2.6
   Control Group mean score = 3.2
   ($p = 0.04$)

   The result for this question is significant ($p = 0.04$) and it supports this thesis' central theme – providing learning control and a positive learner experience. The use of study tools is useful in the planning and strategizing, and it corresponds to self-regulated learning theory wherein a learner has control over his/her own learning when he/she becomes self-regulated. A self-regulated learner is defined as being able to "plan, set goals, organise, self-monitor, and self-evaluate throughout their studies" (Zimmerman, 1990). The Experimental Group' responses indicates that the study tools help them to achieve their goals and becoming self-regulated learners more so than the Control Group.

2. **The study tool(s) provide support for my online studies.**
   Experimental Group mean score = 2.2
   Control Group mean score = 3.1
   ($p < 0.01$)

   The result for this question is significant ($p < 0.01$) and learners are said to have control over their learning experience when they can choose the amount of support (or no support) relevant to their needs (Morrison, Ross, & Baldwin, 1992). The response on this question suggests while it is useful to provide study tool support for learners, for the Experimental Group, it reflects the importance of having flexibility for the learners to choose when they need the support in order to promote a positive learner experience.

3. **I will use one or more of the study tools for my future online studies.**
   Experimental Group mean score = 2.3
   Control Group mean score = 3.2
   ($p = 0.01$)

   The result for this question is significant ($p = 0.01$) and it implies that students in the Experimental Group have a positive learner experience in using the study tools to the extent that they are likely to use one or more of these tools in their future online studies.

6.3.3 Perceived Ease of Use and User Satisfaction Questions (Section 3)

This section of the survey questions deals with perceived ease of use of the e-learning module and the user's satisfaction in terms of the material and the interaction design. Perceived ease of use and user satisfaction are arguably the fundamental determents of user acceptance toward information technology and online systems in general (Davis, 1989). On one hand, perceived usefulness is defined as "the degree to which a person believes that using a particular system would enhance his/her job performance" (Davis, 1989). In this case, I will reposition "job performance" to "online study performance and experience". Perceived ease of use, on the other hand, refers to "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989). Free of effort is connected to the issue of learner control (and ease of learning) as learners will presumably have a more positive experience when less effort is required, and are likely to have a better attitude toward their online learning and acceptance of the system.

Scale: Strongly Agree = 1, Agree = 2, Neutral = 3, Disagree = 4, Strongly Disagree = 5

1. **The module material was easy to access**
   Experimental Group mean score = 2.3
   Control Group mean score = 2.1
   (p = 0.22)

   The result for this question is not significant (p = 0.22) and it could suggest that both modules' navigation design and presentation of materials are equally usable. The reason for this could be that users are accustomed to both formats of information design on the web, and they are equally at ease with the two formats.

2. **I found it easy to do what I wanted to do**
   Experimental Group mean score = 2.2
   Control Group mean score = 2.5
   (p = 0.19)

   The result for this question is not significant (p = 0.19) and the possible reason for this could be that the presentation of material for both Control and Experimental Group – either in a linear way or a circular/non-sequential way did not have an effect on how easy it is for learners to do what they wanted to do. One possible explanation for this is that both modules are presented in Moodle, which is already a familiar LMS for online students at Athabasca University. It presented a limitation on the perceived ease of use for this question.

3. **My interaction with the module material was straightforward and clear**
   Experimental Group mean score = 2.5
   Control Group mean score = 2.3
   (p = 0.29)

The result for this question is not significant (p = 0.29), and again, this could be a matter of the learners being advanced users of the internet and are seasoned e-learning learners so the interaction with the material in both modules is considered straightforward and clear.

4. **I found the content flexible to interact with**
   Experimental Group mean score = 2.1
   Control Group mean score = 2.5
   (p = 0.06)

   The result for this question is approaching significance (p = 0.06) and this aligns with the essence of this thesis – using a flexible instructional design framework to provide an e-learning model for students so as to increase learner control. The fact that students in the Experimental Group found this model more flexible supports the usefulness of a Learner-Directed Model in terms of learner experience and attitudes.

5. **I found the module material useful for my study**
   Experimental Group mean score = 1.7
   Control Group mean score = 2.2
   (p = 0.02)

   The result for this question is significant (p = 0.02) and this suggests that even when both groups were presented with the same learning activities; the perception of the module accessed by the Experimental Group is rated as more useful. In addition, it could also mean that the availability of the key study skills and tools are also perceived as useful for the Experimental Group.

6. **The learning activities took longer to finish than I expected**
   Experimental Group mean score = 3.5
   Control Group mean score = 2.4

($p < 0.01$)

The result for this question is significant ($p < 0.01$), and it could be interpreted that the Experimental Group thought the learning activities were not more time consuming – even the material was presented in a circular (i.e. potentially perceived as more complex). This could imply that learners are indeed making use of the flexible design in the Experimental Group, so they pick and choose the learning activities as they see fit, thus not perceiving this way of learning as taking longer to finish.

7. **The learning activities were easy to complete**
   Experimental Group mean score = 2.0
   Control Group mean score = 2.7
   ($p = 0.02$)

   The result for this question is significant ($p = 0.02$). The Experimental Group perceived the learning activities being easier than the Control Group even though they both were presented the same learning activities. This suggests that the Learner-Directed Model indeed has an impact on the perceived ease of use to learners in the Experimental Group.

8. **I felt frustrated when trying to complete the learning activities**
   Experimental Group mean score = 3.8
   Control Group mean score = 3.2
   ($p = 0.13$)

   The result for this question is not significant ($p = 0.13$). This means the learners from both groups have similar levels of frustration (or lack of, in this instance, as the mean score leans toward neutral/disagree). The implication could be that both designs support learners in finding and accessing the appropriate learning material.

6.3.4 System Usability Questions (Section 4)

This section covers system usability related questions. System usability in an e-learning context refers to a range of things including screen layout; use of language, navigational system and structure; the aesthetic quality of the platform; and all the traits that promote user-friendliness (Koohang & du Plessis, 2004). All these aspects have to be designed to support learning, and be integrated into part of the instructional design process. The two broad areas that sum up usability in e-learning are “does it work well?” and “does it look great?” (Koohang & du Plessis, 2004). The following questions are framed in reference to these two areas. As stated before, it is established that usability is vital to user satisfaction and user acceptance of a system (Nielsen, 1993, 2000; Rosenbaum, 1989; Rubin, 1994); to extend this line of thinking, for online learning, user satisfaction and acceptance empower learners to take control of their learning.

Scale: Strongly Agree = 1, Agree = 2, Neutral = 3, Disagree = 4, Strongly Disagree = 5

1. **I had no problem understanding the language used to present the information**

   Experimental Group mean score = 1.6
   Control Group mean score = 1.8
   ($p = 0.18$)

   The result for this question is not significant ($p = 0.18$), and it could be that the language usage and style are fairly standard for both the Experimental and Control Group modules. Both groups’ modules were developed using the same content and wording aiming for an introductory level computer programming course.

2. **The material in every page was well-organised and structured**
   Experimental Group mean score = 2.0
   Control Group mean score = 2.6
   ($p = 0.05$)

   The result for this question is significant ($p = 0.05$), and this addressed the "does it look great?" aspect of system usability. This result supports this thesis' assumption that a Learner-Directed Model has a higher usability value of aesthetic and presentation design. The presence of these usability properties enhances learning and provides a positive learner experience (Alex Koohang & Jacques du Plessis, 2004).

3. **The material was relevant to my learning needs**
   Experimental Group mean score = 1.8
   Control Group mean score = 2.5
   ($p = 0.01$)

   The result for this question is significant ($p = 0.01$) and this addressed the "does it work well?" aspect of system usability. This result reinforces this thesis' assumption that a Learner-Directed Model has higher usability value for learner support.

4. **The material was concise and to the point**
   Experimental Group mean score = 1.9
   Control Group mean score = 2.6
   ($p = 0.01$)

   The result for this question is significant ($p = 0.01$). Again, this addressed the "does it work well?" question. Even though both modules cover the same learning material, the Experimental Group perceived the material as being considerably more efficient and effective.

5. **There was consistency of appearance, terms, words, and action throughout the module**
   Experimental Group mean score = 2.0
   Control Group mean score = 2.6
   ($p = 0.03$)

   The result for this question is significant ($p = 0.03$), and this answered both the "does it work well?" and "does it look great" usability questions. The Experimental Group's score indicated that they have a considerably better usability experience in interacting with the system.

6. **The links throughout the module were visible**
   Experimental Group mean score = 2.4
   Control Group mean score = 2.2
   ($p = 0.29$)

   The result for this question is not significant ($p = 0.29$), and it could mean that the links for both modules were similarly visible using different presentations. Athabasca University students have been accessing Moodle as the LMS for online learning for some time, so navigating around the system with different interface designs did not make much difference to them.

6.3.5 Learning Experience Questions (Section 5)

This section focuses on learning experience in relation to the content and instructional design. The design of instruction needs to incorporate challenges, rigour, moments for reflection as principles of good online course design (Smulders, 2003). The following questions aim to find out whether the design of the content created an optimal condition for students to engage in the learning process for both groups.

Scale: Strongly Agree = 1, Agree = 2, Neutral = 3, Disagree = 4, Strongly Disagree = 5

1. **The content allowed for deep reflection**
   Experimental Group mean score = 2.8
   Control Group mean score = 3.1
   ($p = 0.08$)

   The result for this question is approaching significance ($p = 0.08$). The Experimental Group regards the content to be more reflective. The availability of the study skills might have added the additional layer of meta-level thinking. It is also possible that the circular interface of the Learner-Directed Model encourages students to be more thoughtful in choosing their learning trajectories.

2. **The learning material made me stop and think**
   Experimental Group mean score = 2.7
   Control Group mean score = 2.9
   ($p = 0.23$)

   The result for this question is not significant ($p = 0.23$) and it could possibly be interpreted as both groups felt that the learning material presented a similar level of challenge in regardless of the interface design and presentation.

3. **The activities provided means for trial and error**
   Experimental Group mean score = 2.2
   Control Group mean score = 2.0
   ($p = 0.28$)

   The result for this question is not significant ($p = 0.28$). It is reasonable to presume that based on the domain of computer programming, students from both groups expected trial and error as an integral part of the content; thus, the scores are similar from both the Experimental and Control Groups.

4. **The information provided was open to interpretation, discussion, and feedback**
   Experimental Group mean score = 2.3
   Control Group mean score = 2.8
   (p = 0.07)

   The result for this question is approaching significance (p = 0.07). The adaptable interface of the Learner-Directed Model in the Experimental Group was viewed as being more supportive of information that was open to interpretation, discussion, and feedback. This confirms the idea behind the model design as being flexible and caters to different learner preferences.

6.3.6 Perceived Controllability Questions (Section 6)

This section addresses questions on perceived controllability. Control is an important aspect of online interactivity (Liu, 2003). A well-designed online course should allow learners to have control over information exchanged as well as their interaction with the material. The following questions were raised to gauge the level of perceived controllability between the two test groups.

Scale: Strongly Agree = 1, Agree = 2, Neutral = 3, Disagree = 4, Strongly Disagree = 5

1. **I felt that I had a lot of control over my learning in this module**
   Experimental Group mean score = 1.7
   Control Group mean score = 2.5
   (p = 0.01)

   The result for this question is significant (p = 0.01). Clearly, the

Experimental Group exhibited a higher degree of perceived control over their learning in this module. This aligns with the thesis' central theme of giving learner control in the design of a Learner-Directed Model.

2. **In this module, I could choose freely what I wanted to see**

   Experimental Group mean score = 1.4

   Control Group mean score = 2.2

   ($p = 0.01$)

   The result for this question is significant ($p = 0.01$). Again, the result indicated a higher degree of freedom being achieved by the Experimental Group. The flexible design of the interface of the module in the Experimental Group corresponded with the learners' perception.

3. **In this module, I had absolutely no control over what I could do**

   Experimental Group mean score = 4.4

   Control Group mean score = 4.3

   ($p = 0.38$)

   The result for this question is not significant ($p = 0.38$). This suggested that while the Experimental Group stated that they have higher control and more freedom in their learning (based on the two previous questions), both groups have achieved some levels of perceived controllability and that these two interaction designs are not at polar opposite when it comes to supporting learner control.

4. **I could determine for myself which learning activities suited me in this module**

   Experimental Group mean score = 1.4

   Control Group mean score = 2.5

   ($p < 0.01$)

The result for this question is significant ($p < 0.01$). Again, this confirms the learner directed model in support of learner control as the Experimental Group has a considerably higher rating on how they are able to determine to choose learning activities as they see fit.

6.3.7 Summary of Survey Results

Table 6.5 summarises the survey results concerning section 3-6 of the survey with the following topics: Ease of Use and Use Satisfaction; System Usability; Learning Experience; and Perceived Controllability. For a complete listing of survey questions, see Appendix 8.

Table 6.5: *Survey Results in Details*

	Group	Mean	Std. Deviation	Std. Error Mean
Ease of Use & User Satisfaction	Experimental	26.89	3.45	0.81
	Control	26.06	4.23	1.03
System Usability	Experimental	24.33	4.12	0.97
	Control	21.41	3.14	0.76
Learning Experience	Experimental	14.11	2.95	0.69
	Control	12.89	1.96	0.48
Perceived Controllability	Experimental	17.61	2.87	0.68
	Control	15.41	2.92	0.71

It is interesting to note that in all cases the mean of the Experimental Group was higher than the mean of the Control Group. In order to test the significance of these possible differences in the means, an independent t-test was performed. One-tailed statistics were used as it was hypothesised that the Experimental Group would have a higher rating than the Control Group. Table 6.6 below shows the results of the test performed on the data related to the four usability components.

Table 6.6: *Independent Samples T-Test for Survey Results*				
	F	T	Df	Sig (one-tailed)
Ease of Use & User Satisfaction	0.41	0.64	33	0.13
System Usability	1.38	2.35	33	0.005
Learning Experience	1.19	1.44	33	0.04
Perceived Controllability	0.02	2.25	33	0.01

Significant differences were found in the System Usability measure ($p<0.01$), Learning Experience ($p<0.05$) also for Perceived Controllability ($p=0.01$). These results indicate that in terms of these three usability measures, the increased ratings observed for the Experimental Group as compared to the Control Group were not due to chance alone, but to the influence of the independent variable, experimental condition. The result of the t-test comparing the means of the Experimental and Control Groups for Ease of Use and User Satisfaction was not significant, though it is fair to say that the difference, although small, was in the expected direction. Only 13% of the time would this result be expected to be due to chance alone. It is likely that the high quality of learning materials used in both Control and Experimental Groups may have produced a ceiling effect, both groups having similar levels of satisfaction.

6.4 Qualitative Findings

6.4.1 Analysis of Survey's Open Questions

To collect more elaborated feedback on learner experience, two open-ended questions were included in the survey at the end (Appendix 8). The two questions were:

1. What do you think the best feature of this module was, and why?
2. What feature of this module did you think should be improved, and why?

The two questions are optional, and there are no word limits as to how much a participant is willing to input into the text field. Below is the summary of responses from the two questions from the Experimental Group and the Control Groups respectively:

1. **What do you think the best feature of the module was, and why?**

Experimental Group comment highlights

Overall, the Experimental Group responded unanimously (18 out of 18) with the sentiment that they like the ability to choose the learning tools and methods the best. They have very positive attitudes and satisfaction with the interaction with the model. Below is a selected listing of the statements participants wrote:

Student ID #5

"Personally, I like the "Trying out" feature simply because I learn by doing mostly. It was good to read the concept theory first and then quickly try it out."

Student ID #11

"I really liked being able to choose activities that cater to my style of learning. I don't really respond very well to reading pages of text, so I spent more time reviewing videos that covered the same material. I thought it was really good to have the option... most courses that I've taken don't really give me that kind of flexibility, and it leaves me trying to fend for myself and search online for my own external resources."

Student ID #12

"I liked how you could choose what you wanted to do for this module. I have taken quite a few University courses and the structure of most of them is to read material, go to lectures, and complete assignments. I am used to being able to read at my own pace, and I learn best while being able to try things out. I don't learn from lectures much at all. While I have been using the internet for almost 15 years, and am quite familiar with discussion boards and videos, I'm much too impatient to wait for other people to respond to a post I made, or wait and watch a video. This is just me personally, and I am sure that many students would prefer the video learning. I'd rather just read the bits that I need to focus on, and skim the bits that I already know about. This may not be a good study skill; perhaps I should be revising and reinforcing the parts that I already know... but from my almost 7 years as a University student I have learned that sometimes there are just not enough hours in the day :) This study was not lengthy by any means, but old habits die hard. So, to make a long story short, I really liked the fact that there were a number of different learning options - text based and "try it out" learning, for those of us who prefer a more traditional type of learning, and video and discussion learning which may appeal to others."

Student ID #16

"I liked being able to choose several different learning methods. I found the video component very useful."

Student ID #17

"I like the choices of various learning activities, so if I didn't understand a topic I could use an alternative view of the topic."

Control Group's comment highlights

Overall, the Control Group tended to focus their responses on the content, in particular, on the video features. It is possible that since the presentation is in a linear style, a style that they are familiar with; the students' focus was placed on the content instead. Below are some highlights of the responses:

Student ID #5

> "The videos because they provided the benefits of human interaction along with the advantages of an electronic medium. You had someone explaining to you what things meant and if you didn't understand something, you could go back and listen to it again."

Student ID #10

> "Having the YouTube videos embedded in the module was a great addition and really helped understanding the content."

Student ID #13

> "I enjoyed the videos mixed in with the text, it made a lot of things much clearer. The videos with 'spoken' instructions appealed to me more than the ones where the explanations were typed on the screen."

Student ID #22

> "Providing video tutorials for different concepts helped the most because it made things easier to understand since you see someone else doing it and explaining it throughout the process. The videos were essential to the material."

2. **What feature of this module do you think should be Improved, and why?**

Experimental Group's comment highlights

The responses from the Experimental Group tended to split between improvement on content and improvement of navigation. A lot of suggestions were made about the interface and instructional design of the module. It is possible that by providing an alternative interface, it heightened the students' sense of awareness on various ways instructional material can be designed and presented.

Student ID #5 commented on the navigational feature:

> "It was good overall. Only minor thing I would have like is to NOT have all the different sections opening in new windows constantly, there is a lot of changing screens, it would be nice if the navigation was on the left column (with all the sections clearly selectable) and have only one part of the screen changing."

Student ID #7 made recommendations on the interface design:

> "There isn't anything particular that I think can be improved in this module. The features are excellent and I can honestly say this module is top-tier when it comes to online studying. Perhaps on the CSE front page, right under discussion forum you can add links to the key study skills. The little red button at the top right corner of Learning Activities doesn't do it enough justice. I found it negligible to even check out until it was mentioned in this survey. It's really too good to not just put out there on the front page"

Student ID #17 suggested improvement on the content:

> "I think the Read This First and the Conceptualizing learning activity could use more examples, with clear explanation, line by line, of what a code do. I also think the videos could use more examples, I think the videos are good but they are too direct to the point, examples would be useful too."

Control Group's comment highlights

The responses from the Control Group tended to split between suggested improvement on the content and recommendations for the course design/instructional design. No navigational feature improvement was mentioned. Below are some of the statements selected from the responses:

Student ID #5 commented about the content and the instructional design:

> “I may have missed something but it seems some material, like the return statement for methods wasn't covered in the text or videos. It would have helped me learn better to have had full coverage of all the material, even if that coverage was redundant. In fact, redundant coverage in different mediums (for example text and videos) would allow the module to cater to a wider variety of learning styles.”

Student ID #12 also mentioned the layout design and content:

> “Sometimes there's just too much information on a page and it gets crowded. Not too much quality, but too much quantity. Though, the presence of diagrams and videos helped.”

Student ID #21 talked about optional content:

> “The videos should all be marked as optional, the text is sufficient.”

For complete responses from the survey results on the open text questions, refer to Appendix 11.

6.4.2 Summary of Survey’s Open Questions Findings

The aim of the open-ended questions part of the survey is to provide opportunities for participants to express in detail about what they like best about the module and to solicit feedback on areas to improve for the module. Their responses also provide insights on the differences between the Experimental Group’s learning experience and the Control Group’s learning experience.

Based on the above responses to the open-ended survey text questions, I venture to summarise the following:

- In general, the Experimental Group appeared to enjoy the learning options and tools provided in the module. All responses made reference to the learning options and tools in some ways.

- In general, the Control Group enjoyed the video feature the most. A number of responses made references to the video section of the module and commented on the usefulness of such learning activity

- The Experimental Group seems to be more aware of the different learning options available to them as opposed to the Control Group. The Experimental Group also commented more on different types of learning activities and how they preferred different styles of learning – videos, text, graphic, discussion forum, hands-on activities, etc. On the contrary, the Control Group emphasised the video part of the material the most.

- The Experimental Group offers suggestions on a number of things including interface design, instructional design, content, navigation, etc. One explanation is that perhaps by offering an alternative style of learning design, it encouraged the students' thinking on different possibilities of learning design and approaches to learning.

- The Control Group offered more insights on the content itself. Interestingly, one participant commented that he/she wishes to have the material redundantly covered in different medium such as text and videos as it would allow the module to cater to a wider variety of learning styles.

6.4.3 Analysis of Interviews

As mentioned in Chapter 5, interviews have been conducted mainly to gather more in-depth feedback to support the data obtained by the end-of-unit survey (Appendix 9 provides a list of interview questions; Appendix 12 contains full interview transcripts). Six students (three from the experimental group and three from the control group) have been interviewed for this purpose. The interviews were conducted over Skype as the interviewees are geographically dispersed, and they had consented to a web-based interview. As per interviewees' requests, none of the interviews were recorded. Careful notes have been taken in regards to the interviewees' responses and had sought clarifications when the responses were unclear in order to minimise misunderstanding and mis-transcription. The entire interview process took about an hour per session and participants were given $40 CAD as a thank you token and were offered to share the outcome of this research study when finalised.

Following are the responses of the interviewees to the questions:

1. **What was your initial impression of the module in terms of layout of the learning material, and what do you think of the navigational structure, color, graphic, etc.?**
   All six interviewees like the home page layout and thought that it is easy to use. The Control Group interviewees all find the module easy to navigate and the structure easy to follow. Two of the Experimental Group interviewees mentioned that initially it took them a little bit to get used to the interface, but once they understood it, they really enjoyed having the options of a different style of learning and the circular interface. One Experimental Group interviewee mentioned the fact that there is a "flow" to the interface, and the other said it is "less rigid" and that she can skip around. One commented: "I wish the rest of my courses were all designed like this one".

2. **Where did you spend most of your time?**
   All six interviewees spent time in different areas. From the Control Group, one learner said his time was evenly distributed among all the learning material; one reviewed the video section the most and it is the easiest way for him to learn programming, and he also looked at the external resources

the module is referring to. Another learner said he spent a lot of time reading the material in general.

For the Experimental Group, one interviewee said she preferred reading but also trying out some of the examples; the second one said she gravitated toward the videos and the last one said that he spent most of the time on the “trying out” and “watching” sections although he sees all the learning modes represents four different types of learning and “felt that it was necessary to go through all of them”. He mentioned that being able to focus on just one or two sections of the module help people who already have some work experience in programming and can focus on just the topic areas that are not familiar to them.

3. **Did you use any of the key study skills and the related tools?**
   This question only pertains to the Experimental Group, so only the three interviewees from that group responded to this question. One responded that she used the concept maps and the IDE as they are useful to her. Another found the discussion forum very helpful as it is open and this layout appeals to people with different learning preferences. He mentioned that this module definitely has more variety than your average e-learning course and that he is very happy to have all those features provided. The last person stated that she has already used OneNote in her online study but she did review all the study skills and thought that they are useful for beginners. She said that she has been taking online courses for some time now and has a routine established already. In general, she found the discussion forum features useful and that she is definitely satisfied with the tool provided to support it.

4. **What are the things you like best about this module?**
   For the Control Group, two responded that they like the video component the best, while one stated that he likes the clear writing and presentation of

the module. For the Experimental Group, all of them like the fact that there are options on which activities to study and the freedom to pick and skip activities. They commented that they feel the system really caters to different people and that they have the option to explore more in-depth if they want. One said “I wish my other courses had more activities to try things out like this module. It is really awesome to be able to try things out!”

5. **What are the things you like least about this module?**
   The Control Group wishes to have more references and examples and to have more explanation on how to set up a programming environment. In addition, one person expressed the need to have an embedded compiler. No references were made about the structure or the presentation of material in the module. For the Experimental Group, two people responded by saying there is nothing they don’t like about this module. One person suggested that the navigation could be tidied up a bit so as to minimise the amount of clicking.

6. **What features would you most like to see added to this module?**
   The responses from the Control Group centred on issues relating to the need for more explanation, graphics and activities to try out. There is also a comment about having some way to have real time conversation or a discussion forum available. Again, the input is largely on content, not much is said about the interaction or the interface. As for the Experimental Group, the interviewees’ comments tend to gear toward the interface/interaction. They suggested that there is a checkbox to check off your progress, and that this would help with motivation. One interviewee proposed a different interface, to have the key study skill button integrated as part of the learning circle, thus make it more obvious to the learners. As far as content is concerned, it was recommended that a “challenge yourself” section be added as additional activities to raise the level of difficulties and to motivate learners. Another interviewee wishes that the

videos/audios would feature our own tutors. She emphasised the need to have a human presence.

7. **Have you encountered any practical challenges e.g. difficulties with features of the tool(s) you are using/any other technical difficulties?**
   None of the interviewees from both groups encountered any technical difficulties using the module. Some suggestions were made in terms of improving on the navigability and usability of the module, such as the size of the pop-up windows, which could be defaulted to a larger size.

8. **Have you encountered any other difficulties with navigating the module?**
   All responses were positive and none had any difficulties with navigating the module. From one of the interviewees from the Experimental Group, he stated "the navigation is the simplest module I have ever encountered". Another said that this design gave her more opportunities to be exposed to different ways of learning. She felt that this type of exposure is very useful in learning computer programming.

9. **Has the overall learning experience been positive, neutral or negative? Please explain.**
   All interviewees recalled their overall learning experience as being positive. One participant from the Experimental Group said that she feels more in control of her learning.

10. **What are the challenges in online learning in general for studying computer science?**
    Interviewees feel that it is hard to try to figure out the abstract concepts on your own and to be able to motivate yourself. Interviewees from the Control Group said that learning computer programming is about learning by example, then to be able to apply the examples and try them out. Online materials need to be more non-linear and with more flexibility.

Having a connection with your tutor and your peers are also mentioned to be an important factor. From the Experimental Group, the interviewees told us that it would be useful for e-learning course design to change to a more personal learning style that give learner control. One person mentioned that it would be good for students to understand that they have a learning preference and that they all learn differently. Another interviewee felt that setting small, separate deadlines for each of the mini-tasks would help her with motivation. Finally, the third interviewee said that a lot of computer science courses assumed some prior knowledge and not all students are familiar with the subject specific terminologies and procedure. It would be best to aim the material to all levels to cater to the differences in prior knowledge.

6.4.4 Summary of Interview Findings

The aim of the interviews for the purpose of this research is to support the results of the survey and give participants a chance to elaborate their survey answers. It is an opportunity to learn more about the participants' attitudes and impressions of the modules, and to gain further insights on the differences between the Control Group's and the Experimental Group's learner experience.

The results of the interviews have supported the survey data in which it indicated that there was a difference in perceived controllability and system usability between the Control Group and the Experimental Group. The interviews provided more details on the differences and also some of the similarities between the learner experiences of using the two modules.

The overall findings of the interviews can be summarised as the following:

- The interview findings indicated that the Experimental Group had to deal with an initial learning curve of adapting to the new interface; however, once they were familiar with it, they thought it helped with the flow of the learning material and provided flexibility.

- It appeared that the Experimental Group learners were able to make use of the various learning modes and study skills. The interface seemed to encourage exploration and non-linear thinking.

- The interface design for the Experimental Group seemed to promote thinking in learning styles and preferences. It also appeared to stimulate thinking in terms of how computer programming for online learning can be presented/designed differently. More comments about how to improve the interface design stemmed from the Experimental Group rather than the Control Group.

- It was evident that the Experimental Group used more constructive and positive descriptive terms when describing their learning experience. For examples, terms such as “feeling in control”, “enjoy the flexibility”, “freedom to pick or skip”, “give me an opportunity to use different ways of learning”, “it has a flow”, etc. all pointed to a stronger sense of learner satisfaction and learning experience.

- The Control Group provided more comments on how to improve or present the content differently while the Experimental Group addressed both the content and the interaction design issues. It suggested that by presenting a different/unusual interface for e-learning, it prompted students to think beyond what the possibilities are for improving their online learning experience.

- The interview findings highlighted a number of challenges and issues in learning computer programming (and computer sciences at large) in an online environment. It validated the idea that learning computer programming requires a “radical novelty” learning design approach (Dijkstra, 1988). It is also suggested that learners have different prior knowledge so it is best to aim the learning material to the basic level while providing options for more advanced learners to skip around to the sections where they need to spend more time.

In conclusion, the findings of the interviews conveyed that the Experimental Group had an overall more positive and constructive learner experience as opposed to the Control Group. They paid attention to both the content and the interaction design, and in general felt in control and satisfied with their learning. This finding is in support of the results from the end-of-module survey.

6.5 Summary

This chapter began with the research hypotheses for this thesis, and once again, they are:

1. Online computer systems that are designed based on learning style theories and educational theories are beneficial to learners
2. Online computer systems that employed unobtrusive learner support for meta-cognitive activities such as study skills are beneficial to learners
3. Online computer systems developed in the above ways could improve learning for students in terms of learner control, attitudes, and learner experience (LX)

Based on the above hypotheses, Section 6.3 and 6.4 presented the results of the data in two broad sections: quantitative findings and qualitative findings in order to find out whether they support or reject the hypotheses. In section 6.3, it stated the quantitative findings with the results for the pre-test/post test scores for domain knowledge and study skill usage, log file data, and the survey results by questions. Section 6.4 described qualitative findings with the information gathered from the written statements part of the survey as well as the follow-up interview analysis and summary of interview findings.

All in all, the experiment was able to show that there was significance in total time spent studying the domain material. The Experimental Group spent longer time on the material than the Control Group ($p<0.01$). However, there was no significant difference in performance between the Experimental Group and the Control Group over the course of this experiment ($p>0.05$). The results of the analysis also show that there was no difference between the performance of the Experimental Group and the Control Group on pre-test and post-test for both domain knowledge and study skills ($p>0.05$). For the survey, the comparison results between the Experimental and Control Group show a significant difference in their responses to attitude questions ($p<0.05$). In all cases for the survey results, the mean scores for the Experimental Group were higher than the Control Group. Significant differences were found for the System Usability measure ($p<0.01$), Learning Experience ($p<0.05$) also for Perceived Controllability ($p=0.01$).

The next and final chapter will interpret and discuss the above results, provide possible explanations and implications, along with recommendations, and direction for future research.

Chapter 7: Discussions, Conclusions, and Recommendations

"If you want a happy ending that depends, of course, on where you stop your story." – Orson Welles

7.1 Introduction

In the space of the past decade, e-learning has gone from being a supplementary form of learning to an increasingly staple part of higher education and industry training. Nowadays, learners are free to enroll in a Massive Open Online Course (MOOC) with diverse topics ranging from The Science of Gastronomy to Jazz Improvisation. The growth of portable digital devices, from tablets, smart phones, touch screen mini-laptops to e-readers further solidify the ubiquitous learn-as-you-see-fit mentality. Yet, the demand for personalised learning is not adequately supported by current technology or practices (Johnson et al., 2013). As students' tastes for online pedagogy become more sophisticated, they will increasingly demand learning that provides learner-directed choices and control. As the e-learning service provider sphere becomes more competitive, competition will drive the change on a more customised education model that cater to each student's unique learning needs. One-size-fits-all e-learning has declined in popularity – it was a solid base to start just as Web 1.0 had its place in popularizing information dissemination electronically in a networked environment. Now, that method is less effective, and in some ways, it is irrelevant to the changing demographics of fragmented global learners. Just as the travellers can opt to drive to their destination instead of journey by train; as self-directed, autonomous adult learners, they need the options to negotiate modes that best support each individual's learning needs, be it the amount of content, the types of learning activities, or the form of devices used to access the material. Granted, the level of control a learner (or a traveller for that matter) has depends on how much she is willing to trade off between having to make independent decisions at a granular level in one end of the spectrum (thus having a greater control) and allowing the system to take care of the bulk of the decision-making process (thus having less control) on the other end. It is a hypothesis of this thesis that having an optimal level of learner control is essential in creating a positive learner-directed learning experience.

The inspirations and motivations for this research are manifold. It primarily came from the desire to support learners in a more holistic and constructive way of learning; in particular, I want to support learners to assume active control and take responsibility for their own learning. It is my desire to be able to meet the expectation of the millennial and adult learners who demand more from e-learning, especially in the age of e-learning 2.0 (Downes, 2005), and to create a positive online learning experience. As an extension of that, I aim to augment the learning of computer programming in a way that would motivate and engage learners, so as to counter the high attrition rate in this domain, especially in an asynchronous online environment.

To create a positive learner-directed learning experience and provide optimal levels of learner control, I developed an alternative approach to learning computer programming online called a Learner-Directed Model for this research study. This model is grounded in the integration of two established education theories that are learner-centric. The two theories are Experiential Learning Theory (ELT) and a modified version of Self-Regulated Learning (SRL) Theory, which I called Self-Directed Regulated Learning (SDRL). ELT was used as a guideline for the domain-knowledge content with the four learning modes. SDRL was used as a guideline for the meta-knowledge (i.e. study skills) content that was integrated and contextualised into the four learning modes. This model caters to learner control with the consideration of freedoms of pace, content and media, and it includes domain knowledge learning activities as well as meta-cognitive skills' interface.

An ex-post facto experiment was then set up with 35 voluntary participants (N=35) randomly assigned to either one of the two e-learning module with identical subject content but different learning design models: a Learner-Directed Model (Experimental Group), and a linear model (Control Group). One unit of learning material from *Introduction to Java Programming* (COMP 268) was redeveloped for this experiment. Learner-directed model-based design content with meta-cognitive learning support in the form of study skills was being presented to an Experimental Group of 18, while static and linear content without meta-cognitive learning support was being presented to a Control Group of 17. The experiment was carried out over a period of six months at Athabasca University, Canada's Open University. Participants went through pre and post tests, accessed and interacted with learning materials and tools, and finished the experiment with an end-of-the-module survey. Participants' pre and post test scores, activities, and survey results within the e-learning module were traced and recorded for the duration of their interaction with the system. Six participants were selected randomly from the two groups (three from each group) for the follow-up semi-structured interviews to collect qualitative feedback about the study.

Five data collection instruments were used to measure the performance and experiences for both the Experimental and the Control Groups. The instruments are: log file data collection, pre-test score, post-test score, survey, and follow-up interviews. The findings – both quantitative and qualitative are presented and discussed in Chapter 6.

This chapter, as the final chapter, will provide a summary of the research by presenting the results, drawing conclusions in light of the results, and making recommendations for further research. The results of the experiment will be summarised in Section 7.2. Section 7.3 will discuss the results in connection with the research questions posted in Chapter 1. Section 7.4 will recount the contributions while Section 7.5 will state the limitations of this research. Section 7.6 will make recommendations to further refine the current model. Finally Section 7.7 will conclude by providing directions for future research and areas of exploration.

7.2 Summary of Results

This research sets out to design, develop, and evaluate an e-learning system that delivers learning based on sound learning style and educational theories within the domain of computer programming. To translate that into actionable objectives, I have achieved the following:

1. Established the requirement of such an e-learning system
2. Investigated learning styles and education theories that were useful as a design framework to create a Learner-Directed Model
3. Developed the application and tested it on target learners
4. Analysed the learners' performance and experience of using such an application

Based on the research aim and objectives, I formulated the following hypotheses:

1. E-learning systems that are designed based on learning style theories and educational theories are beneficial to learners
2. E-learning systems that employed unobtrusive learner support for meta-cognitive activities such as study skills are beneficial to learners
3. E-learning systems developed in the above ways could improve learning for students in terms of learner control, attitudes, and learner experience (LX)

The hypotheses led to the development of the following research questions:

1. Which learning style theory and education theory would be useful to develop an e-learning system?
2. How could an e-learning system be developed based on the learning style and education theories?

3. What is the effectiveness an e-learning system based on a model of learning style and education theories?
    a. What would the effect of such a system be on the performance of learners?
    b. What would be the attitudes and learner experience (LX) of learners to be using such a system?

To investigate the above research questions, learning style and education theories were reviewed and examined. Two theories, one from learning style theory family, and one from education theory family stood out. The two theories are Experiential Learning Theory (ELT) and Self-Regulated Learning (SRL) Theory. ELT belongs to the class of “flexibly stable learning preference” theories where learning preference is seemed not as a fixed trait; rather, it is a differential preference that changes from situation to situation. ELT states that effective learners need four types of abilities to learn: concrete experience (CE); reflective observation (RO); abstract conceptualizations (AC); and active experimentations (AE) (Kolb, 1984). Learning is seen as a continued process of moving from one stage to another in a cycle - experience is translated through reflection into concepts, which are in turn used as guides for active experimentation and the choice of new experience. This is a flexible and learner-centred theory as it allows learners to choose the learning as they see fit and they can start anywhere in the cycle. It is also a constructive theory as knowledge is constructed through the creative tension among the four modes and learners will be exposed to all aspects of learning.

SRL theory emphasises learner autonomy and control while it supports learners to be more aware of their own thinking, monitoring, planning, evaluating personal progress against a standard, and motivating them to learn (Boekaerts & Corno, 2005; Butler & Winne, 1995; Perry, 2006; Winne & Perry, 2000; Zimmerman, 1990). SRL theory states that learners not only need to regulate their performance, but also how they learn. Self-regulated learners are able to use self-regulated strategies, responsive to feedback, motivated to see new and different ways to learn, initiate opportunities for feedback, and refine strategies that can set higher goals. My interest is on Learner-Directed Learning (LDL) - the difference is that self-regulation requires an explicit impetus that guides or informs one to modify and evaluate one's own cognitive or meta-cognitive study habit while learner-direction requires an implicit impetus. Meaning, one doesn't have to externalise the reasoning behind a particular study habit. As a result, I choose to modify SRL theory into what I called a Self-Directed Regulated Learning (SDRL) theory. What sets SDRL apart is that it does not track the end results of any meta-cognitive learning activities and tools usage; instead, it focuses on the provision of the activities and tools embedded as options for students to assist them in becoming better self-regulated, self-reflected learners.

To implement an e-learning system that is developed based on the learning style and education theories stated above, content from one unit of *Introduction to Java Programming* (COMP 268) from Athabasca University, Canada, was redesigned. This e-learning system uses a newly defined model called a Learner-Directed Model. This model integrates both theories to create a holistic e-learning system that caters to optimal learner control and experience. ELT was used as a design guideline for the domain-knowledge content with the four learning modes. Similarly, SDRL was used for the meta-knowledge (i.e. study skills) content that was integrated and contextualised into the four learning modes.

A mixed method with ex post facto experimental design approach was used to collect quantitative data. It involved the assignment of one learning module in Moodle to Experimental Group and Control Group, and subjecting the Experimental Group to the experimental treatment (the alternate module). Pre and post test scores, log files, and the survey results were collected as part of the quantitative data. The open-ended questions part of the survey and follow-up interviews were collected as part of the qualitative data. Thirty-five volunteers participated in this study (N=35), with 18 students being randomly assigned to the Experimental Group and 17 to the Control Group. The study ran for a period of six months.

Five data collection instruments have been used for this research study:

- Pre-test/Post-test– pre-test and post-test have been conducted to measure whether the two groups were initially the same in terms of their prior subject –level knowledge and meta-level knowledge.

- Log file data – log file data has been collected to track the time spent on domain area activities and the study skill activities within the Moodle website for both groups.

- Survey – at the end of the module, a survey was provided to measure learners' attitudes toward study skills and tools provided in the module, their perceived ease of use and satisfaction, system usability, learner experience, and perceived controllability. Questions on how the learners used the study skill tools as well as open-ended text questions were also included in the survey.

- Follow-up interviews – semi-structured interviews with six (three from Control Group and three from Experimental Group) randomly selected participants were conducted. The purpose of the interviews was to verify and extend information obtained from the survey, particularly in discovering more details about the learners' attitudes and impression about the experiment. The interviews also gave learners a chance to elaborate on the survey results.

Two types of data were collected from the above instruments. Quantitative data were gathered from the results for the pre-test/post test scores for domain knowledge and study skill usage, log file data, and the part of the survey that employs the Likert scale. Qualitative data were harvested from the written statements part of the survey as well as the follow-up interview analysis and summary of interview findings.

The first set of data came from the comparison of the quantitative survey data between the Experimental Group and the Control Group. The results show a significant difference in their responses in sum ($p<0.05$). The effects of the Learner-Directed Model are largely on a practical level, as the model is applied to provide a positive attitude and learner experience for learning computer programming. For example, the set of survey questions concern the use of study tools, the Experimental Group has considerably more positive learning experience and attitudes toward the study tools and support than the Control Group. The results for the question “The study tool(s) help me with planning and strategizing my online studies”; “The study tool(s) provide support for my online studies; and “I will use one or more of the study tools for my future online studies” all return significant results ($p = 0.04$; $p < 0.01$; $p =0.01$ respectively). Learners from the Experimental Group stressed the importance of study skill tools and meta-cognitive material in relation to strategizing, planning, and supporting their online learning. When asked whether they will use these study tools in the future, learners responded affirmatively and it implied that they have had a positive learner experience with the study tools and the meta-cognitive resources provided. Positive learner experience encapsulates a sense of empowerment. As participants repeatedly articulated from the survey open-text answers and the interviews that the best feature of the Learner-Directed Model is their control over the learning tools and methods – they can choose learning that caters to their learning preferences with regards to pace, content, and media. It echoed the research by Morrison, Ross, & Baldwin (1992) where they stated that learners are said to have control over their learning experience when they can choose the amount of support (or no support) relevant to their needs. By adapting and modifying Experiential Learning theory and the four stages of learning in a cyclical format, the Learner-Directed Model makes it possible to provide an optimal level of learner control.

Through the provision of the meta-cognitive support material and study skill tools, the Learner-Directed Model encourages learners to plan, strategise, self-organise and reflect on their own learning progress. These are the qualities of self-regulated learners. Self-Regulated Learning theory explained that a learner has control over his/her own learning when he/she becomes self-regulated. A self-regulated learner is defined as being able to “plan, set goals, organise, self-monitor, and self-evaluate throughout their studies” (Zimmerman, 1990). In this sense, the Learner-Directed Model taught students how to self-regulate.

From a perceived ease-of-use and user satisfaction point of view, the Learner-Directed Model presented a useful e-learning system that is satisfying to use. For example, the responses to “I found the module material useful for my study” and “The learning activities were easy to complete” are both significant (both $p = 0.02$). The Experimental Group reported a higher level of satisfaction and perceived ease of use than the Control Group even though the learning materials presented to both groups have the same content. The survey results also corresponded with the follow-up interviews and the open-text comments from the survey for the Experimental Group. For example, student ID #15 stated: “The use of four parallel flows in each section is good -- it is easy to assimilate quickly and provides a meaningful level of organization.” Student ID #25 also said: “Simple examples of all the key concepts, examples show people how to actually use something!”

The important dimension here is that both user satisfaction and perceived ease of use lead to user acceptance of an online system (Davis, 1989). Users’ acceptance of the e-learning system reduces barriers to learning and shifted the usability effort from the students to the system. In my model, the design principles for both the user experience (UX) and learner experience (LX) have been integrated – on learners’ perceptions, responses, and attitudes that emerges from interacting with a learning system.

In terms of system usability, the two umbrella questions that sum up usability in e-learning are “does it work well?” and “does it look great?” (Koohang & du Plessis, 2004). In particular, the questions “The material in every page was well-organised and structured”; “The material was relevant to my learning needs”; “The material was concise and to the point”; and “There was consistency of appearance, terms, words, and action throughout the module” all return significant results ($p = 0.05$; $p = 0.01$; $p = 0.01$; $p = 0.03$ respectively). The Experimental Group commented that the Learner-Directed Model is well organised and presented; it feels approachable, enticing and aesthetically pleasing with consistent information design format. In sum, it does look great. Furthermore, participants also expressed its usefulness and how efficient and effective the way the model works – with an interface that they can access quickly with a logical flow to the learning activities. In the survey open text answers, the Experimental Group made the following usability related comments:

> “The pie chart for the learning activities is really good. It presents 4 possible ways of learning the material, which is really helpful for a wide variety of students who have different learning styles.” (Student ID #7)

> “The use of four parallel flows in each section is good -- it is easy to assimilate quickly and provides a meaningful level of organization.” (Student ID #15)

> “The Module is properly broken into different sections and topics. The flow of module maintain the interest.” (Student ID #21)

The follow-up interviews with the Experimental Group also mentioned the usability aspect of the model. One student expressed that the Learner-Directed Model is laid out simply and efficiently. He knew instantly where to go and what to do within the first minute. He also likes that the design has a flow so he doesn't have to switch between tabs or anything. Another interviewee mentioned that she wishes all her online courses are designed like this one – with the Learner-Directed Model layout and presentation.

The overall learner experience and perceived controllability of the model also have better survey scores for the Experimental Group than the Control Group. For both questions on learning experience: "The content allowed for deep reflection" and "The information provided was open to interpretation, discussion, and feedback", the results are approaching significant ($p = 0.08$; $p = 0.07$ respectively). Of the three questions on perceived controllability: "I felt that I had a lot of control over my learning in this module"; "In this module, I could choose freely what I wanted to see"; and "I could determine for myself which learning activities suited me in this module", the results are significant ($p = 0.01$; $p = 0.01$; $p < 0.01$ respectively). The flexible design of the Learner-Directed Model corresponded positively with the Experimental Group's perception on learner control and experience. The survey open text responses also indicated that the Learner-Directed Model caters to learner control. The following are some examples of responses from the survey:

> "All of the different learning options was the best feature of the module. Everyone learns differently, and having four distinct choices that all supplement each other was great." (Student ID #10)

> "I really liked being able to choose activities that cater to my style of learning. I don't really respond very well to reading pages of text, so I spent more time reviewing videos that covered the same material. I thought it was really good to have the option... most courses that I've taken don't really give me that kind of flexibility, and it leaves me trying to fend for myself and search online for my own external resources." (Student ID #11)

Again, the follow-up interviews with the Experimental Group confirmed the positive learner experience and the ability for learners to control their learning. One student said that the navigation is the simplest module he has ever encountered. Another commented that she feels that the learning options provided her an opportunity to learn more about other learning preferences. All interviewees stated that they had a positive learning experience and that they felt in control of their own learning.

The second set of data came from the comparison of the pre-test and post-test scores between the Experimental Group and the Control Group. The results of the analysis show that there was no difference between the performance of the Experimental Group and the Control Group on pre-test and post-test for both domain knowledge and study skills ($p>0.05$). In addition, there were no significant differences between the Experimental Group and the Control Group in total time spent studying the domain material ($p>0.05$). The reason for this is interpreted as the ceiling effect. Ceiling effect refers to the level at which an independent variable no longer has an effect on a dependent variable, or to the level above which variance in an independent variable is no longer measured or estimated (Duncan & Howitt, 2004). In other words, the presence of a Learner-Directed Model (the independent variable) has no effect on the performance of the students (dependent variable). Other factors that might come into play include a higher sense of motivation and drive for success. Online students possess higher intrinsic motivation than classroom students (Rovai, Ponton, Wighting, & Baker, 2007) and in the case of Athabasca University, about 83 per cent of the student body work in professional fields while they study, and 70 per cent of graduates are the first in their family to earn a university degree – it can be inferred that these students have a higher-than-average drive for success. It is also highly possible that these students have already been working in the field of study; thus they are likely to be more familiar with the study material and different instructional design model presents little impact on their learning outcomes.

Although the Learner-Directed Model doesn't necessarily improve the scores; it presents the students with more in-depth learning opportunity. It has been said that the totality of learning cannot be measured just in test results; however, most learning assessments tend to focus on what is easy to measure instead of what is important (Reeves, 2006). Bain (2004) also asserted that assessment activities should be about "critical thinking, problem solving, creativity, curiosity, concern for ethical issues, breadth and depth of specific knowledge, and the methodologies and standards of evidence used to create that knowledge". He also mentioned that there is a need to use assessment to help students learn, not just to rate and rank their efforts. Score-based assessment doesn't negate the insights that a holistic learning system offers, as scores are just a tiny fraction of the insight about learning.

Sadler (1983, 1989, 2009) advocates the use of holistic judgments as a way to achieve more objectivity and balance in academic evaluation. An important part of holistic appraisal is to engage students themselves in the notion of practise to assist learning. My Learner-Directed Model created a context in which this is a deliberate pedagogical strategy where students are being free to try the learning activities out. As Sadler (1983) stated that learning "loops" could be set up so that students are given opportunity and incentive to rework. The design of the Learner-Directed Model provides a way to practise learning concepts in different learning modes based on their learning preferences. In formative assessment, this will help learners to be able to self-monitor and self-regulate the quality of their work, and more importantly, to be able to "hold a concept of quality roughly similar to that held by the teacher" (Sadler, 1989).

A new way of thinking about online assessment strategy with a base on a constructive learning theory approach would be needed to increase student engagement and to produce more well-rounded scholars. Well-designed online assessment can help students to regularly check their understanding of a given topic and to encourage them to be more reflective learners (Whitelock & Brasher, 2006). A roadmap of e-assessment in the UK that identified enabling factors, barriers, as well as vision of the future is provided by Whitelock & Brasher (2006); this work could be used as a starting point in constructing good online assessment questions that are constructive in nature, encourage reflection, and to support learner control.

A more detailed look at the research questions is needed to put the findings from this experimental study in perspective. The next section will break down each research question and answer, look at how the experimental study's findings relate to the questions, and discuss the answers in details.

7.3 Discussions

7.3.1 First Research Question

The first research question examined:

Q1: Which learning style theory and education theory would be useful to develop an e-learning system?

After an extensive literature review in Chapter 2, it became clear that two theories stood out to be applicable, useful, relevant, and flexible in designing a learner-directed e-learning model. From the learning style theory family, Experiential Learning Theory (ELT) was selected as the theory to use in designing the content. The reasons for that are manifold: it is a well-known theory; it promotes a well-balanced, holistic way of learning; and it acknowledges individual learning preferences without imposing a set sequence or a prescription on the learners. What is more, it could be designed as an iterative process whereby learners can bypass or repeat any or all of the stages proposed by the learning cycle in an e-learning environment. Since there was little empirical support for the Learning Style Inventory (LSI), and it ran the risk of stereotyping learners into a certain learning dimension, this research decided not to include the inventory as part of the design. In relation to constructivist theory, ELT aligns with the constructivist education theory approach in a way that it enables learners to take an active part in selecting and constructing the knowledge relating to their prior experiences.

From the education theory family, Self-Regulated Learning (SRL) Theory was selected as the framework for designing meta-cognitive learning activities in support of the Learner-Directed Model. SRL is a useful theory because it emphasises autonomy and learner control as it states that learners not only need to regulate their performance, but also how they learn. However, self-regulation requires an explicit impetus that guides or informs one to modify and evaluate one's own cognitive or meta-cognitive study habits. On the contrary, learner-direction requires an implicit impetus. Meaning, one doesn't have to externalise the reasoning behind a particular study habit. This research took the view of the learner-direction in a way that in order to manipulate learner-direction, design for learner experience should adhere to a variety of open options for the student to choose from. Therefore, the impetus is not externally manipulatable but is implicitly built-in to the design of the online course. In order to provide learner direction that has implicit impetus, SRL was adapted as what the current study called “Self-Directed Regulated Learning (SDRL)” as it is better suited for the design of a learner-directed e-learning model. SDRL focuses on "proactive self-reflection" as it is the provision of these “how to” study skill guides and tools embedded as options for students to assist them in becoming better self-regulated, self-reflected learners that this research is interested in.

Both ELT and SDRL theories made it possible to develop a Learner-Directed Model for an online system. This model aims to cater to individual learning preferences and foster a solo-constructivist approach for autonomous learning. It also takes into consideration both user experience (UX) and learner experience (LX) principles. The second research question will look at how an e-learning system can be developed based on this model and the theories it employs.

7.3.2 Second Research Question

The second research question concerned the following:

Q2: How could an e-learning system be developed based on the learning style and education theories?

After reviewing and departing from the notion of existing student models based on adaptive technology in Chapter 3, Chapter 4 explained how the design of a Learner-Directed Model for an e-learning system came about. Using an alternative student-modeling approach, the current Learner-Directed Model is a model that can accommodate learner control in providing freedoms of pace, content, and media. This research used the ELT stages of learning cycle in creating a learning design framework for presenting the domain knowledge, namely, introductory Java programming.

The ELT learning cycle was mapped on top of a circular wheel interface with four quadrants representing the four learning stages. Each stage was linked to a learning mode based on Kolb's experiential learning cycle: concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE) (Kolb, 1984). The four learning modes corresponded to Kolb's four stages were: watching, discussing, conceptualizing, and trying out. The aim of this interface design was to encourage the learner to explore and access more than one learning activity.

As supplementary learning material, a Self-Directed Regulated Learning (SDRL) theory based interface entitled "Key Study Skills" was available to assist with learning about meta-cognitive knowledge. The way to provide study skill in this research was a "built-in" approach (Wingate, 2006). Twenty related study skills - five successive skills (to scaffold) for each of the four learning modes - were developed. Each grouping of the five successive skills was paired with a tool for learners to try out and practise these skills. The design consideration was that the key study skills appear as an unobtrusive interface that sat on the upper-right-hand-corner of the main content. Overall, the study skills stated accommodate the four phases of self-regulation as proposed by Winne & Hadwin (2008).

This Learner-Directed Model fits well within an adaptable system. It is adaptable in a sense that learners are being presented the complete set of learning options available, and can make decisions on whether and when to choose, and whether and when to let others (systems and/or human) make those choices – there is no system initiation.

Now a Learner-Directed Model for an online system is in place, the next research questions look at how effective this system is in terms of student performance and attitudes.

7.3.3 Third Research Question

Finally, the third research question investigated two sub-issues:

Q3: What is the effectiveness of an e-learning system based on a model of learning?

- *What would the effect of such a system be on the performance of learners?*
- *What would the attitudes of learners be using such a system?*

An experimental study was conducted using the Learner-Directed Model to answer this research question. Two groups of students were randomly assigned to an Experimental Group and a Control Group. The Experimental Group was subjected to an experimental treatment - a different design and presentation of the learning material along with the additional supplementary study skill content, i.e. the Learner-Directed Model. The Control Group was presented with the regular e-learning content similar to what the current course design is for this particular module.

The results obtained in answering the first part of the third research question have shown that there is no statistically significant difference ($p > 0.05$) between the Experimental Group and Control Group's pre-post test scores in terms of performance. In other words, an e-learning system using an Experiential Learning Theory-based instructional design model does not have substantial influence on the domain-knowledge nor meta-knowledge competency in learning computer programming. The similarity in domain and meta knowledge competency between the two groups could suggest that students enrolled in e-learning courses in computer programming might already be aware and make use of their learning preferences, ability and style (Schrum & Hong, 2002). As discussed above, the ceiling effect took place and that the effect of the Learner-Directed Model is more about the depth of the learning and attitudes to learning rather than the score or rank based on their performance.

The findings could also be interpreted that since all participants are current Athabasca University students, they have significant experience to online learning format. It could be inferred that they have already developed sufficient, even sophisticated study skills to cope with independent online learning. Other e-learning researchers have indicated that successful online learners' characteristics include good study habits and skills, as well as the ability to set goals and purpose (Schrum & Hong, 2002). The Experimental Group and Control Group participants are likely to have developed such study habits and skills early on during their studies as they have all progressed through other courses and have already achieved satisfactory academic standing with the university in order to participate in the current study.

In response to the second part of this research question, the comparison of the quantitative survey data results has shown that there is statistically significant difference ($p<0.05$) between the Experimental Group and the Control Group's survey results in sum. Experimental Group has considerably more positive attitudes toward the Learner-Directed Model for the e-learning system than the Control Group. In other words, e-learning system with the combined design using Experimental Learning Theory and Self-Regulated Learning Theory has a positive influence on the learners' attitudes and their overall learning experience. More specifically, there is a statistically significant difference in the answers for the Study Skills and Tools section – the Experimental Group considered the study skills and tools provision to be considerably more useful and helpful in relation to planning, strategizing, and supporting their online studies. In the Perceived Ease of Use and User Satisfaction section, three answers are significant with an additional one answer approaching significance. The Experimental Group found the material useful for their studies; the learning activities took less time to finish than they expected; the activities are easy to complete; and the content flexible to interact with. For the System Usability section of the survey, the Experimental Group had a more significant response than the Control Group for the following: that the material was well-organised and structured; it is relevant to their learning needs; it is concise and to the point; and that there is a consistency of appearance, terms, words, and action throughout the module. In the Learning Experience section, two results are approaching significant: the Experimental Group found that the content allows for deep reflection, and the information provided was open to interpretation, discussion, and feedback. Finally, the Perceived Controllability section has three answers that the Experimental Group responded with a significant result: they felt that they have a lot of control over their learning; can choose freely what they want to see; and can determine which learning activities suited them best. In addition, it is compelling to point out that in all instances of the survey results, the mean of the Experimental Group was higher than the mean of the Control Group.

These findings indicate that this e-learning approach appear to be beneficial to students in supporting their learning experience for computer programming. In this regard, it could be maintained that a Learner-Directed Model produces a positive effect on learners' attitudes and is in support of learner control. Usability (thus user experience) is vital to user satisfaction and user acceptance of a system (Nielsen, 1993, 2000; Rosenbaum, 1989; Rubin, 1994). For online learning, learner satisfaction and acceptance encourage learners to interact positively with an e-learning system, and to empower learners to take control of their learning.

7.3.4 Learner-Directed Model and Its Benefits to Learners

This thesis presents the argument that the new student modeling approach serves as a viable option in designing online learning that provide a finer, more natural, and purposeful learner control experience at multiple levels. Past research studies in student modeling using adaptive technology indicated that there are still tricky barriers and limitations in developing student models and adaptive systems – they are costly to develop and to update the models; many models make assumptions about the learners and tend to prescribe solutions that are “off-target”, thus, put off learners from interacting with the systems. Stereotyping could run the risk of “putting students in a box” so much so that it limits their thinking and creativity. While user models might work relatively well in an e-commerce system such as Amazon.com for purchasing books, an e-learning system is far more complex. Learning deals with cognitive processing that make use of multiple skills, diverse prior knowledge and background of the learners, affective states, and changing context.

As a new student modelling approach, the Learner-Directed Model works better in a sense that there is no need to update the model, and it can be applied in different contexts. Based on the survey results and the interviews, learners’ attitudes reflected that the Learner-Directed Model is beneficial to their learning process, supported them in becoming self-regulated learners, and contributed to their overall learning experience. Experimental Group participants unanimously (18 out of 18) stated that they liked the ability to choose the learning tools and methods the best. The responses overall from the Experimental Group were very positive, and the emphasis was about their ability to choose, and the variety of learning options. The availability of learning options also heightens learners' awareness on their learning preferences, and at the same time, it could serve as a way to battle learners' tendency towards habituation – by providing more than one way to learn, and offering study skill support tools and information.

Most of all, what sets the Learner-Directed Model apart is the fact that it is a constructive system. Using the ELT's stages of learning, it allows learners to build up their own learning and to work on stages of development in a way as they see fit.

The next section will discuss in details the contributions of the current research, improving the Learner-Directed Model made for students, along with its limitations.

7.4 Contributions

One of the greatest strengths about e-learning is the flexibility and the ability to choose the pace, content, and media of learning as one sees fit. In this research, I have created a new type of student model – a constructive student model. The virtue of this model is that it allows students to choose their own setting of the model – based on the two learning theories – Experiential Learning Theory and Self-Directed Regulated Theory. The Learner-Directed Model presented all the learning material in a way that a student can browse through, and can be accessed in different ways – watch a video, participate in a discussion, look at a concept map, and write a few lines of code. Through these engagements, students construct their own learning pathways. It is this learner construction that set this student model apart. The Learner-Directed Model is both a resource and a tool. It is meant to construct, rather than instruct.

A student model has been described as a type of user model intended for use in an educational context. A User model is a representation of a user that captures a user's goal, tasks, knowledge, background, experiences, interests, traits, and context of work (Nurmi & Laine, 2007). Commonly, a student model is used as a representation of a student in order to modify learning tasks and interaction with systems. These student models contain either learners' domain knowledge or the learners' characteristics such as prior knowledge, age, gender, abilities, and preferred learning styles (Ragnemalm, 1996). Based on the information collected and stored in the model, the student model attempts to prescribe learning onto students. This is a prescriptive approach to student modeling, and as a result, it produces an instructive system. The limitation of an instructive system is that it is teacher-directed. It makes the assumptions that learners should be directed by instructors (or systems) – they are the one to make the decisions about the content and sequence of the learning. For students, this approach limits their ability for self-discovery, critical thinking, and reflection. In addition, prescriptive student models make inferences based on the information collected, and this information could be costly to harvest, inaccurate, and could change over time and context.

With the Learner-Directed Model, it takes on a constructive approach to learning. Constructive learning is based on students' active participation in problem-solving and critical thinking regarding a learning activity, which they find relevant and engaging (Masuyama, 2005). This is a non-adaptive student model – it provides learning in a setting that students can select their learning activities based on the two learning theories. It is adaptable in a way that students can actively work through the material in their own way, and adapt to their learning preferences.

This has important implications for designing the next generation of e-learning systems as the Learner-Directed Model enables us to present an alternative to the existing instructional design framework. It goes beyond presenting and delivering online material to a theory-centric, user-centred and Learner-Directed Model for asynchronous learning. This study highlighted a shift in underpinning learning design philosophy, especially one for learning about computer programming online. It also served as a departure from the view on student modeling using adaptive systems, to distinguish the difference between adaptive system and adaptable system with the aim to optimise learner direction and learner control.

I have repurposed the experimental module to the current model that emphasises the role of the learner and to empower learners in choosing different learning paths and study strategies. Experiential Learning Theory (ELT) was deployed in a fresh and exciting way, capitalizing on the strength and the popularity of the theory while overcoming some of its limitations and criticisms. ELT was used in a way that allow maximum flexibility. Using self-directed learning strategies that are discipline specific contextualised study skills. A new kind of self-regulated learning called Self-Directed Regulated Learning (SDRL) was created. It is viewed as an extension of the self-regulated learning theory and a subset for Learner-Directed Learning. SDRL is perceived as a "proactive self-reflection" and aimed at 'regulation" in a more implicit manner – as regulation is being implicit in the design and interactions, measurements related to regulation are intertwined with other components of the system. Finally, as a learning design reference, I have created a comparison table to detail the differences between designing learner experience (LX) and user experience (UX), and to provide further guidelines on incorporating both LX and UX in e-learning design.

7.5 Limitations

Like all research studies, the current research study has its own strengths and limitations, as well as room for improvement. The main limitation is that the current study's data has been confined to undergraduate Athabasca University students in Canada with the main mode of course delivery being online, asynchronous, self-paced study over the course of a six-month period. In addition, this study is limited to the subject area of computer programming, a core course requirement as part of a four-year Bachelor of Science degree in Computing and Information Systems. Although this course is offered as an elective to other students and has no prerequisite, it is likely that most learners enrolled in this course have a certain level of computing background and prior knowledge. Conducting this research with another institution that has blended learning as well as face-to-face teaching component over a longer period of time would strengthen the study.

In addition, the context of e-learning is limiting in itself since technology changes every day. This study was conducted using Moodle as the LMS for hosting the course. Moodle in itself has its own interaction interface and usability issues. This may have had an impact on the results. It would be useful to investigate as to whether using different learning management systems (e.g. Blackboard, Moodle, Sakai Project, SAP) would generate different results. It would also be curious to implement a Learner-Directed Model on a larger scale with MOOCs such as the ones offered by Coursera or Udemy with enrollment numbers in the hundred thousands.

Despite the above limitations, this research can be generalised for future studies across disciplines and contexts. The Learner-Directed Model can be generalised because it is based on general learning theories. Both of the learning theories used to develop the Learner-Directed Model are about the psychology of learners – Experiential Learning Theory is about the different ways people learn; Self-Directed Regulated Learning Theory is about the way people interact with learning autonomously. As opposed to domain-specific/character-specific student modelling approach, this can be applied more widely into other subject domain and situations as the two theories provide insights on how humans learn and that behaviour could be applied in different sectors, ranging from multi-national corporations, higher education, non-profit organizations, military, or training and development field.

7.6 Recommendations

Overall, the participants generally praised the idea of implementing an e-learning system that integrate multiple learning modes and embedded study skills based on the framework of two learning theories. They were positive and enthusiastic about the current study. A number of participants commented on how much they enjoy the fact that they are being able to choose activities that cater to their style of learning and the study skill supplements. One particularly enthusiastic learner commented “The features are excellent and I can honestly say this module is top-tier when it comes to online studying.” This validated the thesis’ central theme that there should be guided freedom in giving learners the ability to choose the type of learner-content interaction they prefer in the sequence they want.

In light of the participants’ input and the research findings, the following recommendations are to be made:

Better integration of the interface

As Sims, Dobbs, and Hand (2002) proposed that the keys to a successful online environment are the origin of the content and the design of the interface, it is foremost important that we pay attention to constantly make improvement to the interface design for e-learning. Participants have commented that the red button at the top of the right-hand corner of the module webpage might not be an ideal location for the study skills, as students sometimes would overlook it. It is suggested that a more integrated interface would be used so as to highlight the availability of study skill support better. One person commented that: “The little red button at the top right corner of Learning Activities doesn't do it enough justice. I found it negligible to even check out until it was mentioned in this survey. It's really too good to not just put out there on the front page.” Based on the suggestion, I have re-designed a new interface that could be put forward for future research. Figure 7.1 illustrates the new integrated design with the four learning modes and the study skills button situated in the centre.

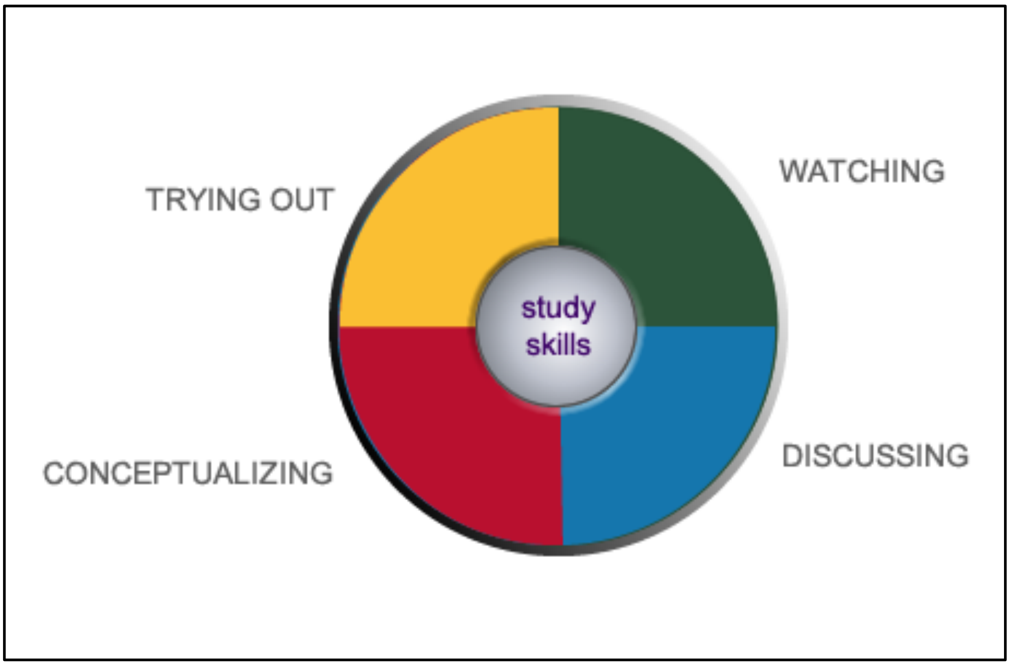

Figure 7.1: A new integrated design of the four learning modes and study skills

Provide learning options that cater to different needs and styles

The availability of learning options as a positive feature of the Experimental Group module is a prevalent statement in the survey. Experimental Group participants consistently said that the four learning modes are a strength of the module: “The use of four parallel flows in each section is good - it is easy to assimilate quickly and provides a meaningful level of organization.”’; and also: “(I like)…the choice of learning activities, so if I didn't understand a topic I could use an alternative view of the topic.”

Some participants requested that more examples and explanations on certain sections would be helpful. One learner suggested that the “Read this First” section and the “Conceptualizing” learning activity could use more examples, and with explanations in a line-by-line format to explain what a code does. Another participant pointed out that it would be more personal if the tutors for the course would record the narration for the video recordings.

Since designing materials with different learning modes and supported study skills is somewhat time-consuming, it is recommended that this learning design approach would be applied to concepts that are difficult to grasp or needed elaboration. “Control structure” was chosen as a topic to re-design because it is a difficult yet fundamental concept for students to learn in computer programming, and then by varying the presentation and instructional format, it helps sustain the attention of the learners (Keller, 1987a).

Make learner control more explicit

As motivation is one contributing factor on high online attrition rate (Hodges, 2004), being able to put the learner in the control seat would help with motivation and to develop a positive learning experience. In the Time Continuum Model of Motivation (Wlodkowski, 1985), it suggests that instructions should allow for choice and self-direction. Interfaces for online learning should be created to support and encourage those choices and motivations appropriately.

Based on this study’s survey and interview results, participants also stress the importance and relevancy of learner control in an e-learning environment. One suggestion was to provide learner-control options more explicitly and to make it easier to try out different learning modes and to skip around content as they see fit. Perhaps one way of giving better learner control is to employ the interface design technique called progressive engagement (Wroblewski, 2008).

Progressive engagement allows users to try out a programme or a piece of software without fully committing to using it. A similar design technique could be applied in instructional design. Learners can preview different learning modes, and the system can collaborate with the learners by either providing more like-minded activities in-depth or return the learner to the main interface and allow them to preview again for different learning modes.

Instructional design adapted to different domain areas

Ideally, instructional design should be adapted to different domain areas. Different subject matters need to have different instructional design consideration. Kanuka (2006) asserted that:

> "Hence, in order to develop effective instructional design, instructional designers need to understand not only pedagogical strategies and learning theory, but also have some understanding about the subject matter being taught and the culture of the discipline. In particular, in order to select the most appropriate instructional methods, instructional designers need to see how ideas connect to the discipline and to everyday life as a professional."

Since there are differences in thinking and validation processes among disciplines, it is crucial for instructional designers and educators to adopt e-learning course design instead of following a pre-determined pathway. It is recommended that the Learner-Directed Model would be adapted for different domain areas by using different types of learning activities. Some of these learning activities were suggested by Mobbs (2005) to be used for the four stages of the ELT cycle (Table 7.1).

Table 7.1: *Different Types of Learning Activities For the Four Stages of the ELT Cycle (Mobbs, 2005)*

Concrete Experience	**Reflective Observation**	**Abstract Conceptualization**	**Active Experimentation**
readings examples problem sets trigger films simulations/games	logs journals discussion brainstorming	lecture projects analogies model building	projects fieldwork laboratory case study simulations

7.7 Directions for Future Work

As all earnest researchers know, the quest for knowledge is a never-ending task. The findings of one research study open doors to many more opportunities and topics to be explored and investigated. Never before had we the ability and access to the diversity of learners from around the world, with the abundance of technological options, and the easy availability of online course development tools. You can create and host your own MOOC course with Google's eLearning Course Builder, or Blackboard's newly launched CourseSites – both sites provide free access and tools, without writing a line of code yourself. Now is a good time to experiment, to chart new territory, to redefine e-learning, and to place learners deservingly in the driver's seat in order to be in control of their own learning when they choose to do so.

One significant area of growth in e-learning is the corporate training sector. In corporate training, literature indicated that statistics on e-learning course's attrition rates are as high as 80% (Bonk, 2002). Too often, corporate e-learning is treated as dull, shallow, Power-Point-like presentations with narration, completely devoid of any kind of interactivity and learner engagement. Staff was required to take e-learning training as part of a performance related task or as compliance training. It would be useful to conduct studies on the issues of self-directed learning and learning experience for employees in a work-place learning setting. It would also be interesting to track whether the increase in learner control and a positive learner experience would have any effect on on-the-job performance and employee engagement.

Additional study skill supports, including social interaction interfaces that make use of Web 2.0 technologies, should be investigated as applicable to different domain areas. Even the notion of co-regulation is out of the realm of this research, it would be a worthwhile area to delve into as social tools are becoming more standardised and often integrated into the LMS as part of the overall learning ecosystem in both the corporate sector and in higher education.

It will be beneficial to carry out additional research in other post-secondary institutions in the area of computer programming and in other domain areas. Research studies that involve students studying in a traditional classroom setting, blended learning, and e-learning environment are needed to provide further points of comparison. It would also be useful to scale up the research in a MOOC setting with student enrollment numbers reaching hundred thousand. As Anderson (1972) said “more is different”, having significantly more students in a massive online course can help us to have richer data to test new hypotheses at many levels of granularity. With big data becoming more readily available, and more off the shelf web-tracking tools easier to use, it is now possible for us to look at research and data collection at a scale that we couldn’t reach before.

The Horizon Report 2013 defined learning analytics as big data applied to education (Johnson et al., 2013). Learning systems can benefit from learning analytics even if the information is logged anonymously. It would help to know what sorts of activities students spend more time on; what kind of activities students attempted but give up eventually (near misses). The notion of self-directed regulated learning could be extended to “self-tracking” to create a greater awareness. It could be the kind of self-report that relies on the individuals’ words about what she does. The next step could be to explore a platform that would allow learners to define goals and report the stats. It could coach you through activities that help meet your quantifiable goals by displaying your progress as an overall trend. There is a growing trend in increasingly automatic capturing of self-tracking information.

From a mobile learning angle, developing apps that could provide contextually appropriate feedback, motivation, and a little reward at the exact moment when it can help us to make aware and perhaps change our study habits could also be handy. I envisioned it as a tool for micro-measurement of learning, and also to engage students at a deeper level. It will provide an "ambient awareness" – so we don't feel isolated as individuals sitting in front of our separate computers all alone. Currently, Coursera has over 2 million students enrolled in 200 courses; edX and Udacity reached around 500,000 students. There is a need to cater to personalised learning in these massive enrollment courses when the dropout rate is approximately 90%.

However, data is only one side of the story – it is literal, objective and measurable (Young, 2012). The danger of using self-learning-tracking/analytics is that it would render learning into objective, external factors. We will lack genuine introspection about our learning. We need to be able to explore and understand more about the subjective experience of learning. We need to be careful so as not to take the joy and spontaneity of learning and reduce it to stat-driven, objectified activity. After all, catering to learner control and learner direction should incorporate the elements of both user and learner experiences, as well as balancing the quantifiable, measurable learning outcomes.

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Appendix 1 - Listing of the 13 Prominent Learning Styles Models

Gregorc's Mind Style Model and Style Delineator (GSD)

Dunn and Dunn model and instruments of learning styles

Riding's Cognitive Styles Analysis (Palincsar & Brown)

Myers-Briggs Type Indicator (MBTI)

Apter's Motivational Style Profile (MSP)

Jackson's Learning Style Profiler (LSP)

Kolb's Learning Styles Inventory (LSI)

Honey and Mumford's Learning Styles Questionnaire (LSQ)

Herrmann's Brain Dominance Instrument (HBDI)

Allinson and Haynes's Cognitive Styles Index (CSI)

Entwistle's Approaches and Study Skills Inventory for Students (ASSIST)

Vermunt's Inventory of Learning Styles (Wilson)

Sternberg's Thinking Styles Inventory (TSI)

Appendix 2 – University of Hertfordshire Ethics Approval

UNIVERSITY OF HERTFORDSHIRE

FACULTY OF SCIENCE, TECHNOLOGY AND CREATIVE ARTS

M E M O R A N D U M

TO **Stella Lee**

CC **Trevor Barker**

FROM **Dr Steven Adams – Chair, Faculty Ethics Committee**

DATE **7 March 2011**

Your project entitled:

Design of an Adaptive Learner-Directed E-learning Model

has been granted ethics approval and has been assigned the Protocol Number: **1011/155**

This approval is valid as follows:

From 1 April 2011
Until 30 September 2011

Please note that if it is possible that the project may continue after the end of this period, you will need to resubmit an application in time to allow the case to be considered.

Appendix 3 – Athabasca University Ethics Approval

MEMORANDUM

Athabasca University
Canada's Open University™

DATE: April 15, 2011

TO: Stella Lee

COPY: Dr. Vive Kumar (Co-Applicant)
Janice Green, Secretary, Research Ethics Board

FROM: Dr. Simon Nuttgens, Chair, Research Ethics Board

SUBJECT: Ethics Proposal #10-69 *"Design of an Adaptive Learner-Directed Model for E-learning"*

Thank you for your April 13, 2011, resubmitted application arising from the Research Ethics Board's "Conditional Approval" decision of February 23, 2011. On behalf of the Athabasca University Research Ethics Board, I am pleased to advise that this project has now been granted **FULL APPROVAL** on ethical grounds, and you may proceed immediately once the item below has been addressed for file purposes only (further review not required).

For file purposes only (no further review required)**,** please provide the following:

- A copy of **Athabasca University Institutional Permission**, issued from Vice-President Academic Dr. Margaret Haughey, allowing access to AU systems, staff, and students for research purposes.

  The AU Research Ethics office will assist you in requesting the institutional permission from Dr. Haughey by forwarding a copy of your final approved ethics application, along with a request on your behalf.

The approval for this study "as presented" is **valid for a period of twelve months** from the date of this memo. **A final Progress Report (form) is to be submitted when the research project is completed.** Reporting forms are available online at http://www.athabascau.ca/research/ethics/.

As you progress with implementation of the proposal, if you need to make any changes or modifications please forward this information to the Research Ethics Board as soon as possible. If you have any questions, please do not hesitate to contact rebsec@athabascau.ca

Appendix 4 – Participant Information Sheet (PIS)

Design of a Learner-Directed Model for E-learning

Researchers

Stella Lee, SCIS, Athabasca University, Edmonton, Canada; Department of Computer Science, University of Hertfordshire, Hatfield, England
Vive Kumar, SCIS, Athabasca University, Edmonton, Canada
Clayton Clements, SCIS, Athabasca University, Edmonton, Canada

Introduction

You are being invited to participate in a research project. Only currently registered AU students are eligible to participate in this study. Please read this Participant Information Sheet carefully before deciding whether or not you wish to participate in this research project. Please note that you are not required to take part in this research as part of your studies at AU. Participation is completely voluntary.

What is the aim of the project?

The purpose of this research is to evaluate the effect an adaptive online system has in helping learners to improve their domain and meta-knowledge based on theory-centric design. Effectiveness is to be measured in terms of: quizzes results; learners' experience of the system; time spent on the learning activities and resources; whether or not the students achieve desired learning outcomes; and whether or not a learner-directed learning design lead to an enhanced learning and user experience.

One unit of study material has been prepared to cater to learners' learning preferences in the context of five learning concepts from Control Structures in Java Programming. No background in Programming or Programming Languages is necessary to participate in this study. Along with these learning activities, key study skill supports are also available depending on the learning activity the student is accessing. Again, no background in study skills is necessary to participate in this study.

What types of participants are being sought?

We are seeking adult learners who are currently students of Athabasca University. Additionally, we will also be seeking 6 participants willing to take part in follow-up interviews once the first part of the study is finished.

What will participants be asked to do?

If you agree to take part in this research, you will be directed to a website for an outline of this research and a taste of custom content. Students who want to participate will be directed to another webpage that shows the online Participant Information Sheet (this document). The "I have read" on that page button will require the participant to acknowledge to have read the information sheet. Then the participant will be shown the Participant Consent Form in a separate page. Two buttons will appear at the bottom of this page – "I have read and I agree to participate" and "I have read and I do not agree to participate". The responses of the participants will be recorded along with their names and email IDs. Those participants who do not agree will be thanked for their time and invited to exit the page.

Those participants who agree to take part will be taken to the server that hosts the study material. At this time, participants will be asked to take a Moodle quiz, a pre-test, to estimate their knowledge in Control Structures and Study Skills. The participants will then either study material using adaptable content or study material using non-adaptable content. It will take anywhere between 2 to 4 hours, depending on your background and motivation, among others. After completing this study activity, participants will be asked to take another quiz, a post-test. Finally, participants will be asked to respond to a survey about the entire study process.

We anticipate all contact with the participants to be virtual – by email or phone or other online communication tools such as Skype.

Out of all the participants, we will ask 6 volunteers for the follow up interviews that will evaluate their learning as well as user experience after they interact with the system. The interview is expected to last an hour. We will send out emails to recruit students for the interviews. We will only send one interview recruitment email per randomly selected student and will stop recruiting after we have collected usable interview data from 6 participants.

Can participants change their minds and withdraw from the project?

You are free to withdraw from the research at any time by advising either of the investigators that you want to leave the study. If you choose to withdraw, we will destroy any data that we have collected from you.

What data or information will be collected and what use will be made of it?

This study will collect data from the pre-test, the study pattern within Moodle pages, the post-test, the survey, and the interview. All the information will be stored at a secure server computer in Athabasca University. A hard copy of the student survey and the semi-structured interview notes and results will be used for data analysis and will be stored in a locked filing cabinet during data analysis. Personally identifiable information such as the names of participants and their addresses (for sending the compensation cheques) will be collected by the Principal Investigator. Only the Principal Investigator will have access to these personally identifiable data. Once the analysis is complete, the Principal Investigator will replace the personally identifiable data with a symbolic id, for example “Participant 2A”. All data that contain personally identifiable data and all hard copies of data will be destroyed by December 2011. The anonymised data will then be shared with two other researchers who are involved in statistical analysis of the data. Electronic files generated as a result of data analysis will be encrypted and stored in the personal computers of Ms Stella Lee and Dr Vivek Kumar, for further analysis.

The anonymised data will be permanently archived securely in the iCORE research lab at Athabasca University, Edmonton, stripped of any personally identifying data. Only the three named researchers (see above) will have access to this data. This is to allow us to write up a report and publications from the research. If the information that you provide is reported/published in conference papers and/or journal articles, this will be done in a way that does not identify you as its source.

Risks and benefits

There are no risks to participants in this research. There are a number of benefits to Athabasca University. The findings from the research will inform learning design and course development at Athabasca University. The benefits include providing a diversity of learning activities that are better suited to students' learning preferences, supporting key study skill development, providing adaptive feedback and an enhancement in learning and user experience.

What if participants have any questions?

If you have any questions about our project, either now or in the future, please contact either:

Stella Lee
PhD Research Student
iCORE
Athabasca University
Edmonton
Canada
Phone: 403-918-5352
Email: stellal@athabascau.ca

Dr. Vive Kumar
Associate Professor
SCIS
Athabasca University
Edmonton
Canada
Phone: 780-707-7895
Email: vive@athabascau.ca

This study has been reviewed by the Athabasca University Research Ethics Board. Should you have any comments or concerns regarding your treatment as a participant in this study, please contact the Office of Research Ethics by email to rebsec@athabasca.ca.au

Appendix 5 – Participant Consent Form (PCF)

This form will be held for a period of five years.

Researchers

Stella Lee, SCIS, Athabasca University, Edmonton, Canada; Department of Computer Science, University of Hertfordshire, Hatfield, England

Vive Kumar, SCIS, Athabasca University, Edmonton, Canada

Clayton Clements, SCIS, Athabasca University, Edmonton, Canada

Consent

I have read the Information Sheet concerning this project and understand what my participation in this research will involve. I understand that I am free to request further information at any stage. In its entirety this project will run from April 1, 2011-August 1, 2011. Please acknowledge all of the following points by ticking the boxes.

- I have been given and have understood an explanation of this research project.
- I understand that participation in the study is voluntary and I am not required to take part in the research as part of my enrollment at the University and it will not affect my academic record at Athabasca University.
- I understand that the pre-test will take approximately 30 minutes, the study activity anywhere between 2 to 3 hours, and the post-test approximately 30 minutes to complete.
- I understand that my participation in the research is confidential, and only the Principal Investigator will have access to personally identifying data. I can choose to withdraw from the research at any time during this study. Once I withdraw, all my data will be immediately destroyed and not used in the study.

- I understand that participation in the interview will last approximately an hour. The timing of the interview will be negotiated with the Principal Investigator.
- I understand that participation in the interview is not anonymous, and that I am able to withdraw my interview responses once submitted by notifying one of the investigators. The final date for withdrawal would be August 1st 2011 or the date of submission of the first publication (whichever comes first).
- I understand that the interview will remain confidential unless I give additional consent to being identified in research outputs. I understand that data will remain confidential if I do not agree to being named in research outputs.
- I am happy for any of the information I provide in the survey to be used anonymously in any reports, presentations and publications (including verbatim quotes).
- I am happy for any of the identifiable information I provide in the interviews to be used in any reports, presentations and publications (including verbatim quotes).
- I understand that anonymised data will be stored permanently and securely, in an electronic form.

If you have any questions about our project, either now or in the future, please feel free to contact either:

Stella Lee
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iCORE
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This study has been reviewed by the Athabasca University Research Ethics Board. Should you have any comments or concerns regarding your treatment as a participant in this study, please contact the Office of Research Ethics by email to rebsec@athabasca.ca.au

Appendix 6 – Pre-Test Sample Items

1. What method does a Java program need to have in order to be runnable?

   a. main()
   b. run()
   c. start()
   d. init()

2. What does the following code output?

```
int x = 24;

int Y = 3;

System.out.print( y );

System.out.println( x );
```

   a. Nothing.
   b. yx
   c. 3
   d. 324

3. The number 25.4 is:

   a. A float
   b. A double
   c. An int
   d. a) or b)

4. What is a keyword in Java?

   a. The first thing you should place at the top of a Java code file.
   b. A special reserved word in Java that you use to make the computer behave a certain way.
   c. An indicator of a special method (e.g. ‘main’).
   d. A labeled container for a particular kind of value.

5. What do these expressions evaluate to?

14 <= 14, 14 < 14, -9 > -25, -25 > -9

   a. true, false, true, false
   b. true, false, false, false
   c. true, true, true, true
   d. true, false, true, true

6. What does the following code fragment write to the monitor?

```
int sum = 14;
if ( sum < 20 )
  System.out.print("Under ");
else
  System.out.print("Over  ");
System.out.println("the limit.");
```

a. Under the limit.
b. Over
c. Under
d. Over the limit.

7. How many choices are possible when using a single if-else statement?

a. 2
b. 3
c. 4
d. 1

8. Are following code fragments Identical?

```
1) if (isMoving)
currentSpeed--;
System.err.println("The bicycle has already stopped!")
```

```
2) if (isMoving) {
currentSpeed--;
System.err.println("The bicycle has already stopped!");
}
```

a. True
b. False

Appendix 7 – Study Skill Items for Pre/Post Tests

Please rank the following questions according to the five-point scale provided. There are no 'correct' answers to these questions, and they will not contribute to your test score.

On a scale of 1-5

1- Strongly Agree

2 - Agree

3 - Neutral

4 – Disagree

5 – Strongly Disagree

1. I take notes while I study
2. I organize, review, and use my notes
3. I know what Netiquette is
4. I know how to properly phrase my questions when asking for help
5. I reflect on my writing to try and identify improvements
6. I know how to source information relating to what I am studying
7. I am proficient in the use of search engines
8. I use mind maps to organize, refine, and reflect my ideas
9. I know how to troubleshoot problems I encounter
10. I keep track of solutions to problems I've solved, and refer to them later if I have further difficulties

Appendix 8 – Survey Items

Study Skills and Tools Questions

1. Specify which of the following study tools you used:
   - Evernote
   - Discussion Forum
   - FreeMind
   - BlueJ
   - None of the above

2. The tool(s) help me with planning and strategizing my online studies

3. The tool(s) provide support for my online studies

4. I will use one or more of the tools for my future online studies

5. I am more aware of the essential study skills I need for studying this course (experimental group only)

6. I find the study skills useful in improving my learning outcomes for this course (experimental group only)

7. I will select and apply some of these study skills for my future online studies (experimental group only)

Perceived Ease of Use & User Satisfaction questions

Source: (Davis, 1989; Unger & Chandler, 2009)

1. The module material was easy to access
2. I found it easy to do what I wanted to do
3. My interaction with the module material was straightforward and clear

4. I found the content flexible to interact with
5. I found the module material useful for my study
6. The learning activities took longer to finish than I expected
7. The learning activities were easy to complete
8. I felt frustrated when trying to complete the learning activities

System Usability questions

Source: (Alex Koohang & Jacques du Plessis, 2004)

1. I had no problem understanding the language used to present the information
2. The material in every page was well-organized and structured
3. The material was relevant to my learning needs
4. The material was concise and to the point
5. There was consistency of appearance, terms, words, and action throughout the Module.
6. The links throughout the Module were visible.

Learning Experience questions

Source: (Smulders, 2003)

1. The content allowed for deep reflection
2. The learning material made me stop and think
3. The activities provided ways for trial and error
4. The information provided was open to interpretation, discussion, and feedback

Perceived Controllability questions

Source: (Liu, 2003)

1. I felt that I had a lot of control over my learning in this module
2. In this module, I could choose freely what I wanted to see

3. In this module, I had absolutely no control over what I could do
4. I could determine for myself which learning activity(s) suited me in this module

Open-Ended questions

Source: (Tullis & Albert, 2008)

1. What do you think the best feature of this module was, and why?
2. What feature of this module did you think should be improved, and why?

Appendix 9 – Follow-up Interview Questions

1. What was your initial impression of the module (in terms of layout and presentation of the learning material, the navigational structure, color, graphic, etc.)?

2. Where did you spend most of your time?

3. How satisfied are you with any of the following features: (This question only applies to the Experimental Group)
    a. The four learning modes
    b. The key study skill supports
    c. The study skill tools

4. What and why are the things you like best about this module?

5. What and why are the things you like least about this module?

6. What features would you most like to see added to this module?

7. Have you encountered any practical challenges e.g. difficulties with features of the tool(s) you are using/any other technical difficulties?

8. Have you encountered any other difficulties with navigating the module?

9. How was your overall learning experience as you used the tool? Pease explain

10. What are the challenges in online learning in general for computer programming?

Appendix 10 – Comments from an UX Professional in Validating the Interview Questions

Ammneh Azeim <Ammneh.Azeim@iomer.com> Thu, Jun 6, 2011 at 10:08 PM

To: "stellaylee@gmail.com" <stellaylee@gmail.com>

Hi Stella,

Thank you for asking me to validate your PhD thesis research follow-up questions for the learner experience. From my perspective, the questions read fine. The only input I have is to add "why" to questions 4 and 5
And to rephrase question 9 to:
" How was your overall learning experience as you used the tool? please explain"
The rest reads well.

Thanks,

Ammneh Azeim

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Appendix 11 – Complete Survey Open Text Answers

Question 1: What do you think is the best feature of this module was, and why?

Experimental Group answers:

Student ID #8

> The ability to choose the method you wanted to learn with. Such as conceptualization, group discussion, etc.

Student ID #5

> Personally, I like the "Trying out" feature simply because I learn by doing mostly. It was good to read the concept theory first and then quickly try it out.

Student ID #7

> The pie chart for the learning activities is really good. It presents 4 possible ways of learning the material, which is really helpful for a wide variety of students who have different learning styles. Personally, I like the discussing section most. It shows me how the code should look and then there's the forums. It's pretty useful to be able to search up threads about people having the same trouble and having asked the same questions I have and already having the answers.

Student ID #9

> The ability to go through the material at my own pace at a time that I wanted to.

Student ID #10

> All of the different learning options was the best feature of the module. Everyone learns differently, and having four distinct choices that all supplement each other was great.

Student ID #13

Structure of information

Student ID #11

I really liked being able to choose activities that cater to my style of learning. I don't really respond very well to reading pages of text, so I spent more time reviewing videos that covered the same material. I thought it was really good to have the option... most courses that I've taken don't really give me that kind of flexibility, and it leaves me trying to fend for myself and search online for my own external resources.

Student ID #12

I liked how you could choose what you wanted to do for this module. I have taken quite a few University courses and the structure of most of them is to read material, go to lectures, and complete assignments. I am used to being able to read at my own pace, and I learn best while being able to try things out. I don't learn from lectures much at all. While I have been using the internet for almost 15 years, and am quite familiar with discussion boards and videos, I'm much too impatient to wait for other people to respond to a post I made, or wait and watch a video. This is just me personally, and I am sure that many students would prefer the video learning. I'd rather just read the bits that I need to focus on, and skim the bits that I already know about. This may not be a good study skill; perhaps I should be revising and reinforcing the parts that I already know... but from my almost 7 years as a University student I have learned that sometimes there are just not enough hours in the day :) This study was not lengthy by any means, but old habits die hard. So, to make a long story short, I really liked the fact that there were a number of different learning options - text based and "try it out" learning, for those of us who prefer a more traditional type of learning, and video and discussion learning which may appeal to others.

Student ID #14

I like the idea of having different options for how the material is taught. Not everybody learns the same way so having the flexibility to decide which delivery method works best for you would be a benefit to the student.

Student ID #15

The use of four parallel flows in each section is good -- it is easy to assimilate quickly and provides a meaningful level of organization.

Student ID #16

I liked being able to choose several didn't learning methods. I found the video component very useful.

Student ID #17

The choice of learning activities, so if I didn't understand a topic I could use an alternative view of the topic.

Student ID #18

Module 1 easy and clear to understand

Student ID #20

Short online quizzes with little to no negative consequences, which were an excellent way to compare my learning with course expectations.

Student ID #21

The Module is properly break into different sections and topics. the flow of module maintain the interest.

Student ID #26

I really liked being able to learn in many different ways -- both hands-on approach, reading about it in theory and watching a video really helped!

Student ID #24

Content was presented in short "sound bytes" which were easy to digest. I was not reading a manual per se, as much as reading a conversation I might have had with someone.

Student ID #25

Simple examples of all the key concepts, examples show people how to actually use something!

Control Group answers

Student ID #7

The inclusion of charts and diagrams is a nice addition for COMP-type courses. This should make it easier for a student to see what exactly is happening when a program statement is executed. Also, my major complaint about COMP268 and COMP272 was the lack of original content (a poor text, and about 80% wikipedia links, respectively). So I feel having original content in modules such as this can make the content more focused, enjoyable, and easier to understand, especially if it supplements and clarifies the text.

Student ID #10

Having the youtube videos embedded in the module was a great addition and really helped understanding the content.

Student ID #2

The wording of the text was clear and concise and as a result it was easy to understand the material.

Student ID #6

The study material are short and precise, the online/visual demonstration helped

Student ID #5

The videos because they provided the benefits of human interaction along with the advantages of an electronic medium. You had someone explaining to you what things meant and if you didn't understand something, you could go back and listen to it again.

Student ID #11

There was a problem with the IDEone links an video. Labels were not described at all but used. I found the documentation at Oracle was better worded and laid out.

Student ID #8

The videos with a narrator which allowed me to attempt and learn visually what he was trying to teach.

Student ID #14

I think the best feature for the module should be the instructor explanation on the all the topics and the java oracle sites should be for reference purpose only.

Student ID #13

I enjoyed the videos mixed in with the text, it made a lot of things much clearer. The videos with 'spoken' instructions appealed to me more than the ones where the explanations were typed on the screen.

Student ID #12

Step-by-step Youtube video showing the concepts applied.

Student ID #16

Using multiple choice questions to re-enforce learning was probably the best feature of the module, or at least it would have been had the questions and answers been created with care. Smaller quizzes, perhaps one per unit, would help people taking COMP 268 identify the units they are having trouble with and gain confidence when they've mastered a unit. This would allow them to better focus their learning.

Student ID #17

The best feature was the video presentation and exercises allow us to practice the concept learned.

Student ID #21

It was written in clear language.

Student ID #20

I liked the examples and the exercises.

Student ID #22

Providing video tutorials for different concepts helped the most because it made things easier to understand since you see someone else doing it and explaining it throughout the process. The videos were essential to the material.

Student ID #23

Nothing significant steps out for me.

Student ID #24

The fact that everything is online and accessible at any time. Not to mention the addition of youtube videos were definitely a plus.

Question 2: What feature of this module did you think should be improved, and why?

Experimental Group answers

Student ID #8

> The features were straight forward so I couldn't say which ones need improvement. The learning material was not straight forward and this lead to misinterpretations.

Student ID #5

> It was good overall. Only minor thing I would have like is to NOT have all the different sections opening in new windows constantly, there is a lot of changing screens, it would be nice if the navigation was on the left column (with all the sections clearly selectable) and have only one part of the screen changing.

Student ID #7

> There isn't anything particular that I think can be improved in this module. The features are excellent and I can honestly say this module is top-tier when it comes to online studying. Perhaps on the CSe front page, right under discussion forum you can add links to the key study skills. The little red button at the top right corner of Learning Activities doesn't do it enough justice. I found it negligible to even check out until it was mentioned in this survey. It's really too good to not just put out there on the front page.

Student ID #9

> There should be a more description of what is presented in the module. The navigating this module is a good start, but did not provide enough information. For example, I had no idea what is the purpose of each of the quadrants and I did not know that the red button labeled "key study skills" contained links to info about study skills. I thought those where

the study skills I was supposed to be using when reading the document.

Student ID #10

Some links for section 2 didn't work; they linked back to section 1 learning material.

Student ID #13

A more web 2.0 interfaces would be easier to use.

Student ID #11

I think the organization was confusing. Some of the links weren't working very well for me, so I had to go and edit the URL in order to get to the next activity. The layout wasn't the greatest either.

Student ID #12

I didn't feel that much needed to be improved - it was pretty straightforward. One comment perhaps would be that if you enter the text exactly as described in the module, into ideone.com, it doesn't compile. I was able to make it work, but some people may have had difficulty. It's also possible that there was an obvious mention of this somewhere and I missed it. Secondly, and this is just me being nit-picky, in Activity 2 of (I believe) Learning Activity 1, Vartype long is written twice in the table. All in all, I really liked it, and I think it's a great idea to have options so that students can study according to their personal learning style.

Student ID #14

Nothing stands out

Student ID #15

I don't like programming videos, they are slow to watch and I think not very useful compared to straightforward paragraph, code, paragraph, code. Having the videos for people who like them is fine, but they should not contain material not also presented elsewhere (i.e., they shouldn't be mandatory in order to understand the unit material).

Student ID #16

I found the coding samples a little confusing. At an introductory level, it would be nice to have sample programs that the student can compile and execute as is, instead of snippets of incomplete code.

Student ID #17

I think the Read This First and the Conceptualizing learning activity could use more examples, with clear explanation, line by line, of what a code do. I also think the videos could use more examples, I think the videos are good but they are too direct to the point, examples would be useful too.

Student ID #18

More explanation on the modules should be given and examples

Student ID #20

Navigation and outlining of essential concepts that are required. The "choose 1 of 4" learning style feature was not very helpful, as it was unclear whether the entirety of the concept had been successfully grasped without seeing them all. The fact that they were broken up made that difficult. Navigation was slightly confusing, and the opening of new windows didn't help, as it interrupts flow.

Student ID #21

The module should have different discussion form for each Topic, so that someone can take participation according to their need and interest.

Student ID #26

I didn't really find the discussion forum too useful but that just might be because that is not my learning style.

Student ID #24

I had some technical issues with the Activity selections in each section. The "Watch" activities may be better if they were narrated, or perhaps made available for download for use off-line (I tend to consume content while taking public transportation).

Student ID #25

The post Quiz is wrong, the question about the continue out; and break partout; doesn't have the correct answer, and the two closest ones where a coin toss since they both said "continue next iteration" for the break middle loop. The random number question had a thumbs down instead of a (n); at the end of a System.out.print so i logically assumed the code wouldn't compile!

Control Group answers

Student ID #7

A hard copy alternative would be nice (if it's within the budget), or a printable PDF, but self-contained (ie, no links). The ability to study away from the computer or not connected to internet makes it a lot easier for me. Being a deaf person, I can't comment on the effectiveness of the videos, but a transcript and/or alternative code format might help (especially if a hard copy is available).

Student ID #10

The feature that I think should be improved would be embedding the http://ideone.com/ website into the module so everything is done easily in the module.

Student ID #2

I believe there are a couple of errors on the post test. Please check and see if they need to be corrected.

Student ID #6

Controlled video demos, while YouTube has a lot of training videos and presentations; there were some "previews" of video materials that are not part of the course. Also because YouTube is user driven, some of the presenters used non-technical or professional language. I couldn't see the 2nd video from ideone.com at this link http://mobile.athabascau.ca/~claytonc/comp268/index.php?url=unit3/linear1.html

Student ID #5

I may have missed something but it seems some material, like the return statement for methods wasn't covered in the text or videos. It would have helped me learn better to have had full coverage of all the material, even if that coverage was redundant. In fact, redundant coverage in different mediums (for example text and videos) would allow the module to cater to a wider variety of learning styles.

Student ID #11

The language. Again, check out Oracle for their explanation. It was clearer, and more concise.

Student ID #8

I think more of a breakdown for the activities, and I understood the videos but when it came to activities, I felt a bit lost. As well as the video's with no voice over, I lost interest.

Student ID #14

Modules that have just the links to the java oracle site should also include some explanation from the instructor.

Student ID #13

There are some fairly large gaps in the module; it is introduced as a 'beginner' module. Then assumes people use BlueJ very early on, it also assumes people know how to import other java libraries as this is in the sample code but never explained. I never saw anywhere I could go to review my answers or see how other solutions may have looked to the presented problems.

Student ID #12

Sometimes there's just too much information on a page and it gets crowded. Not too much quality, but too much quantity. Though, the presence of diagrams and videos helped.

Student ID #16

The accuracy of the questions/answers on the quizzes is in dire need of correction. There are multiple posts regarding the issue in the forum, however, that forum appears to be unused. The low quality of quizzes likely unjustifiably skewed your data by making the "new" version of the course appear to be more effective. Your research practices are as shameful as those in the psychiatric professions.

Student ID #17

Video quality and sound.

Student ID #21

The videos should all be marked as optional, the text is sufficient.

Student ID #20

The text was fairly dense. For the videos, it wasn't clear what their purpose was before watching them, and the one which was just someone soundlessly typing out a block of code was completely useless - why not just save time and show the finished code? Some of the questions on the test marked me wrong when my answer was in fact correct (for instance, there was one where a bracket was missing, but it didn't accept my answer of "will not compile").

Student ID #22

More videos, and more examples.

Student ID #23

Contain the content in the primary window, do not do pop ups, the pop ups when opened were very small, maximize the window if you are going to use pop ups, there were spelling errors, proof read. Question #2 of the post-quiz is in error The code should not compile as the int Y is upper case and the statement System.Println(x+y) ; y is lowercase, but no option given for the correct answer The post quiz was a little difficult trying to visualize the code excerpts in my head I am disappointed in use of free YouTube materials for the course curriculum, students pay good money to learn and should get that value I am very familiar with this topic thus I did not use any of the study aids or do any of the exercises, for a new student to the subject the examples are worthwhile. I think that is all. A good experience overall.

Student ID #24

The tests I guess. Somehow I did better on the pre tests than on the last test. I don't know how or why that happened...

Appendix 12 – Follow-up Interview Transcripts

Follow-up Interview - Ajmal Hafizi (Experimental Group)

1. **What was your initial impression of the module (in terms of layout of the learning material, and what you think of the navigational structure, color, graphic, etc.)?**

I really like the home page - simple and sufficient - have topic outline, all layout simply and efficiently. Function properly. I knew instantly where to go and know what to do - in the first minute. It has a flow - don't have to switch between tabs or anything.

2. Where did you spend most of your time?

All the learning concepts - I see it as four different types of learning and felt that it was necessary to go through all of them. I like "trying out". I like hands on and also the "watching" part. I spent most of the time on those two sections for all the learning concepts. It works for people who already have some work experience/and also know more about the topic to be able to focus on those two.

3. How satisfied are you with the following features:

a. The four learning modes
b. The key study skill supports
c. The study skill tools

Personally, I am not a fan of note taking - not something I would use. I found the discussion forum very useful. I like it that it is open - each person learn differently - this layout appeals to it. It definitely has more variety than your average e-learning course. In general, I am happy to have all those features provided.

4. What are the things you like best about this module?

I like the variety of it - i like the most is the circle, it looks interesting and flexible - gave me what i am looking and help me a lot

5. What are the things you like least about this module?
Nothing

6. **What features would you most like to see added to this module?**

The key study skill button, maybe to connect to the circle with the arrow or make it more obvious to the learners. More examples of some of the learning material. In the Trying out section of If-Else, just give more examples. It would be nice to include a "Challenge Yourself" section or additional activities.

7. **Have you encountered any practical challenges e.g. difficulties with features of the tool(s) you are using/any other technical difficulties?**

There is an aesthetic bug - the key study skill button hovering on top - there is a overlapping of colors when your resize the window.

The "Read this First" pop-up window, the window is small. It would be better to set the default size a bit bigger or to resize automatically according to the end-user's screen size.

8. **Have you encountered any other difficulties with navigating the module?**

The navigation is the simplest module I have ever encountered. It would be cool to have the tutor to do a voice over and introduce the videos in the Watching section, also the tutorial, would be good for the tutor to voice over how to install the JDE. Tutorial videos are definitely a really good addition.

9. **Has the overall learning experience been positive, neutral or negative? Please explain.**

Definitely positive

10. What are the challenges in online learning in general for computer science?

It would be useful for e-learning course design to change to a more personal learning style. Have videos you can pause, rewind, etc. So that way you won't feel you missed something. Most students graduated from high school, they are so used to traditional, linear process. For them, to understand what their learning style is. They don't know how to pace themselves. Some students get overwhelmed, and need to learn that.

A presentation on learning style - a survey, and a talk. Which area are stronger. It would be good for students to understand that they have a learning preference and that they all learn differently. It would be good to make students aware of it.

Add colors to the home page - just to add more visual appeal. Most computer science online courses look so dull, it would be good to add some visual appeal.

Follow-up Interview - Kathryn Dunphy (Experimental Group)

1. **What was your initial impression of the module (in terms of layout of the learning material, and what you think of the navigational structure, color, graphic, etc.)?**

The design is pretty straight forward - initially, I was not sure if i had to do all of them. After I read the details, I then understood. The online site to go to try it out - that doesn't seem as easy - I would like to see more instruction since I don't have programming background for running the IDE. I think this design is less rigid and that I can skip around.

2. **Where did you spend most of your time?**

I didn't watch the videos much although I understand that is useful for others. I prefer reading, so I spent most of the time reading and also for trying out some of the examples provided.

3. **How satisfied are you with any of the following features:**
    a. **The four learning modes**
    b. **The key study skill supports**
    c. **The study skill tools**

I used the concept maps and the IDE. They were useful to me.

4. **What are the things you like best about this module?**

The fact you can pick and have the options - for different people, that is really helpful and flexible.

5. **What are the things you like least about this module?**

Nothing - can work on my own pace. I think having some deadlines would be good, just so you are able to pace yourself better.

6. **What features would you most like to see added to this module?**

I am wondering maybe some people don't like to jump around and they rather follow a linear structure or some kind of structure. What about a check box - so you can check off after you read somethings, pretty much like a progress bar. So that it could show how much you read, where you have been, etc. Good to know how much you have done - it helps with motivation.

7. **Have you encountered any practical challenges e.g. difficulties with features of the tool(s) you are using/any other technical difficulties?**

Nothing - the pop-up windows are fine. They are predictable and I know how to navigate them.

8. **Have you encountered any other difficulties with navigating the module?**

No. This really gave me more opportunity to different ways of learning.

9. **Has the overall learning experience been positive, neutral or negative? Please explain.**

Positive, I feel more in control of my learning.

10. What are the challenges in online learning in general for computer science?

Online learning - it is so easy to put it off. Leave it to last minute, it is easy to do that. I would like to have some deadlines imposed on me even small, separate deadlines for mini-tasks. Some stuff should have deadline, but some don't, so it should have some flexibility in the system.

Personally, I also found that I can never pay attentions to watching lectures online, I get distracted too easily. I think maybe using a chat room, somewhere you can go and interact. To have someone to interact with you like on MSN or any chat rooms, it would be easy to get TAs to go and use it with the students.

I also like looking at other examples, I like the w3school website.

Follow-up Interview - Stacy DuBois (Experimental Group)

1. **What was your initial impression of the module (in terms of layout of the learning material, and what you think of the navigational structure, color, graphic, etc.)?**

At first, I was a little bit of confused about getting to other section. I had to back track (use the back button on the browser) a lot. However, I really like the options of different style of learning and the circle.
At my current course, I have been frustrated all along, this one (the experimental module) is easier to follow than the rest of the courses I have taken online. I wish the rest of my courses are all designed like this one. I like seeing more pictures/more videos. I feel like in my current study, I have to search for this type of stuff on my own instead of having them available in the course homepage.

2. **Where did you spend most of your time?**

More time on videos, I just gravitated toward that, I like the visual.

3. **How satisfied are you with any of the following features:**
    a. **The four learning modes**
    b. **The key study skill supports**
    c. **The study skill tools**

I have already use OneNote before but I did looked at all those study skills. I think they are good for beginners. I have been doing online study for a while, so I have a routine going and a set of study skills acquired. In general, I do tend to gravitate towards using the discussion forums. I find other students' experience really valuable and I am definitely happy with using it.

4. **What are the things you like best about this module?**

I really like giving the options of which activities suits me best and have the freedom to pick or skip activity. Currently there are a lot of reading in all my online courses, I wish that there are more activities to try things out like this module. It is really awesome to be able to try things out! It is great having a bit of flexibility also. I mean, I can get by with reading if I already knew the topic, but I really feel like I have to put in a lot of effort without a lot of help with the tutor or from the course website. I wish some of the topics they can dump down a bit and explain it better for beginners.

5. **What are the things you like least about this module?**

   I would like to see the navigation to be tidy up a bit - it is a bit buggy. Sometimes I clicked a button and it didn’t move forward.

6. **What features would you most like to see added to this module?**

I would click to see my progress as I go - not able to tell where I am is a problem as I get discouraged or lost. I would like to see breadcrumb.

Content - would be really nice of videos of our own teachers teaching - standing in front of the lectures teaching type of thing. Seeing someone standing there and talk - it is so much more interesting. It would be more useful if they make their own instead of linking to the outside ones. Even audio is good if the tutors are doing that themselves. A lot of it is really hard to know where the emphasis is on certain topic. There are so many data types and options, I couldn’t tell how important it is, and I need to know what are the “must know” and what are the “nice to know”. If there are audio accompanying the content, that is good. Online, you don’t see other students and you don’t know if you are the only one who is confused. So a human presence would be so so useful.

7. **Have you encountered any practical challenges e.g. difficulties with features of the tool(s) you are using/any other technical difficulties?**

No

8. **Have you encountered any other difficulties with navigating the module?**

See comments on Question 5.

9. **Has the overall learning experience been positive, neutral or negative? Please explain.**

Positive

10. **What are the challenges in online learning in general for computer science?**

Well, I had some prior knowledge from working in the industry, so I know some of the content because I already am familiar with the jargon and what not. But I think the computer science courses assume a lot of prior knowledge, especially technical knowledge, and not all students have that. These are courses with no prerequisites, so they need to be able to explain things at the lowest level so everyone can understand.

Follow-up Interview - Philip Stadler (Control Group)

1. **What was your initial impression of the module (in terms of layout of the learning material, and what you think of the navigational structure, color, graphic, etc.)?**

The layout is good. Can scroll through it, easy to see all in one page. Some of the videos are better than others. At the end of the module, it would be nice to include a summary of content.

2. **Where did you spend most of your time?**

I reviewed the videos. It is the easiest way for me to learn programming - to read various commands and programs, and play around with it to figure out himself. Spent a lot of time going through the Java library and look at various commands.

I had a hard time learning methods/class so I spent time looking at other resources outside the course.

3. **What are the things you like best about this module?**

I like audio and video and supporting text, and to have multiple videos.

4. **What are the things you like least about this module?**

Nothing

5. **What features would you most like to see added to this module?**

It would be nice to have an online embedded compliers.

6. **Have you encountered any practical challenges e.g. difficulties with features of the tool(s) you are using/any other technical difficulties?**

It would be nice to get an automated confirmation that I had finished the module. I didn't know if I have done everything I was supposed to do to complete it.

7. **Have you encountered any other difficulties with navigating the module?**

nope

8. **Has the overall learning experience been positive, neutral or negative? Please explain.**

positive

9. **What are the challenges in online learning in general for computer science?**

It is always hard trying to figure out the abstract on your own and to motivate myself - to read through the material. Occasionally I email my tutors, but I don't stay in contact with tutors. Sometimes I rather go on the internet to research questions myself.

I would like to see the e-learning designers to make the modules more fun and as easy as possible to learn. Involved tech support people - live text conferencing with tutors would be useful for people trying to learn. (virtual office hours)

Follow-up Interview - Toby Ali (Control Group)

1. **What was your initial impression of the module (in terms of layout of the learning material, and what you think of the navigational structure, color, graphic, etc.)?**

I really enjoyed the YouTube videos - showing how it is implemented.
I watched all of them - they are good lengths and I had no problem getting into it. I got a good idea on what you will get. Not hard to follow. A damn good way to learn Java.

2. **Where did you spend most of your time?**

I think it is evenly distributed

3. **What are the things you like best about this module?**

Pretty satisfied with all of them - a bit of inconsistency with YouTube videos, one has audio, the other doesn't.

The best thing about YouTube is that you can make comments and ask questions. It could also be open to others outside the university environment. I like that it is open to the rest of the world for discussion. Keep the video public, so students can have a broader discussion.

Overall, I found it easy to follow, aiming at just the right level
And I would take more courses this format and I prefer this way of learning

4. **What are the things you like least about this module?**

Consistency with videos - some have audios and some don't, just make it all have audio or none has it. Typing instructions on video would be helpful. More practical examples would be good.

5. What features would you most like to see added to this module?

How to set up a programming environment - I think that section needs more explanation. Some instruction would be nice too.

Are tutors allowed to set up Skype appointment with students? The delay in asking questions is always an issue. A Skype conversation would be useful. Some real time element would be really neat. A facilitated Skype call. You always need two-way interaction. As long as there are some discussions going on. Livestream, Youstream, to set up a live broadcast. e.g. Justin.TV

6. Have you encountered any practical challenges e.g. difficulties with features of the tool(s) you are using/any other technical difficulties?

None - two different kind of instructions for downloading IDE would be helpful - one for beginners in laymen's term and one for people who are more technical if they want to do the advanced stuff.

7. Have you encountered any other difficulties with navigating the module?

No, I like the table format. Enjoy the format.

8. Has the overall learning experience been positive, neutral or negative? Please explain.

Very positive
It works for programming - it needs to be more non-linear.
Allow students to enjoy programming
“Programming is like math on steroid”
There is learning how to program, and there is understanding it

9. What are the challenges in online learning in general for computer science?

Online study can make you feel so disconnected. Anything that makes it more personal is fantastic. Any extra voice would help as you are alone all the time. You are “speaking” to people in discussion forum, but you don’t know what you are doing. So a human presence. Also it needs to be more non-linear, more flexibility.

Follow-up Interview – Michael Olajide (Control Group)

1. What was your initial impression of the module (in terms of layout of the learning material, and what you think of the navigational structure, color, graphic, etc.)?

Navigation - I find it easy to navigate. Good content and can easily see what I want, and I can scroll down. I am quite ok with the navigation.

The links within the content are very good. Very easy for me and the graphic is good.

2. Where did you spend most of your time?

Easy - didn't spend a lot of time for the software but just reading through the text. The program - COMP 268, the first part of it, it is quite ok. Most of that have instructor explanation. (as a first time online course). I started having problem on Unit 5, then this is just like a general information. Not a classroom feel. Feel like I was doing research on myself. My friends from IT help me a lot. Most of the web links in the program itself should be a reference.

Researcher's note: He was talking about the computer science degree program he was in rather than this module. He said he had no problem with this module but had a lot of trouble with the program at large)

3. What are the things you like best about this module?

I always think I am like this quote: "Someone coming out of the ocean, you will never fear the rain." It is much easier to study comparing to some of the stuff I had to go through before. I feel like the instructor is talking to us, feel the instructor's explanation.

4. **What are the things you like least about this module?**

I can't remember anything about it now! I think more information to send to reference guides/more external resources/more examples.

5. **What features would you most like to see added to this module?**

More explanation from the instructor, more graphics. Have the instructor to show you how the program works in graphics. More little questions to test your ability - write a small program at more places.

6. **Have you encountered any practical challenges e.g. difficulties with features of the tool(s) you are using/any other technical difficulties?**

No

7. **Have you encountered any other difficulties with navigating the module?**

No, I like this module better - can easily go back to the top bar, and can drop down on the module to navigate back.

8. **Has the overall learning experience been positive, neutral or negative? Please explain.**

Really positive. I can understand this content and it feels like I am in a classroom.

9. What are the challenges in online learning in general for computer science?

Learning computer programming - I think it is all about examples, and more practical stuff. You study something, you have to apply. That is the only way it is going to help.

List of Publications Based on the Thesis

List of conference papers, presentation, and doctoral consortium that originated in the research carried out for this thesis.

Publications, Conference Papers and Presentations

Lee, S., Barker, T., & Kumar, V. (2012). Learning preferences and self-regulation: Design of a learner-directed e-learning model. In Kim, T., Kim, H., Kim, K. J., Adeli, H., Kang, H., & Kiumi, A. (Pressley & El-Dinary), *Software Engineering, Business Continuity and Education.* (pp. 579-589). (Communications in Computer and Information Science). Springer. doi: 10.1007/978-3-642-27207-3_63

Lee, S., Barker, T., & Kumar, V. (2011). Models of eLearning: The development of a learner-directed adaptive eLearning system. In Sue Greener and Asher Rospigliosi (Pressley & El-Dinary), *Proceedings of the European conference on e-learning held in University of Brighton, Brighton, UK, November 10-11, 2011* (pp. 390-398)

Barker, T. & Lee, S. (2010). *Approaches to student modeling in the context of eLearning 2.0.* Paper presented at the 9th European Conference on e-Learning, Porto, Portugal.

Lee, S. (2010, December). *Design of an adaptive learner-directed model for E-learning.* Poster presented at Australian Society for Computers in Learning in Tertiary Education (Ascilite) Conference, Sydney, Australia.

Lee, S., & Dron, J. (2008). Giving learners control through interaction design. In C. Bonk et al. (Pressley & El-Dinary), *Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2008* (pp. 1737-1744). Chesapeake, VA: AACE. Retrieved October 12, 2013 from http://www.editlib.org/p/29891.

Doctoral Consortium

Lee, S. (2009, September). Development of a design model for personalized E-Learning. Paper presented at the *Human Computer Interaction (HCI) 2009 Conference Doctoral Consortium*. Cambridge University, Cambridge, UK.

Lee, S. (2009, June). Design of an adaptive model for E-learning. Poster presented at the *17th International Conference, User Modeling,* *Adaptation, and Personalization (UMAP) 2009 Doctoral Consortium*. Trento, Italy.

Learning Preferences and Self-Regulation – Design of a Learner-Directed E-Learning Model

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Abstract. The main challenge of learning online remains how learners can accurately direct and regulate their own learning without the presence of tutors to provide instant feedback. Furthermore, learning a complex topic structured in various media and modes of delivery require learners to make certain instructional decisions concerning what to learn and how to go about their learning. In other words, learning requires learners to self-regulate their own learning[1]. Very often, learners have difficulty self-directing when topics are complex and unfamiliar. It is not always clear to the learners if their instructional decisions are optimal.[2] The aim of this research is to explore how learners can self-direct and self-regulate their online learning both in terms of domain knowledge and meta knowledge in the subject of computer science. Two educational theories: experiential learning theory (ELT) and self-regulated learning (SRL) theory are used as the underpinning instructional design principle. To assess the usefulness of this approach, we plan to measure: changes in domain-knowledge; changes in meta-knowledge; learner satisfaction; perceived controllability; and system usability. In sum, this paper describes the research work being done on the initial development of the e-learning model, instructional design framework, research design as well as issues relating to the implementation of such approach.

Keywords: learning theory, learning preferences, self-regulated learning, E-Learning, instructional design, learning design

1 Introduction

In e-learning, questions concerned how one can create online material that support and motivate students in guiding their own learning and make meaningful instructional decisions have attracted an increasing number of research interests ranging from areas in adaptive learning systems design to personal learning environments and learning styles/preferences theories. The main challenge of learning online remains how learners can self-regulate their own learning without the presence of tutors to provide instant feedback. It is especially difficult when topics are complex and unfamiliar and it is not always clear to the learners if their learning decisions are optimal[2]. Research into adaptive e-learning systems has attempted to facilitate the learning process by providing recommendations with respect to classifying learners into preferred learning styles and by associating recommended learning paths with these learning styles[3]. Indeed, research has shown the importance of adapting online course material to support learners with different background knowledge and skills[3, 4]. Another work has described a user modeling approach that is beneficial to learners who are interacting with complex learning applications in an online environment[5]. However, system-initiated learning aid is just one way of supporting learners; a more holistic approach, we would argue, is to provide a simple, all-in-one interface that has a mix of delivery modes and self-regulation learning activities embedded in order to help individuals learn how to improve their learning process.

Broadly speaking, user modeling is a technique employed to provide users with options with respect to performing tasks and interacting with systems differentially. The common variables to model include the user's personalities, abilities, prior knowledge, preferences, performances and intentions[6]. User modeling can also be defined as a model of users residing inside a system or computational environment[7]. However, many of these models attempt to "match" students with a certain learning styles or learner characteristics that it falls short on placing the initiative on the learners themselves and encourage them to take control of their learning. In fact, there has been no evidence in matching teaching to learning styles as the best way to improve learning. Instead, there is an optimal way to teach chunk of content to all students[8]. In this study, our design approach is centered on the constructive cognitive model - a model that helps students to self-direct their own learning, makes learning constructive while providing adaptive feedback. A simple, all-in-one interface for e-learning has been designed that has a mix of delivery modes and self-regulated learning activities embedded in order to help individuals learn how to improve their learning process. Self-regulated learning activities are provided contextually in the form of key study skills. Information and tools relating to these study skills are provided alongside the course material. Adaptive feedback is provided at the end in the form of a self-quiz to evaluate whether the learners have progress through their learning with adequate domain and meta learning knowledge. The domain we have chosen for this study is in computer programming. Specifically, we are conducting our study within an online introductory Java programming course (COMP 268) in a Western Canadian university. Two relevant educational theories: experiential learning theory (ELT) and self-regulated learning (SRL) have been selected as the underlining instructional design principles for this approach.

This paper aims to describe the design and development of such a learner-directed model in an e-learning environment, with the focus on how the two educational theories are being applied, the overall research design and data collection plan as well as discussions on issues and challenges. To assess the usefulness of this approach, we plan to measure: changes in domain-knowledge; changes in meta-knowledge; learner satisfaction; perceived controllability; and system usability.

2 Literature Review

2.1 Experiential Learning Theory (ELT)

Experiential Learning Theory (ELT) emphasizes experience as the central focus in learning [9]. Learning-styles theories[10] raised questions about what learning strategies we operate with and how we use learning strategies to enhance student learning. By studying these theories, one would also attempt to gain insights into what motivates learners and how to help them to understand more about their own strengths and weaknesses as learners. Kolb's model of learning styles could be represented as "flexible stable learning preferences" [10] as ELT is not about fixed learner traits, but rather a "differential preference for learning, which changes slightly from situation to situation" [10]. For instance, a student working in a group setting during a field trip for geo-caching might prefer to take a turn at hands-on interaction with the device even though he would normally prefer reading textual instruction at home alone. In his research, Kolb observed that some students have a definite preference for certain learning activities [9]. For example, one student might prefer reading lecture notes whilst another student might prefer working on an interactive simulation.

ELT sees learning as "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience" [11]. Figure 1 shows how a learner can progress through the experiential learning cycle. Kolb (1984) stated that a learner could begin the learning cycle at any one of the four modes, but that learning should be carried on as a continuous spiral. As a result, knowledge is constructed through the creative tension among the four modes and learners will be exposed to all aspects of learning: experiencing, reflecting, thinking and acting.

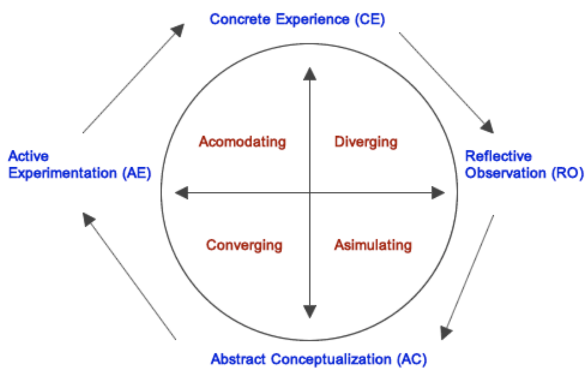

Fig 1. Kolb's Experiential Learning Cycle

Furthermore, there are four dominant learning styles that are associated with these modes [9]

The four learning styles are: Converging (AC and AE focus); Diverging (CE and RO focus); Assimilating (AC and RO focus); and Accommodating (CE and AE focus). Converging interested in practical applications of concepts and theories. A learner who has this preference is good at problem solving, decision making and practical application of ideas. Diverging interested in observation and collection of a wide range of information. A learner who is strong in this preference is imaginative and aware of meanings and values. They are interested in people and are socially inclined. Assimilating interested in presentation and creation of theoretical models. A learner leaning toward this preference is more concerned with ideas and abstract concepts than with people. Accommodating interested in hands-on experiences. A learner with this preference likes doing things; carry out plans and trial-and-error method.

Our research is grounded in individualized instruction. To further Kolb's take on distinctive learning preferences and to be able to provide options on learning activities accordingly, the four modes in the learning cycle has been used to design task-level content in the Java programming course in our research design. However, it is important to note that it is not our intention to prescribe and match a learner with a particular learning preference, as every learner uses a mix of learning styles, and not just one.

2.2 Self-Regulated Learning (SRL) Theory

Self-Regulated Learning (SRL) fits in well with our learner-initiated e-learning approach because in an individualized learning environment, learners are often left to their own devices, and a flexible e-learning system can help make them aware of their own thinking, monitoring, planning and evaluating personal progress against a standard, and motivation to learn[12-16]. When learners adapt their approaches to learning, learning is said to be self-regulated[17]. Self-regulated learning (SRL) states that learners not only need to regulate their performance, but also how they learn. Literature shows that self-regulation can positively affect learners' achievement[18]. Self-regulated learning (SRL) is "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior" [19]. Furthermore, [20] revealed that 'ordinary' collaboration (as found in traditional online forums and chats) is insufficient to transform learners' everyday "reflection" into productive "regulation".

What sets self-regulated learners apart is their awareness of when they know a skill or fact and when they do not, at a meta knowledge level - i.e. they plan, set goals, organize, self-monitor, and self-evaluate thorough out their studies[16]. In addition, self-regulation works best when learners are provided with continual feedback concerning the effectiveness of their learning approach. This is something that an adaptive system can provide as it can support and reinforce self-monitoring techniques as well as self-regulated learning strategies. We mainly focus on this aspect of self-regulation in relation to the design of an e-learning system wherein students can receive feedback if they choose to do so.

Our model's SRL interface includes components that allow students to self-reflect along with components that engage them in self-regulation. On one hand of the spectrum, self-reflection could be as simple as a thinking process made self aware, the intangible 'ah ha' moment of a conceptual breakthrough; on the other hand, self-regulation could be more tangible as a system or a tutor can observe what students do after they self-reflect. For example, in debugging, a student can self-reflect on errors identified by the compiler at the end of each compile of the program being developed. The system can track/record the number of errors and warnings faced by the student at the end of each compile. The system can also classify the types of errors encountered by a single student over multiple sessions of program development. Looking at this list of errors is an act of self-reflection. However, self-regulation takes it one step further. The student may try to identify most common errors and warnings he/she faced, take notes on how he/she resolved these common errors and warnings, and refer to these notes when he/she encounters these common errors and warnings when writing another program. This "proactive self-reflection" is what we identified as self-regulation even thought at this stage, we are not planning on tracking the end results of using the study skill tools, it is the provision of these "how to" study skill guides and tools embedded as options for students to assist them in becoming better self-regulated, self-reflected learners that we are interested in.

3 Methodology

3.1 E-learning Model Design Approach

The e-learning model we created is a learner-directed model. This is a model that places full learning control in the hands of the learner. The model does not automatically adapt or assign any differentiated content to the learner[21]. Simply put, the model provides multiple options to the learner where he/she can make instructional decisions based on these options. Learners can pick and choose their learning activities and paths. This approach enables personal autonomy, active involvement and engagement with the content and serves as a motivational factor for online learning. For prior knowledge and skills, the comparisons of the pre-test and post-test results will help inform the instructor as to what to recommend and adapt in class, online or both. The post-quiz also provide adaptive feedback. However, the feedbacks are not prescribed, it is served more as a guide than a mandate.

3.2 Participants

Estimated 60-80 voluntary participants are currently undergoing the research study. We recruited from students who enroll in COMP 268 - Introduction to Java Programming course started July 1, 2011. The participants are adult learners in various age groups with various programming skills. This is an introductory level course and there is no prerequisite. The majority of the students enrolled in this course in the past are computer science majors or minors, so we would expect that they would at least have some background and basic knowledge of computer science and technical ability to comprehend the content as well as navigating the course. Students who volunteer to be participants have received a complete debriefing at the beginning of the experiment and ethics approval has been sought prior to the start of the experiment.

3.3 Research Design

The e-learning model has been developed in Moodle (an open source Learning Management System currently in use at the authors' home institution) providing alternative content for Unit 3 of the course for the experiment. After the redesigned of the unit, it composes of five learning concepts and each concept starts with the same home page interface that present the four modes of learning. The five learning concepts are: *If-Else Statement; Loops; Break, Continue, and Return; Switch, Try-Catch-Finally, and Labels*; and *Recursion*. Figure 2 below illustrates the home page of each learning concepts.

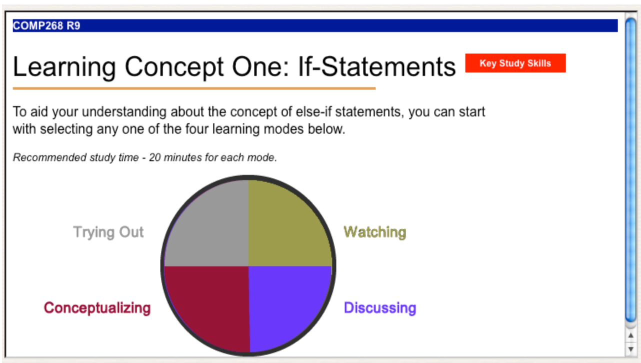

Fig 2: Home page for learning concept 1 - If-Else Statement.

Once a student access the learning concept home page, a circular wheel interface with four quadrants will be presented to them. Each quadrant is linked to a different but comparable learning activity based on Kolb's experiential learning cycle learning modes: *experiencing, reflecting, thinking* and *acting*. We have converted the modes into the following four activities: Watching (videos), Discussing (forums), Conceptualizing (visual diagrams), and Trying Out (coding). For instance, under

“Watching”, the learning activity is presented as a series of tutorial videos on YouTube on how to program If-Statements (see figure 3).

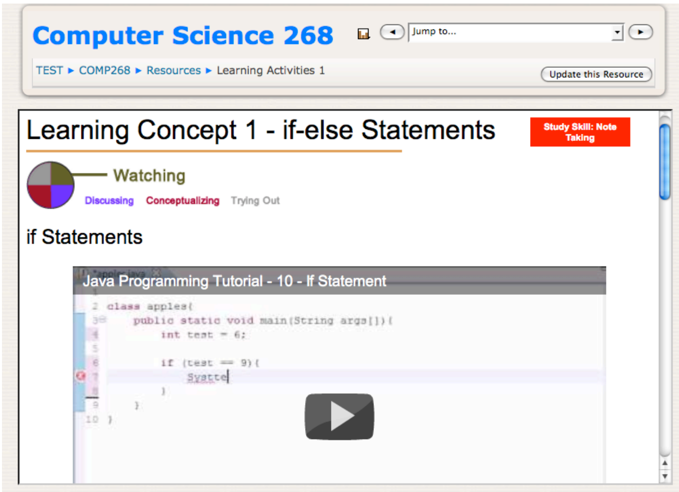

Fig 3: YouTube tutorial videos on how to program If-Statements.

A learner is free to choose any of the learning activities to begin his/her study. According to ELT [9], a learner can begin at any stage of the learning cycle, but it is most beneficial for acquiring new knowledge if he/she would go through them all eventually to fully understand and apply this new knowledge. He/she might or might not choose to go through them all; the decision is his/her to make. A post-test is available at the end of the unit for learner to self-assess his/her knowledge both at the domain and meta level. In another word, learners can test how well they have learn a certain programming concepts in Java as well as whether the associated key study skills are helpful to them in regulating their own learning and deploying them as learning strategies. The post-test is a formative test and it will not affect the participants’ grade in their overall course performance.

To help with self-regulation at a meta learning level based on the SRL theory, twenty study skills – five successive skills for each of the four learning modes -have been developed. These “Key Study Skills” is available on the upper right-hand corner of the webpage to assist with learning about meta knowledge. Meta knowledge in terms of key study skills for studying programming has been selected as: *note taking skill*, *reflection and discussion skill*, *conceptualization skill*, and *problem solving skill*. For example, within the “Watching” activity, the key study skill we emphases is “note taking”. The design consideration is that the key study skills appear as an unobtrusive interface that sits on the upper-right-hand-corner of the main content. Learners can choose to engage and learn how the “note taking” skill helps with the “watching” activity or he/she can just ignore it and carry on with watching the

YouTube tutorial video on its own. Figure 4 shows that the Note Taking skill is being presented with Evernote, a note-taking software. The rest of the study skills are paired with the following: Communications – Moodle discussion forum; Conceptualizing – FreeMap (mind mapping tool); and Problem Solving – BlueJ (an integrated development environment tool).

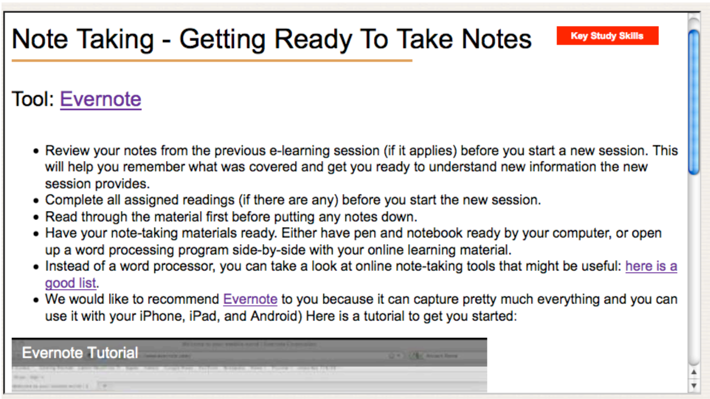

Fig 4: One of the key study skills – Note Taking skill.

3.4 Measurement

One pre-test has been developed with 25 questions for domain-knowledge and 20 questions for meta-knowledge (study skills). Similar to the pre-test, one post test is available with 25 questions for domain knowledge and 20 questions for meta-knowledge (study skills). It is designed to measure the efficacy of each learning mode. Questions are generated based on the content from select mode of each learning concept. For each answer, the system will then give feedback and suggestions according to the test results, and direct the student to focus more in the learning mode in which the student is weak. The aim is to help learners to become more efficient and aware in self-monitoring their learning.

In addition, there is an end-of-unit survey and follow-up structured interviews with 10-15 participants two weeks upon the completion of the study. The survey aims to measure learner experience, usability, user satisfaction and perceived controllability of the e-learning model. At the end of the survey, we invite participants to take part in a 40-min structured interview using Adobe Connect. Participation in the interview is entirely voluntary and has no effect on their grades. The purpose of the interview is to discover more details about the learners' attitudes and impression about the experiment, and give learners a chance to elaborate on the survey results. Questions will also be geared towards whether they find the system and the options provided helpful, in both the domain specific content as well as the meta-cognitive activities, i.e., study skills. It is anticipated that the experiment will conclude by the end of this calendar year (December 2011) and will begin the data analysis phase of this research.

4 Conclusions

This paper has summarized the initial framework of the design of a self-directed e-learning model. Two learning theories - self-regulated learning theory (SRL) and experiential learning theory (ELT) serve as the instructional design structure. The next step in this research will be the continuous monitoring of the actual experiment, collecting and analyzing data. Data concerning learning competency, user satisfaction, system usability, learners' experience, and perceived controllability will be collected and analyzed. As a result of this study, we hope to gain an understanding of how this learning approach and model may be of benefit to learners.

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Models of E-Learning: The Development of a Learner-Directed Adaptive E-Learning System

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Abstract: In many e-learning contexts, materials are designed to be self-paced, with the content being available anytime, anywhere for learners to study independently. Commonly, without the presence and immediate feedback of an instructor, distance learners are left to their own devices to negotiate their learning path and to monitor their own progress. Furthermore, learning a complex topic structured in terms of various media and learning materials requires learners to make certain instructional decisions concerning what to learn and how to go about their learning. In other words, self-paced learning requires learners to self-regulate their own learning(Hadwin & Winne, 2001). Very often, learners have difficulty regulating learning in higher education when topics are complex and unfamiliar and it is not always clear to the learners if their instructional decisions are optimal.(Azevedo, Cromley, Seibert, & Tron, 2003) Research into adaptive e-learning systems has attempted to facilitate this process by providing recommendations, classifying learners into different preferred learning styles, or highlighting suggested learning paths(Brusilovsky, 1998).The aim of this research is to explore how learners can self-directed and self-regulate their online learning both in terms of domain knowledge and meta knowledge in the subject of computer science with a flexible and adaptive e-learning system. Two educational theories: experiential learning theory (ELT) and self-regulated learning (SRL) theory are used to aid learners' in their learning paths. As a result, changes in domain-knowledge, meta-knowledge, learner experience, learner satisfaction, perceived controllability, and system usability are being measured. All in all, this paper sums up the research work being done on the initial development of the system, instructional design framework based on the two theories, experimental design plan and course material examples as well as related issues.

Keywords: adaptive systems, E-Learning, instructional design, learning design

1. Introduction

E-learning has become so prevalent in higher education and corporate training that we have seem every effort being made to reshape and digitized contents online in the past decade or so. E-learning uses the internet to deliver instructions to the learner and it may be argued that one of the most popular forms of e-learning is web-based distance learning (Koohang & Du Plessis, 2004) In many cases, these web-based learning materials are designed to be self-paced, with the content being available anytime, anywhere to allow learners to study independently. Commonly, without the presence and immediate feedback of an instructor, distance learners are left to their own devices to negotiate their learning path and to monitor their own progress. Furthermore, learning a complex topic structured in terms of various media and learning materials requires learners to make certain instructional decisions concerning what to learn and how to go about learning. In other words, e-learning requires learners to self-regulate their own learning(Hadwin & Winne, 2001). Very often, learners have difficulty regulating learning when topics are complex and unfamiliar and it is not always clear to the learners if their learning decisions are optimal(Azevedo et al., 2003). Research into adaptive e-learning systems has attempted to facilitate the learning process by providing recommendations with respect to classifying learners into preferred learning styles and by associating recommended learning paths with these learning styles(Brusilovsky, 1998). Indeed, research has shown the importance of adapting online course material to support learners with different background knowledge and skills(Brusilovsky, 1998; Weber, 1999). Another work has described a user modeling approach that is beneficial to learners who are interacting with complex learning applications in an online environment(Adisen & Barker, 2007).

Broadly speaking, user modeling is a technique employed to provide users with options with respect to performing tasks and interacting with systems differentially. The common variables to model include the user's personalities, abilities, prior knowledge, preferences, performances and intentions(Barker & Adisen, 2005). User modeling can also be defined as a model of users residing inside a system or computational environment(Fischer, 2001). However, many of these models attempt to "match" students with a certain learning styles or learner characteristics that it falls short on placing the initiative on the learners themselves and help them make aware of their own learning and in control of their learning paths. In fact, there has been no evidence in matching teaching to learning styles as the best way to improve learning. Instead, there is an optimal way to teach chunk of content to all students(Pashler, McDaniel, Rohrer, & Bjork, 2008). In this study, our modeling approach is centred around a constructive cognitive model of learning (Liu & Matthews, 2005). This approach involves a model that helps make learning constructive while providing adaptive feedback to learners. As a result, an adaptive e-learning system has been designed that is task-based and support learners to self-direct their own learning paths by choosing the learning preferences (or learning modes as we called them) as they see fit. Additionally, contextually appropriate meta level skills (i.e. study skills) information and tools are provided along with the domain-level material. Adaptive feedback is provided at the end in the form of a self quiz to evaluate whether the learners have progress through their learning with adequate domain and meta knowledge.

The domain we have chosen for this study is in computer science. Specifically, we are conducting our research study within an introductory Java programming course at a distance learning university in Canada. Two relevant educational theories: experiential learning theory (ELT) and self-regulated learning (SRL) have been selected as the underlining instructional design principles for this e-learning system. We will discuss more about these theories in Section 2. Section 3 will cover the planned research and the experimental design in details while Section 4 provides examples of the material we have redesigned to suit this learning approach. Finally we conclude with discussion and future work in Section 5.

2. Background on the two educational theories used

Two educational theories have emerged from authors' experiences in designing e-learning models and reviewing relevant literature in learning preferences and online learning - the Experiential Learning Theory (ELT) and Self-Regulated Learning (SRL) theory. The fundamental ideas underlying the two theories are explained below.

2.1 Experiential Learning Theory (ELT)

Developed in the early 1970's by David Kolb, Experiential Learning Theory (ELT) emphasizes experience as the central focus in learning. Learning-styles theories(Coffield, Moseley, Hall, & Ecclestone, 2004) raised questions about what learning strategies we operate with and how we use learning strategies to enhance student learning. By studying these theories, one can also gain insights into what motivates learners and how to help them to understand more about their own strengths and weaknesses as learners. Kolb's model of learning styles could be represented as "flexible stable learning preferences"(Coffield et al., 2004) as ELT is not about fixed learner traits, but rather a "differential preference for learning, which changes slightly from situation to situation". For instance, a student working in a group setting during a field trip for geo-caching might prefer to take a turn at hands-on interaction with the device even though he would normally prefer reading textual instruction at home alone. In his research, Kolb observed that some students have a definite preference for certain learning activities(Kolb, 1984). For example, one student might prefer reading lecture notes whilst another student might prefer working on an interactive simulation. "From this emerged the idea of an inventory that would identify these preferences by capturing individual learning differences." (Kolb & Kolb, 2005)

Figure 1 shows how a learner can progress through the experiential learning cycle: concrete experience (and new information acquired) is translated through reflection into concepts, which are in turn used as guides for active experimentation and the choice of new experiences. Kolb stated that a learner can begin the learning cycle at any one of the four modes, but that learning should be carried on as a continuous spiral. As a result, knowledge is constructed through the creative tension among the four modes and learners will be exposed to all aspects of learning: experiencing, reflecting, thinking and acting.

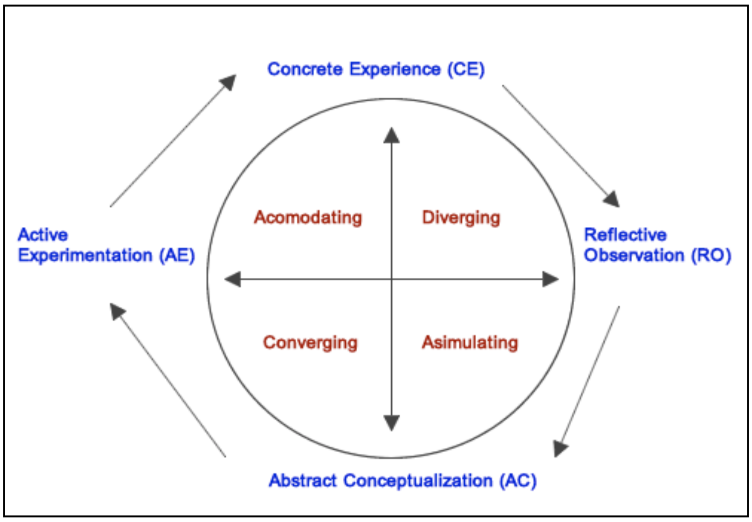

Figure 1. Kolb's Experiential Learning Cycle

Furthermore, there are four dominant learning styles that are associated with these modes: converging, diverging, assimilating and accommodating(Kolb, 1984)

Our research is grounded in individualized instruction and the intention is to make explicit to the learners why we are employing this instructional design approach. To further Kolb's take on distinctive learning preferences and to be able to provide options on learning activities accordingly, ELT has been used to design task-level content and skills in Java programming along the two dimensions of Concrete Experience-Abstract Conceptualization (CE-AC) and Reflective Observation-Active Experimentation (RO-AE). Content for the Java programming course has been redeveloped to present the course online content along the four modes of learning. The four modes of learning will be discussed in details in Section 3.

2.2 Self-Regulated Learning (SRL) theory

Self-Regulated Learning (SRL) fits in well with a learner-initiated e-learning model because in an individualized learning environment, learners are often left to their own devices, and a flexible e-learning system can help make them aware of their own thinking, monitoring, planning and evaluating personal progress against a standard, and motivation to learn(Boekaerts & Corno, 2005; Butler & Winne, 1995; Perry, 2006; P.H. Winne & Perry, 2000; Zimmerman, 1990). When learners adapt their approaches to learning, learning is said to be self-regulated(Winne, 1997). Self-regulated learning (SRL) states that learners not only need to regulate their performance, but also how they learn. Literature shows that self-regulation can positively affect learners' achievement(Azevedo, 2005). Self-regulated learning (SRL) is "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior" (Pintrich, 2000). Furthermore, Hadwin, Wozney, & Pontin (2005) revealed that 'ordinary' collaboration (as found in traditional online forums and chats) is insufficient to transform learners' everyday "reflection" into productive "regulation".

What sets self-regulated learners apart is their awareness of when they know a skill or fact and when they do not, at a meta knowledge level - i.e. they plan, set goals, organize, self-monitor, and self-evaluate thorough out their studies(Zimmerman, 1990). In addition, self-regulation works best when learners are provided with continual feedback concerning the effectiveness of their learning approach. This is something that an adaptive system can provide as it can support and reinforce self-monitoring techniques as well as self-regulated learning strategies. We mainly focus on this aspect of self-regulation in relation to the design of an e-learning system wherein students can receive feedback if they choose to do so.

Our model's SRL interface includes components that allow students to self-reflect along with components that engage them in self-regulation. On one hand of the spectrum, self-reflection could be as simple as a thinking process made self aware, the intangible 'ah ha' moment of a conceptual breakthrough; on the other hand, self-regulation could be more tangible as a system or a tutor can observe what students do after they self-reflect. For example, in debugging, a student can self-reflect on errors identified by the compiler at the end of each compile of the program being developed. The system can track/record the number of errors and warnings faced by the student at the end of each compile. The system can also classify the types of errors encountered by a single student over multiple sessions of program development. Looking at this list of errors is an act of self-reflection. However, self-regulation takes it one step further. The student may try to identify most common errors and warnings he/she faced, take notes on how he/she resolved these common errors and warnings, and refer to these notes when he/she encounters these common errors and warnings when writing another program. This "proactive self-reflection" is what we identified as self-regulation even thought at this stage, we are not planning on tracking the end results of using the study skill tools, it is the provision of these "how to" study skill guides and tools embedded as options for students to assist them in becoming better self-regulated, self-reflected learners that we are interested in.

3. Program of research

3.1 Participants

In order to undertake this program of research, 60-80 voluntary participants who enroll in COMP 268 - Introduction to Java Programming course at a distance learning university in Canada will participate in the study. The participants are adult learners in various age groups with various programming skills. This is a *100 level* (all introductory computer science courses start with the number "2" at this institution) course and there is no prerequisite. We expect participants to have at least basic computing and distance-learning skills.

3.2 Material and procedure

One unit from COMP 268 - Introduction to Java Programming course consists of five learning concepts has been redesigned and redeveloped to presents a series of learning activities designed according to the ELT theory - i.e. the material has been designed to be presented in four different learning modes: watching, discussing, diagramming, and trying out. These four modes correspond to ELT's four learning dimensions as discussed in Section 2. For example, for "watching" mode, the material might be presented in a YouTube video tutorial with narration and textual explanation. A learner is free to choose any of the learning activities to begin his/her study. The system doesn't initiate or suggest any particular learning paths. The idea is that we are giving the learner complete control with respect to which learning activity suits his/her learning preference at the time of the study while providing learning options. According to ELT, a learner can begin at any stage of the learning cycle, but it is most beneficial for acquiring new knowledge if he/she would go through them all eventually to fully understand and apply this new knowledge. He/she might or might not choose to go through them all; the decision is his/her to make. If at the end of any chosen learning activity, the learner feels that he/she has a good grasp of the material, he/she can opt to skip the rest of the cycle and go to the next topic. A post-test is available at the end of the unit for learner to self-assess his/her knowledge both at the domain and meta level. In another word, learners can test how well they have learn a certain programming concepts in Java as well as whether the associated key study skills are helpful to them in regulating their own learning and deploying them as learning strategies. The post-test is a formative test and it will not affect the participants' grade in their overall course performance.

In addition, as supplementary learning material, a SRL theory based interface titled "Key Study Skills" is available on the upper right-hand corner of the webpage to assist with learning about meta knowledge. Meta knowledge in terms of key study skills for studying programming have been selected as: note taking skill, reflection and discussion skill, conceptualization skill, and problem solving skill. For example, within the "Watching" activity, the key study skill we emphases is "note taking". Learners can choose to access this supplementary material at any given time during his/her study. The design consideration is that the key study skills appear as an unobtrusive interface that sits on the upper-right-hand-corner of the main content. Learners can choose to engage and learn how the "note taking" skill helps with the "watching" activity (i.e. how to take better notes while watching a tutorial video online and what are the appropriate tool to use for note taking), or he/she can just ignore it and carry on with watching the YouTube tutorial video on its own.

One pre-test has been developed with 25 questions for domain-knowledge and 20 questions for meta-knowledge (study skills). In this test we are looking at two types of data:

1. Test score for the domain-knowledge - to gauge how much a student has already know about control structures in java programming prior to this unit. This test score will be compared to the post-test domain-knowledge test score.

2. Test score for meta-knowledge (study skills) - to gauge a student's study skill competency. This is more of a self-report rather than an objective measurement of specific study skills. This test score will be compared to the post-test meta-knowledge test score to identify whether the study skills provided help improve students' overall study strategies and make them aware of certain meta-level skills.

Similar to the pre-test, one post test is available with 25 questions for domain knowledge and 20 questions for meta-knowledge (study skills). It is designed to measure the efficacy of each learning mode. Questions are generated based on the content from select mode of each learning concept. For each answer, the system will then give feedback and suggestions according to the test results, and direct the student to focus more in the learning mode in which the student is weak. The aim is to help learners to become more efficient and aware in self-monitoring their learning.

It is intended that there will be an end-of-unit survey and a follow-up structured interviews with 6-10 participants two weeks upon the completion of the study. The survey aims to measure learner experience, usability, user satisfaction and perceived controllability of the system. At the end of the survey, we will invite participants to take part in a 40-min structured interview using Adobe Connect. Participation in the interview is entirely voluntary and has no effect on their grades. The purpose of the interview is to discover more details about the learners' attitudes and impression about the experiment, and give learners a chance to elaborate on the survey results. Questions will also be geared towards whether they find the system and the options provided helpful, in both the domain specific content as well as the meta-cognitive activities, i.e., study skills.

3.3 Research questions

This study was designed to answer the following research questions:

1. How would the two named learning theories, ELT and SRL, be useful in the production of constructive adaptive system?
2. How might such a system be tested and evaluated in a real context?
3. What are the effects of such a system on:
    - domain-knowledge competency
    - meta-knowledge competency
4. What are the effects of such a system on:
    - learners' experience
    - system usability
    - user satisfaction
    - perceived controllability

3.4 Modeling approach

The form of modeling we used is a learner-directed model. A learner initiated system as a system that places full learning control in the hands of the learner. The system does not automatically adapt or assign any differentiated content to the learner(Marzano, 1992). Simply put, the system serves a suggested guide to the learner where he/she can accept or reject the suggestions. This approach enables personal autonomy, active involvement and engagement with the content and serves as a motivational factor for online learning. For learning styles, learners will self-select from the multiple learning content representations, so there is no need for an automated system intervention. For prior knowledge and skills, the comparisons of the pre-test and post-test results will inform the system as to what to recommend and adapt at the end. If the post-test results indicate a deficiency in certain domain knowledge area, then the system will provide appropriate feedback to the students. It is not so much a specific prescription; rather, it is used as reference guide.

4. Example of the course

Prototype of the e-learning system has been developed in Moodle (an open source Learning Management System) providing alternative content for Unit 3 of the course for our study. Traditionally, Unit 3, similar to the rest of the course, is written in a linear, textual format with heavy reference to the textbook.

Currently, after the redesigned of the unit, unit 3 composes of five learning concepts and each concept starts with the same home page interface that present the four modes of learning. The five learning concepts are: *If-Else Statement; Loops; Break, Continue, and Return; Switch, Try-Catch-Finally, and Labels*; and *Recursion*. Figure 2 below illustrates the Unit 3 layout design for the course while Figure 3 shows the home page of each learning concepts.

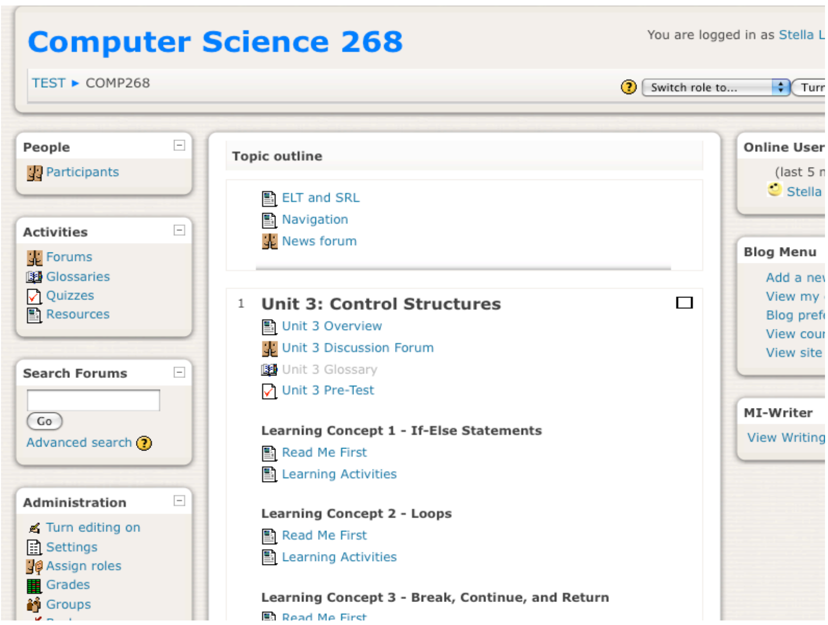

Figure 2: Unit 3 home page as viewed by students entering into the experiment

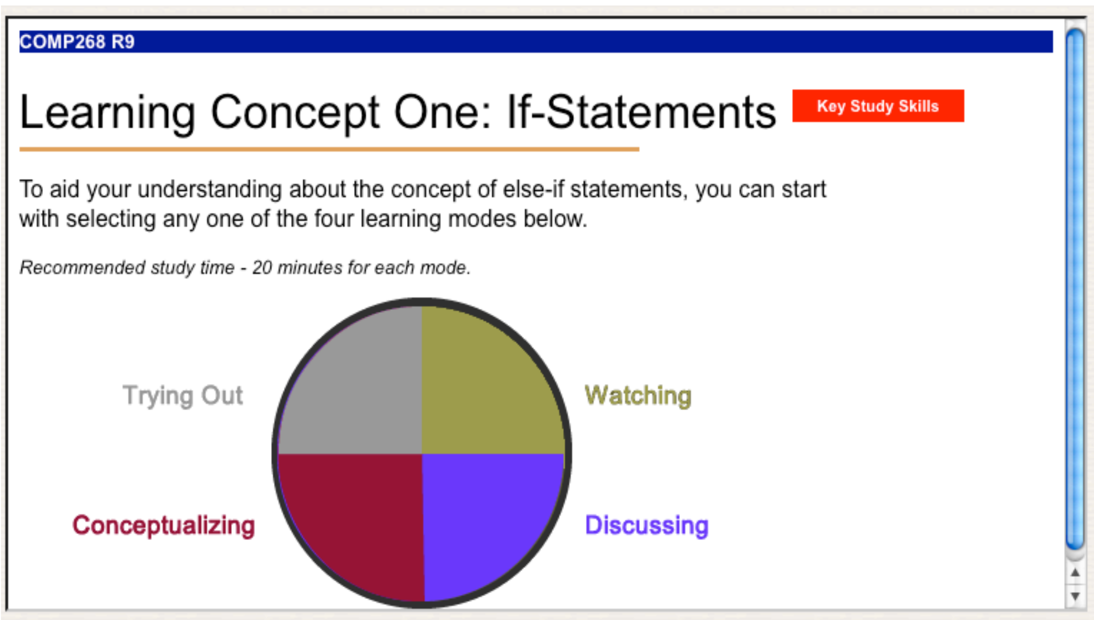

Figure 3: Home page for learning concept 1 - If-Else Statement.

Once a student access the learning concept home page, a circular wheel interface with four quadrants will be presented to them. Each quadrant is linked to a different but comparable learning activity based on Kolb's experiential learning cycle: experiencing, reflecting, thinking and acting. For instance, the experiencing, the learning activity is presented as a series of tutorial videos on YouTube on how to program If-Statements (see figure 4).

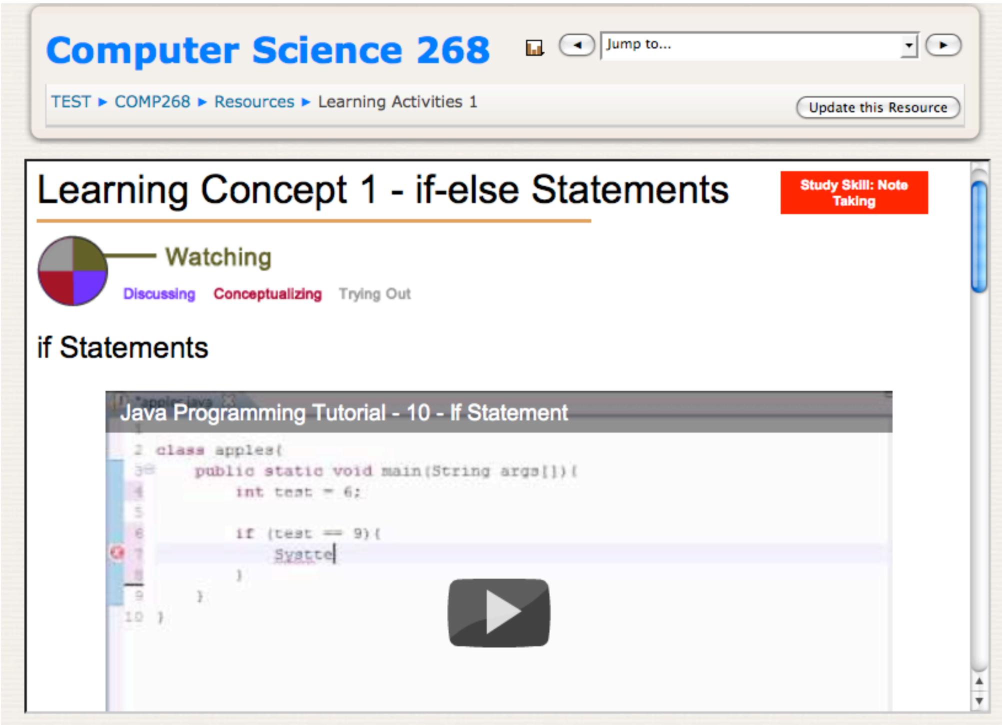

Figure 4: YouTube tutorial videos on how to program If-Statements under the "Watching" quadrant learning activity.

Twenty study skills --five successive skills for each of the four learning modes-- have been developed. The four key study skill areas we focus on are: note taking, communications, conceptualizing, and problem solving skills. Each study skill is paired with a tool for learners to try out and practice these skills. Figure 5 shows that the Note Taking skill is being presented with Evernote, a note-taking software. The rest of the study skills are paired with the following: communications – Moodle discussion forum; conceptualizing – FreeMap (mind mapping tool); and problem solving – BlueJ (an integrated development environment tool).

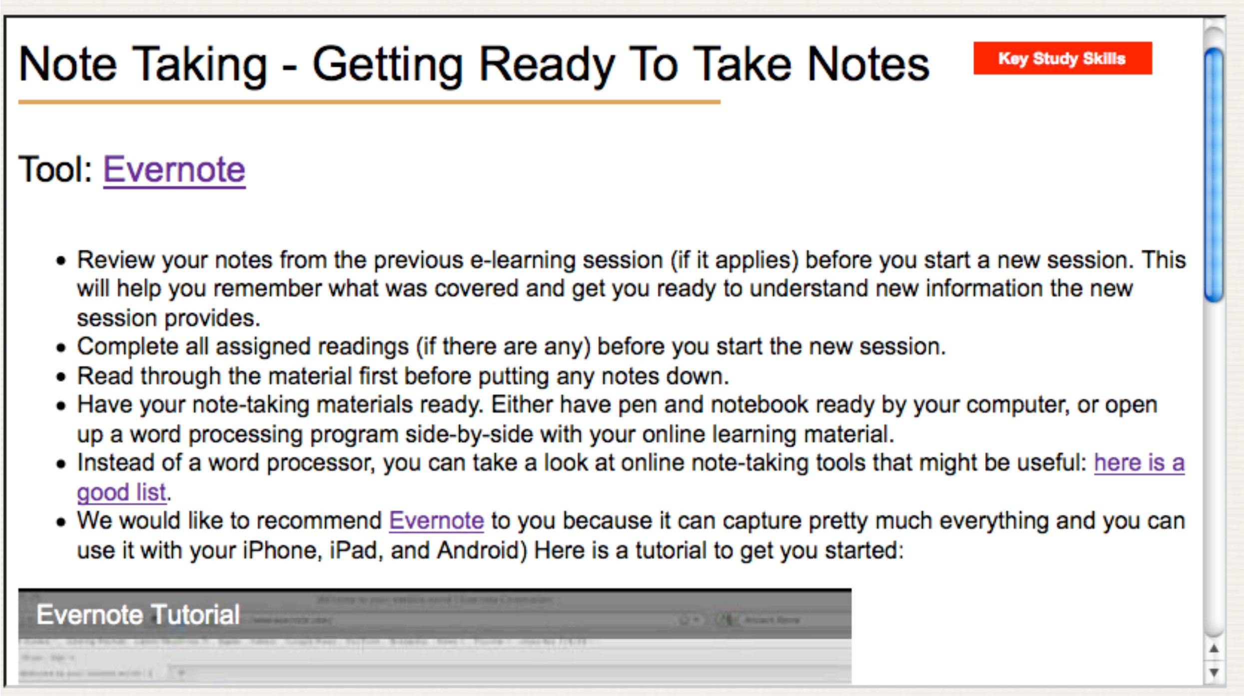

Figure 5: One of the key study skill – Note taking skill along with suggested tool to use.

5. Discussion

The research reported here relates to the design of a quite significant implementation of an e-learning system in a pragmatic educational context based on constructive models of learning. The approach differs in several ways from other approaches we have used in the past. In the first place the modeling approach is intended to foster a constructive approach to learning. To this end two learning theories have been employed in the design of the system. Modeling approaches we have used in the past have been to some extent instructive in that they have been used (Adisen & Barker, 2007; Adisen, Barker, & Britton, 2004; Barker, Jones, Britton, & Messer, 2002; Brusilovsky, 1998). In the authors' opinion, e-learning 2.0 implies self-directed learning and a student taking personal responsibility for his or her learning. The question remains: *how can a system based on a modeling approach foster constructive rather than instructive learning?* The ways that student models have been used in the past to recommend or prescribe presentation can be seen as fostering instruction rather than construction of knowledge. Secondly in our approach the model we use relates directly to the tasks that learners are undertaking and their approaches to them, rather than to models of an individual learner. Our modeling approach does not attempt to model the characteristics or knowledge of a learner, but rather models the relationship between the task the learners are undertaking and the level of confidence, skill and general strategy they are using. The support and presentation strategy provided for learners is therefore not intended to deliver instruction differentially based on settings of a student model, but rather is intended to help the learner to construct his or her own learning path through the material in order to solve a problem or to learn new material related to a problem. The use of learning theory or cognitive style was previously used in our research to classify or categorize learners(Barker et al., 2002). In the current approach we have avoided this method and have instead modeled the tasks and the approaches to solving them that best fits the needs of an individual learner. In the next stage of the research a full-scale evaluation of the initiative is currently underway with learners at an online university in Canada. It is hoped to gain an understanding of how this approach may be of benefit to learners.

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Approaches to Student Modeling in the Context of e-Learning 2.0

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Abstract: This paper reports on the development of a student model suitable for use in a web based adaptive educational system. Previous research has related to the use of co-operative psychological models used in adaptive educational multimedia based on learning style, language and other psychological descriptors (Barker et al., 2002). More recently we have developed and tested adaptive student models that relate to the visual and verbal skills of learners (Adisen and Barker, 2007). In this work, important verbal and visual factors were identified and tested using statistical methods. Factor analysis was used to produce a student model capable of implementation in adaptive web-based e-learning systems. In the research reported in this paper, the next stage of this research is presented. This work presented is based upon a summary of our previous findings and is taken in the context of recent developments in web 2.0 technology. It is hoped to relate our models to the use of student models in a variety of real world scenarios. A feature of psychological student models is the wide range of contexts in which they are used. For example such models may be used in relative isolation, one student with one computer. We have found this sort of modeling often to be problematic and to rely on many assumptions that the system developer and pedagogical designer must make. Our previous work has shown that co-operative student models rely on far fewer assumptions and enable rich and complex dialogue between learners, computers and teachers (Barker et al., 2002). With this in mind we have produced a series of scenarios related the functions and properties of such co-operative models within a variety of the various contexts, for example student working co-operatively with teachers, students working in groups with other learners and teachers working with groups of learners. The richness of the new e-learning 2.0 paradigm necessitates a deeper understanding of the ways in which learning takes place by means of computers. In these cases the simple student model must be extended, we argue, to take into consideration this richness and diversity. In this paper we present our ideas of how this might be achieved and suggest a new student modeling approach for use in these circumstances.

Keywords: Co-operative student model; e-learning 2.0; scenarios.

1 Introduction

In Higher Education today, and in general teaching and learning, an ever increasing reliance is being placed upon the use of online learning (Dearing, 1997; DfES, 2005). This has resulted in a proliferation of online educational computer systems to manage, assess and deliver teaching and learning. Often such systems perform these functions in an entirely undifferentiated way, whereby all users have exactly the same view of the system as any other. With the development of increasingly large and complex computer applications, the advent of web 2.0 technology and greater diversity in learner groups, the consideration of individual differences has become an important issue in designing usable and useful applications. In face to face teaching, a good teacher is able to adapt presentation to the learning needs and styles of the learners they are teaching. The ability to do this well is a great skill and it demands speedy feedback and sensitivity to the characteristics and needs of learners and how this affects teaching strategy. This is becoming increasingly difficult with large class sizes. Indeed many lectures at the author’s own institution have more than 200 learners. Practical classes may have as many as 70 students working individually or in groups at the same time in a single computer laboratory. It is possible however, by means of a range of modeling techniques within the domain of Artificial Intelligence and the use of high powered computers that the management and delivery of teaching and learning may be individualized. A computer has the '*capability'* learn a great deal about the characteristics, skills and abilities of a user and to apply this to the delivery of teaching and learning. This information may be made available to teachers or to instructional computer environments for the configuration of the presentation of learning (Barker et al., 2002). Barker and colleagues were able to show that it was possible to accommodate a range of learners with differing skills, motivations, learning styles and approaches to learning, by means of a student model of learner characteristics used in conjunction with an adaptive multimedia computer system.

The aim of this paper is to present an empirically based modelling approach and a related student model that it is hoped will be useful in future

2 Student models

A student model is a type of user model that is intended for use in an educational teaching and learning context. Ragnemalm (1996) distinguishes between students models that contain students' actual domain knowledge to those that contain student characteristics. A wide range of modeling approaches are available to the software developer according to Ragnemalm. Student models therefore may hold information that relates to the knowledge a user has in a particular domain, their personality, preferences, individual skills, learning or cognitive styles and in fact any information about the user that may be useful in configuring a computer application for individual use. Adaptive systems often rely upon the performance or interactions of a user to check on progress as students use and interact with the application. In this way the student model may be updated automatically to reflect any changes in performance, interaction or preference.

An important distinction exists between student models that are based on the performance of a learner within a domain and those based on user characteristics. The first type of models are sometimes referred to as *overlay models* as they compare the *'knowledge'* of the learner with that of the expert model, embedded in the system, based upon performance. A delivery model is then used to deliver aspects of the domain, the intention of which is to reduce the difference between the student model and the expert model.

Models based on student characteristics on the other hand, are often referred to as psychological models. They may hold general information about the characteristics or '*global descriptors*' of a student such as language skills, intelligence, motivation, learning style or preference, in fact any characteristic of a learner that might prove useful to the system in order to configure the presentation or management of learning.

Brusilovsky has suggested that some features of psychological student models must be provided by the user as they are too difficult to deduce from interaction alone (Brusilovsky, 1996). Such models are referred to as being collaborative or cooperative. Also many psychological characteristics of a user such as such as intelligence or learning style cannot easily be implied from user interaction alone. Collaboration is often based upon user's input and may take place at one or more of the three main stages in the development and application of user modelling; data collection; application; presentation stage (Vassileva, 1996).

3. Our approach to student modeling

In this section is presented some examples of our previous research on the use of student models in adaptive computer systems.

3.1 Psychological student model in multimedia application.

In this research, Barker and colleagues (2002) established a psychological student model that was comprised of descriptors related to language skills, cognitive level - based on Bloom's taxonomy

(Bloom, 1957), support level (scaffolding), task level – the level at which tasks were set for learners and question difficulty level. This model was implemented in an educational multimedia application to deliver and assess basic skills in UK Higher Education Colleges. It was found that a cooperative approach was valued highly by teachers. Figure one presents a diagram of the model (Barker et al., 2002). The learning application itself was developed to run over a PC network. A simple database application was employed located on a central file server to hold the values of the student model for learners. Learners were required to log in, so that they might use the application which configured presentation of the multimedia material individually, based upon the values held in the student model. It was also possible to collect user data unobtrusively and securely at any time from the file server.

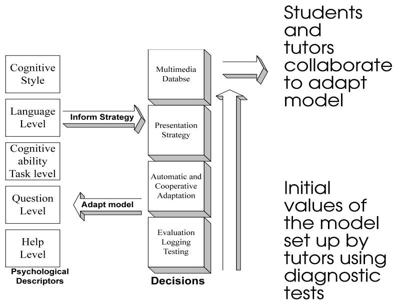

Figure 1. Psychological student model employed in a multimedia application.

The model was used quite successfully. It was concluded that the characteristics of learners employed in the student model represent a balance between the need for automatic configuration of variables, as in language and cognitive style and their co-operative configuration, as in task, question and help levels. In this way important aspects of learning that could best benefit from computer-based control were differentiated from those aspects of learning that required and benefited from human input. The research showed that, by and large, a balance was achieved that supported a high quality learning experience that was of benefit to all the stakeholders involved in the process. A major limitation of this research was the relatively inefficient way that the model had to be adapted and updated cooperatively.

3.2 Computer Adaptive Testing used to develop a student feedback model.

This study related to the use of Computer Adaptive Testing (CAT) in order to configure an adaptive student model intended to deliver appropriate individual feedback to learners following undergraduate Computer Science degree courses. Initially a CAT application was developed and is reported by Lilley and colleagues (Lilley et al. 2004; 2006). The application comprised a graphical user interface, an adaptive algorithm based on the Three-Parameter Logistic Model from Item Response Theory (Lord, 1980; Hambleton, 1991; Wainer, 2000) and a database of questions. This contained information on each question, such as stem, options, key answer and IRT parameters. In this work, subject experts were employed for question calibration. The subject experts used Bloom's taxonomy of cognitive skills (Bloom, 1957; Anderson & Krathwohl2001) in order to perform the calibration. Questions were first classified according to cognitive skill being assessed. After this initial classification, questions were then ranked according to difficulty within each cognitive level. Table 1 summarises the three levels of cognitive skills covered by the question database and their difficulty range. It can be seen from Table 1 that knowledge was the lowest level of cognitive skill and application was the highest. An important assumption of our work is that each higher level cognitive skill will include all lower level skills. As an example, a question classified as application is assumed to embrace both comprehension and knowledge.

Table 1: Level of difficulty of questions

Difficulty *b*	**Cognitive Skill**	**Skill Involved**
$+1 \leq b \leq +3$	Application	Ability to apply taught material to novel situations
$+1 < b < -1$	Comprehension	Ability to interpret and/or translate taught material
$-1 \leq b \leq -3$	Knowledge	Ability to recall previously taught material

Figure two presents a view of how the model was used and the relationships between its parts.

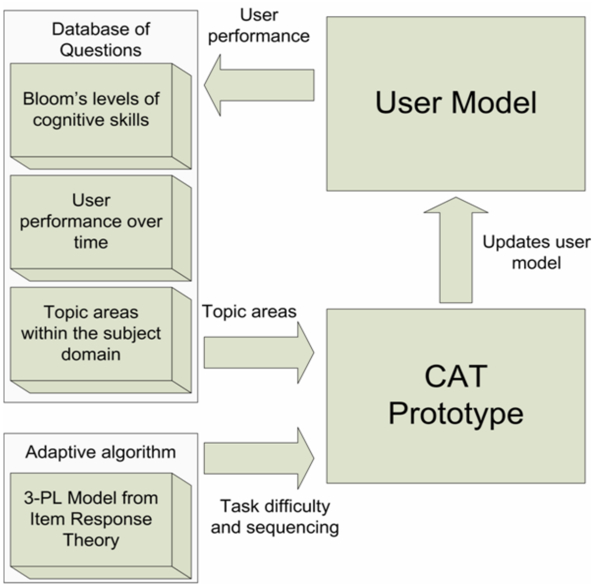

Figure 2. Student model based upon a CAT system showing the relationship between the various parts.

The user model was used to deliver individual feedback to learners based on their performance on the CAT. The systems employed a question database, a feedback database and a feedback delivery system. The adaptive feedback system shown above had several benefits. It was tested and evaluated by staff and students and shown to be effective and generally valued. Feedback was individual, as it was based on an adaptive test. No two students would be expected to have the same test, thus feedback would also be individual. Feedback was also set to and delivered at the most appropriate level for each individual learner and it was also related to Bloom's cognitive domain, an additional benefit. So far we have successfully used the CAT / feedback system in computer programming, English language, civil engineering, human-computer interaction and multimedia. We intend to further develop the CAT feedback system for even wider use.

3.3 The development of a psychological model based on verbal and visual skills.

In this study an empirically based student model was developed, based on the verbal and visual skills of a learner (Adisen and Barker, 2007). The skills required to interact with complex computer based and online applications are often very different from the traditional working and learning skills that served computer users in the past. A new set of visual and verbal skills are important in organizing processing and communicating information while interacting with increasingly complex computer applications. According to Schnotz, et al. (2002), texts and graphics are complementary sources of information insofar as they contribute in different facets in the construction of a domain based mental model. For these reasons it was decided to establish a student model that accommodates different levels of visual and verbal abilities. Based on previous experiences in modeling and a survey of relevant literature (Adisen et al., 2004; Adisen & Barker, 2007), a set of visual and verbal skills were identified as likely to be important in performing tasks and interacting with complex computer applications. Table 2 presents the list of visual skills and table 3 presented the verbal skills we identified as likely to be important in performing complex computer-based tasks. The terms Verbaliser/Imager and Wholist/Analytic mentioned in tables 2 and 3 below are dimensions of Ridings Cognitive Style system and candidates for a student model (Riding, 1997; Riding & Watts, 1997; Adisen & Barker, 2007).

Table 2. Important visual skills required to perform complex tasks

• Remember an image and compare with the one seen earlier • Compare an image with one present on the screen at the same time • Remember details of an image not present on the screen • Adoption of a Verbal or Image strategy when solving computer-based problems • Adoption of a Wholist or Analytical strategy when solving computer-based problems • Analyze information contained in a graph or chart • Remember verbal instructions about an image no longer present on the screen and perform tasks • Remember verbal instructions about an image still present and perform tasks • Remember and estimate the size of an image not present on the screen • Rotate and manipulate an image present on the screen mentally • Remember objects in an image not present on the screen and compare to other similar images

Table 3. Important verbal skills required to perform complex tasks

• Answer a question related to a passage of text present on the screen • Answer a question related to a remembered passage of text no longer present on the screen • Answer questions regarding a spoken passage of text • Complete sentences with the most appropriate selection from a list of missing words • Find analogies between words • Find antonyms of the given words • Find synonyms of the given words • Answer questions that require analytical skills • Recall a list of words presented on the screen

- Recall a list of words presented aurally
- Perform tasks according to verbal instructions

For use in a student model, the list of verbal and visual skills presented in tables 2 and 3 was too long. It was therefore decided to develop tests to measure these skills in computer users and then use correlation and factor analysis in order to reduce the number of variables. In this way it was hoped to remove redundancy in the model and to produce a smaller model that might be implemented efficiently. Details of this approach are described by Adisen & Barker (2007).

There were five independent visual factors were identified for potential use in a student model:

- Factor 1: Analyzing information given in image or graph format
- Factor 2: Predicting information based on an image
- Factor 3: Self reporting on Wholist/Analystic cognitive style dimension
- Factor 4: Remembering information presented earlier
- Factor 5: Self reporting Verbalise/Imager cognitive style dimension

Four independent verbal factors were identified for potential use in a student model:

- Factor 1: Finding the synonyms and antonyms of the given word
- Factor 2: Analytical skills required to recall information
- Factor 3: Completing sentences
- Factor 4: Ability to recall spoken information

An adaptive computer application is currently under construction to implement and test a student model based on the above factors with the addition of language skills in the model based on the findings of Barker et al. (1999). In order to achieve this it was first necessary to consider how such a complex student model might be used in a real educational context. This is by no means a simple matter as it relates to the individual learning styles of a learner (Rasmussen & Davidson-Shivers, 1998), the context of the application, the types of objects that learners have to interact with and tasks they have to perform. Also there are many ways in which learners are able to interact with teaching and learning applications, for example interaction with other learners (as in web 2.0 applications) and with teachers. In this paper we present some ideas about the last of these problems in the form of ten hypothetical scenarios.

4. Scenarios for the use of a Student Model

In the following section, we provide suggested scenarios for the use of an adaptive student model in the context of the use of modern complex computer applications.

4.1 Scenario one: One learner working alone with the system

This is perhaps the commonest application of educational computer systems. Students will often wish or need to work alone, at home or in a learning centre. The student model should be able to identify when this is the case and set up the system in such a way that it is optimized for an individual learner. Managed learning environments (MLE) for example are designed primarily for a single user to access the system and to undertake task, manage their activities and learning, enter into discussions and communicate with teachers or fellow students. Generally speaking learners have an undifferentiated view of the system, each learner seeing an identical system. The underlying assumption of the system designer for the most part is that learning is an activity undertaken by a single student sitting at a single computer. Although students sometimes use MLEs in ways different from this, it is clear that the designers of such systems make little provision for this.

4.2 Scenario two: One learner and one teacher working together

In this scenario, there is a one-to-one interaction between a teacher and a learner in order to perform tasks. Here, the teacher might be acting as a guide rather than the *centre-stage sage* in directing the learner's learning paths. In this way there is cooperation between the user(s) and the application. This could relate to project work/supervision or practical assessment for example. The application should recognize the learner and the teacher and be able to accommodate both users and their individual styles of use and preferences. It would be ideal if an application could accommodate and adapt to multiple inputs from networked computers. Cooperation and adaptation might be direct and negotiated between learner and teacher.

4.3 Scenario three: Two learners with similar intellectual and prior knowledge working together (peer to peer).

This is a common scenario. Learners often work together in pairs to solve problems, learning from each other. A system should be able to access the student models of both learners and to integrate these into the context of their use. For example they may be seated next to each other working on one computer, seated next to each other using several networked computers or separated by space. Learners may cooperate with the system and with each other. A system should be able to recognize this situation and provide options for pairs of learners to set up and modify the system in individual ways.

4.4 Scenario four: A group of three or more learners using the system.

Group work is becoming increasingly important in teaching and learning. Not only is it an important way to facilitate learning, it is also a life skill. Knowing how to interact with others in appropriate ways and how to work in a team are vital skills in life. Team working is also an important skill at work. In real work situations rarely do we work in isolation. Adaptive computer systems need to adapt to the individuals within a group, irrespective of the complexity of the shared interface, to access the student models of individuals and to update both individual models and a group model that will be useful in future interactions with the same group. Members may come and go flexibly and their interactions be situated in different spaces and different times. The system should be able to handle the complexities of these interactions.

4.5 Scenario five: One instructor with a group of learners using the system.

It should also be possible for groups to work together with a teacher (or even more than one teacher) in a range of contexts and a range of interaction styles. The application must be able to recognize and deal with the nature and complexities of these situations and to establish and optimize conditions, update multiple models and handle the complexities of separation in space and time.

4.6 Scenario six: One advanced learner working as a mentor with one novice learner

Mentoring is an important skill that may be beneficial to both mentor and mentee. A computer system should recognize this situation and be able to differentiate it from peer to peer working or from working with a teacher. An important difference might be the level of cooperation and how the models of both mentor and mentee respond to the interactions.

4.7 Scenario seven: One, two or several learners with a mobile device

An advanced system should be able to interact with the increasing array of mobile devices that may connect and communicate with the system. The system may be located on a networked computer or indeed on a mobile device itself. Mobile devices may include both input and output features, for example a podcast and a series of questions might be presented on the device. The learner may answer through the mobile device some time later. It should be possible to make use of and update the student model based upon interactions such as this. A natural extension would be for several learners to be linked together undertaking group work by means of such devices. The system should be able to handle the complexities of these interactions not only updating individual models but also maintaining a group model that might be useful later.

4.8 Scenario eight: One or more learners performing off-line tasks with the system's help

It is important to recognize that not all computer-mediated tasks are performed on a computer (Barker et al., 2002). An adaptive computer system should be able to recognize this situation, establish off-line tasks, accept data on the outcomes of such tasks and update single or multiple models accordingly. It should also be able to accommodate interaction style and styles of work in the ways outlined in sections 4.1 to 4.7 above.

5 Conclusion

The nature of the tasks that learners undertake on computers to solve problems, involve assimilating information in a wide variety of formats from diverse sources. The use of interaction, text, image, audio and video as well as social and group working skills are important components of understanding how students learn today. They also work in new ways with new tools and in new situations and contexts. From this it can be seen that not only is it important to have a useful student model, it is also important to consider and accommodate flexibly the ever increasing contexts and modes of working and learning on adaptive systems.

In the above section we have provided scenarios which we intend to use in order to implement our new student model. The model we are developing is based on ideas outlined in sections 3.1, 3.2 and 3.3 above. It was important for us to realize that the ways in which learners interact with and perform tasks on computers is rapidly changing. Not only are tasks more complex and multi-dimensional, they are increasingly framed in a social context. Computers may be seen as shared resources where learners may be seated next to each other, or separated by time and space. The development of adaptive student models to facilitate these changes must be as flexible as the uses to which the systems are put. The use of cooperative psychological models will enable understanding in one domain to be passed to other domains. The incorporation of overlay type student models based on adaptive testing will allow the development of general strategies that might be applied in a range of subject areas (Barker, 2006). A major limitation of domain-based models is that they cannot readily be applied to other domains. The use of CAT levels ensures that generalized presentation strategies may be employed based on the CAT levels that may be applied widely over many domains. Finally the psychological factors identified in section 3.3 are empirically derived and tested (Adisen & Barker, 2007) and relate directly to important skills that learners require when undertaking tasks with scenarios such as are presented above.

The research summarized and presented here stretches back more than 15 years. During that considerable time the researchers have formed some general opinions related to the student modeling process which, although untested, may be of interest to researchers and practitioners or at least present a focus for discussion.

Flexibility: It would be important to have options with which learners and teachers might disable and enable aspects of the student model from time to time. Flexibility of use is an important message that has come through our research and adaptive systems must not mark a return to the days of highly instructive learning environments.

True cooperation: Although the model should be able to recommend and adapt virtual environments for learners based on the settings of the student model, this should be a two-way process. Learners should be able to have control over whether they accept or reject the recommendations/adaptation. In addition, learners might *improve* on the model by ranking or re-ranking the model's recommendations and by sharing or discussing the model's recommendations with others.

Environment: It is important that student models do not micro-manage the learning environments of learners**.** Learners should be able to control their own learning environment to a greater extent. For example issues of text size, style and colour are best left to the learner to control as are issues of layout of pages. The model might recommend, but the learner should decide.

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Design of an adaptive learner-directed model for E-learning – Ascilite poster presentation

Abstract

This research examines how and to what extent an adaptive system can aid learners to be effectively self-directed and self-regulated for online studies both at domain knowledge level and meta knowledge level in the discipline of computer science. Two learning theories - experiential learning theory (ELT) and self-regulated learning theory (SRL) - act as an interlaced framework underpinning the adaptive model.

Aim

Our research aims to interlace ELT and SRL theories into the design of an online adaptive learning system where learners are presented with options as to what to learn, how to learn, and whether they are aware of what they know or do not know of a new skill set.

Research Questions

- How can an adaptive system help learners to improve skills at domain knowledge level by providing theory-centric variation (ELT) in concept learning acitvities?
- How can an adaptive system help learners to improve skills at meta knowledge level by providing theory-centric varaitons (SRL) in meta-cognitive activities?
- How do the interlacings of cognitive learning and metacognitive learning activities affect learning experience?

Design of a Self-Directed Learner Model for E-Learning
An initial framework

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Two Theories

Experiential Learning Theory (ELT)

This theory presents a cyclical model of learning, consisting of four stages:

1. ***Concrete Experience (CE)***
2. ***Reflective Observation (RO)***
3. ***Abstract Conceptualization (AC)***
4. ***Active Experimentation (AE)***

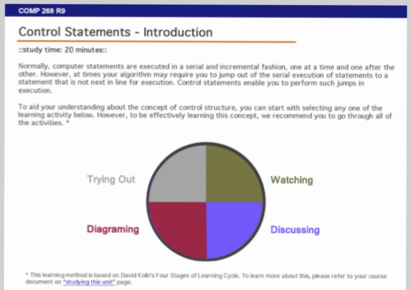
Knowledge is constructed through creative tension between the four modes and learners will be exposed to all aspects of learning: observing, reflecting, thinking and trying out.

Self-Regulated Learning Theory (SRL)

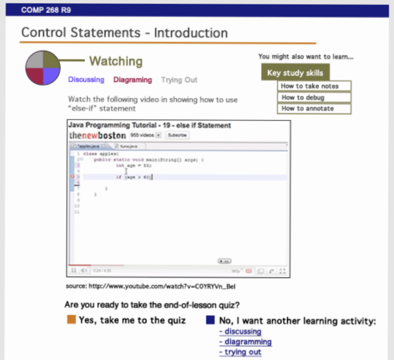
- learners need to regulate their performance along with how they learn
- self-regulation works best when learners are provided with continuing feedback concerning the effectiveness of their learning approach
- adaptive system can support and reinforce self-monitoring techniques and self-regulated learning strategies

Model Design & Prototype

When learners log into the website they will be presented with the unit objectives, a pre-test to gauge prior knowlege, and the "read this first" common study material before coming to this screen where they have the option to choose what and how to learn:



Once a learner selects an ELT "learning activity" to perform, the screen will also present a SRL adaptive "key study skill" interface on the upper-right-hand corner to support their learning.



Giving Learners Control through Interaction Design

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Abstract: The design of learning environments should cater for the needs of diverse online learners and give learners control over their own learning, but it is not enough simply to provide choices: without the associated power to make informed decisions too many choices are, if anything, worse than no choice at all. Without guidance, bad choices may be made and, even when correct, the learner may be insecure about the outcomes. To be in control, the learner must be able to delegate some control to others more able to make informed decisions about a learning path. Interaction design can help the learner to make a good decision about how to proceed. This paper discusses relevant interaction design frameworks and combines them with transactional control theory and Paulsen's laws of co-operative freedom to offer design principles for online courses that can help to put the learner in control. Outstanding issues for future development on interaction design and e-learning will also be discussed.

Introduction

When designing e-learning courses, it is desirable that we attempt to give learners control over their own learning. This is not a question of simply providing more choices. Although it is a prerequisite of control that more than one choice must be available, there comes a point when too many choices become overwhelming and actually reduce the learner's level of control (Dron, 2007; Schwartz, 2004). Too little choice may result in boredom and activities that actively discourage the learner. Too much choice may lead to uncertainty, confusion and fear, again affecting motivation. Achieving the right balance will vary from circumstance to circumstance and learner to learner. Intentional choices about what to do next on a learning trajectory are sometimes made by the learner, sometimes by some other, who we will call a 'teacher' for the sake of brevity, but who may be the author of a book, the director of a video or any number of other decision-making roles. For a learner to be in control, it is important that he or she is the one choosing whether and when to choose, and whether and when to let the teacher make those choices.

There are many ways that learners can be given control within an educational transaction. The most common approach is through dialogue. Dialogue allows learners to ask questions, express misconceptions, request changes in pace or content, provide formative evaluations, and more: essentially, to influence what a teacher does. A step away from this is to allow the teacher's role in the dialogue to be taken by a machine. For example, a well-programmed search engine may provide answers to requests for more clarity or more detail, or a multiple-choice quiz may give feedback to the learner on what is going well and what is not. At the far end of the dialogue spectrum are systems that do not explicitly interact with learners at all: books, static websites, videos and so on. although these they may involve an internal didactic conversation, guided somewhat by authors and creators (Holmberg, 1986). It is this end of the spectrum that concerns us in this paper.

Control, learning, and interaction design

In this paper, we aim to highlight relevant interaction design frameworks and how they can be combined with transactional control theory (Dron, 2007) and Paulsen's laws of co-operative freedom in e-learning (Paulsen, 2003).

Anderson (2006) extends Paulsen's Laws of Cooperative Freedom that describe a learner's freedom to negotiate the **time**, the **pace**, the **content** and the **media** of education with the freedom to choose the **type of relationship** with other learners and the teacher. It is also a long-touted benefit of online learning that the learner can usually choose the **place** in which he or she learns (Creed, 1996). If we are to give control to the learner, each of these freedoms should be addressed. Because our current interest is in interaction design for static online resources, we may assume that time and place are already under the control of the learner. Although we may be designing learning activities that involve other learners and/or teachers, it is not our concern in this paper to consider Anderson's freedom of relationship. This leaves us with the freedoms of **pace**, **content** and **media**.

Transactional control theory concerns the amount of control that a learner has in choosing a learning trajectory, viewed from a perspective of constraints and affordances, which may be intrinsic (such as, say, what has come before) or extrinsic (such as, say, the shape of a classroom). An important aspect of control is the ability to delegate it to another. Learning is potentially scary as it represents a leap into the unknown and we do not always know what to do or where to go next. We therefore often put our faith in trustworthy guides. The more control that we delegate to the system, the greater our commitment and trust we delegate to it. This is the price to pay for not having to think about our choices (Maeda, 2006). However, sometimes our guide may take us to places that we do not want to go. In such an event, if our guide presents us with informed choices only at significant branches in the path, then we retain control of the overall trajectory without having to make detailed and difficult decisions as we go. Bearing that in mind, a set of tentative interaction design principles and guidelines will be presented so as to help online designers to think about how to put the learner in control in his or her virtual quest for knowledge.

Interaction design in the online environment

According to Cooper (Cooper, 2007), interaction design is the practice of designing interactive digital products, environments, systems, and services. Furthermore, interaction design is largely concerned with meeting the needs of people who will interact with the object or system. It is the design of behavior; design that affects human behavior. Translating this to online learning platform, interaction design could include the appropriate use of navigation, interfaces, layout design, icons, pictures, fonts, music, and other audio-visual cues, and in general, options for configuring the look and feel of the online environment. This implies that, by manipulating these factors, we may to some extent manipulate learners' behaviors.

Existing design guidelines have paid little attention to the online learning environment and optimal level of learners' control in their learning paths. For the most part, production e-learning environments are built on the one-design-fits-all principle. The problem of this principle is that there is no one design that satisfies all learners as learners are diverse and they all learn differently. Even adaptive systems often assume that the teacher (mediated through the adaptive environment) knows what is best for the learner. Through interaction design, course designers and teachers can shift this mindset by suggesting and indicating various learning options and alternatives as learners work their way through the virtual landscape, giving them more control over their own learning.

So the questions remain, as online course designers, how can we design courses that will achieve the balance of giving just the right amount of choices to learners? Which aspect of pace, content and media can we modify in order to give control? What kind of design principles could be applied for online courses?

Designs that reduce control

It is not hard to design interactions that take away learner control. Most notably, an instructional designer can develop the course material in a way that gives learners too few or too many choices:

- **One choice** – one choice indicates that there are no other alternatives. For an online course, if a learner only has the option of going in one direction to progress through, then, the level of control over where one can go within that course is reduced to just clicking the "forward" button. Control is taken away from learners both in terms of pacing and in terms of content as they have no way of finding out where they are in the course, how to navigate around in an non-linear way, how to get out of the current screen, or how many more screens they have to go through until they reach the end of the unit. Of course, this is a slightly unrealistic scenario as modern learners always have other choices – to seek further information via Google Search or Wikipedia, for example. However, within the context of design, the point still holds. If we assume that we are offering something of value, we must assume that whatever we provide will hold the learner's attention.

- **Many choices** – At first glance, many choices suggest that learners should have more control. However, if these choices provided have no indication of how to distinguish among them, there is essentially no choice at all. For example, in the virtual seminar site shown in figure 1, learners have many options to choose from, but there is no indication or description to help viewers to differentiate or identify which link to follow without committing to a click. Even when the choices are meaningfully labeled, too many of them can be overwhelming and it can be hard to choose between similar items. It is a small hassle to follow a link to an unwanted page but when the choosing of the options become time consuming and confusing, there is a sense of helplessness and learners may become unmotivated. Worse, if learners are unable to make effective use of technologies, then any attempt to learn online falls at the first hurdle (Palloff & Pratt, 1999; Salmon, 2000).

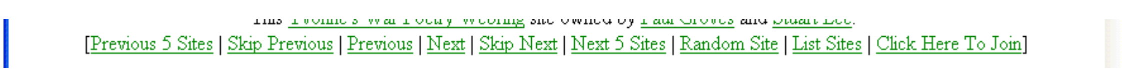

Figure 1: a virtual seminar site where the navigation offers many unclear choices.

Designs that give control

The corollary of the fact that we can reduce control through interaction design is that we can take steps to increase it as well. There are many ways to achieve this but, before we can explore how interaction design can help with giving or taking control from online learners, we will first look into interaction design as a discipline and how various types of design relate to it and how they can be incorporated into shaping online learning experience.

A Framework for Interaction Design

Interaction design is a design discipline with its focus on the digital design material such as websites, DVDs, software, and mobile technologies. It is also viewed as an extension of human-computer interaction (HCI). (Lowgren, 2008)

Four types of interaction design are closely associated with creating online learning environments that provide learner control: information design, emotional design, information architecture, and usability design.

Information design

Information design, by and large, is understood as a broader application that encompasses graphic design, interaction design, visual design and other two-dimensional design disciplines in general. We will define it here as: "…the transfer of complex data to, for the most part, two-dimensional visual representations that aim at communicating, documenting and preserving knowledge. It deals with making entire sets of facts and their interrelations comprehensible, with the objective of creating transparency and eliminating uncertainty." (Schuller, 2007) In designing e-learning, Information design plays a role in shaping complex content with clarity, precision and efficiency. It deals with how the design support the goals of the learners and teachers, how we interact and present the material, as well as how the information is being represented. This relates most closely to freedoms of content and pacing.

Emotional design

An emerging subset of interaction design is on emotional design,. It came out of the product design tradition and focus on the aesthetic of design: attractive things make people feel good, think more creatively, and are more open to alternatives (Norman, 2004). According to Norman, People who are happy are more prompt to find alternative solution and more tolerant of mistakes in systems/products. According to Norman there are three levels of processing: Visceral, Behavioral, and Reflective. At visceral level, one makes a rapid judgment of what is good or bad, by sensory information, no reasoning involved. At behavioral level, one analyzes a situation and alters behavior accordingly At reflective level, one can look back at ones behavior and learn from the experience (thus be able to draw inferences and generalizations). Each level may play an important role in determining whether a learner chooses to follow one path or another, in particular relating to freedom of content.

Information architecture

Information architecture (IA) deals primarily with structure and content for websites and other interactive media (Knemeyer, 2003): "(it) is the term used to describe the structure of a system, i.e. the way information is grouped, the navigation methods and terminology used within the system." (Barker, 2005) Different information architectures will offer different levels of control to the learner. For example, if it involves large chunks of information then there may be fewer potential choices available to the learner than if the chunks are smaller. This affects freedoms of pace, content and media.

Usability design

Usability is "a quality attribute that assesses how easy user interfaces are to use." It is defined by five quality components: learnability, efficiency, memorability, errors and satisfaction. (Nielsen, 2003) Thus, usability design puts the user at the center of the design process by testing users individually and let them navigate the system and complete a set of assigned tasks. By employing usability design, e-learning designers can gain understanding in how users actually interact with the system and where and how to improve on the current design. This affects freedoms of content and pace in particular.

Interaction design principles that give control

The following interaction design principles can assist online course designers in providing learners control over their own learning space. The majority of these principles are concerned with the freedom to select content, but it is also important to consider pace and media. Lidwell, Holden & Butler (2003) describe a number of design principles that act as a starting point for discussion. We have selected and extended some of their design principles that could be applied to give control when designing online courses in the light of transactional control. Broadly, these may be split into three main categories: logical, navigational and pedagogic design.

Logical design

In considering logical design we are concerned with the structural aspects of a learning environment – primarily, the information architecture. Structure can help to determine and make concrete decision points on a learning trajectory. Getting the structure right in the first place can greatly ease the process of giving control as most other aspects that we can influence derive from it. As Senge (1993) tells us, structure influences behavior.

Scale

Transactional control theory draws from principles of ecology and systems architecture in claiming that the larger, slow moving parts of a system affect the smaller, faster moving parts more than vice versa. Larger scale decisions are generally more important. For example, there is a usually a big difference in terms of information needed and potential impact between choosing a degree program and choosing whether to read the next paragraph of a text, although it is not always true that the consequences are proportionate: a single paragraph may be life changing under the right circumstances while the consequences of choosing one degree program over another may sometimes be slight.

More control can potentially be given by dividing the material into smaller chunks. However, if the chunks are too small then choices may become overwhelming. One solution to this is to make use of hierarchies that are split at a finer level of granularity. For instance, differences in scale at a conceptual level can be illustrated through various contextual cues such as hierarchical trees and layering. We may also consider approaches to helping the learner to decide on pacing, such as suggestions about how long a task might take or visual cues such as timelines.

A different issue of scale relates to the amount of information displayed, which in turn may be affected by the choice of medium. For example, typically, smaller chunks will be required for a mobile phone interface than for a website intended to be viewed on a PC and different again on an interface designed to be printed or for interactive TV. While it is not uncommon for such choices to be made by the designer, it may be desirable to give the learner control over the choice of medium and, consequently, the way and the scale at which that information is displayed.

80-20 Rule

Also known as Pareto's Principle, the 80-20 Rule is an assumption that the critical 20 percent of the information/design features are used 80 percent of the time. In interaction design, displaying the most common 20 percent of the user interface while hiding the remaining 80 percent is a way of reducing complexity of the display of information and helping learners to focus on the primarily resources. By constraining the learner's view to the 20 percent, choices are limited to a manageable number that are likely to be relevant. Transactional control theory suggests that the most important choices are those that entail a change in learning trajectory. If that number is still too large, then larger scale choices should be presented. A change in learning trajectory occurs when a deliberate choice is made to do something different to learn, such as to switch to a new topic or new means of presenting a topic. This is in turn affected by medium – lower resolution screens or, say, screen readers demand smaller amounts of information and chunking at a larger scale.

Navigational design

Navigational design is perhaps the most obvious way of giving learners freedom to select content. Effective navigation design can allow learners to make informed choices about which content they choose.

Constraints

Constraints can be both physical and psychological. Physical constraints limit the range of motion a learner can perform (e.g. scrolling, dragging, dropping and clicking on a screen, keystrokes, etc.). More interesting are psychological constraints relating to emotional design that limit the way learners think and perceive information. (e.g. use of symbols; conventions to communicate meaning, such as list order, font size and so on; colors to evoke emotions: red means pay attention, blue underline is a hyperlink). It is thus possible to guide the learner without necessarily limiting choices.

Navigational aids

Designers can use navigational aids to organize information and help learners to find what is relevant and useful. Different approaches include clustering, layering, signposts and emphases. Clustering is used to put similar information together. Depending on the kind of control desired, this might be according to (for example) subject, level, pedagogy or usability. Layering, similar to clustering, can enable similar information to be clustered together but with a hierarchical organization, enabling big choices to be made before smaller ones. This can help with pacing by helping the learner to get a sense of location within the bigger picture. Signposts and emphases can be added by increasing or decreasing font sizes, list order, using alternative fonts, effects and colors. Similarly, offering navigational cues such as icons, headings, bullets and other signals can enable more informed choices For instance, tag clouds, with different keywords emphasized according to their perceived relevance, offer suggestions about where it would be fruitful to follow that do not rule out the potential for following other paths.

Wayfinding

Wayfinding is a process that uses spatial and environmental information to navigate to a destination. Way finding usually involved four stages: orientation, route decision, route monitoring, and destination recognition. In online orientation, learners are trying to locate where they are in relation to the course. It would be helpful to use signage and landmarks (similar to the "you are here" arrow in a city map). Route decision needs to be minimized as learners are selecting their ways through their learning journey. For example, navigation buttons should be designed in such a way that learners are not confused or overwhelmed with too many options. Visual cues should be provided at decision points (e.g. use of maps, sliders). Transactional control theory suggests that such points may be identified as those in which the learner makes a change in learning trajectory. The decision about what constitutes a change in trajectory is sometimes a difficult one: what may seem to be a natural continuation to a subject expert may appear discontinuous to a learning designer or to the learner. Similarly, a subject expert may consider some parts of the subject to be distinct while, from a learning perspective, they may need to be tightly coupled or interlinked.

Route monitoring is used to confirm that the chosen route is heading to the right destination and can help with pacing. Visual cues help to indicate where the learners are in a particular path (e.g. breadcrumbs, indication of "slide 2 of 10"). Destination recognition needs to be provided so that learners know when they reach that point. Signage is important, such as barriers to indicate that the flow of the space has come to an end.

Design for mistakes

Users make mistakes all the time when interacting with systems. Providing choices also mean that people will make the wrong choice, get stuck and become frustrated. When the system fails to perform what we expect, it is a violation of trust; we will assign blame and become angry(Norman, 2004). When designing online environment to give learners control, we need to make sure that the system is as forgiving as possible. For example, there should always be a way to exist or get back to the beginning of the task. When faced with options, there should be self-explanatory or provide a "help" button to explain the differences of the options.

Pedagogic design

Pedagogic design has to do with deciding appropriate learning activities and helping the learner to choose those that are most suited to him or her.

Use of levels

If possible, there should be a varying level of control from beginner to expert level. It is relating to proficiency and levels of experience in a particular subject matter as well as use of technologies. As a general rule, a beginner needs more structure and simplicity while advanced learners favor flexibility and efficiency. Usability design requires us to think of all of our potential users when designing the interface, with different degrees of familiarity: for instance, drop-down menus as well as graphical buttons offer people a simple way of accessing and performing a task for new users. For advanced users, keyboard shortcuts offer a quick and efficient way of accessing the same set of functions. Online courses should be able to accommodate various levels by offering multiple ways to acquire knowledge and performing tasks.

Use of metadata

By adding metadata, whether as tags, tables of contents, indices or more formal metadata such as that conforming to Dublin Core or IEEE-LOM standards we can allow learners to more precisely identify and/or specify their needs. As well as helping to identify the appropriate topic, pedagogical metadata should be supplied that enable the learner to make informed choices about whether a particular piece of content is suitable to his or her needs. For instance, we might give some indication of level, prior knowledge required, general pedagogic approach and (controversially) learning style catered for.

Issues requiring further research

Applying appropriate interaction design for e-learning is a good way to give learners control on their learning experience, but much work remains to be done and dangers to be avoided.

Cultural differences

Differences between cultures in how visual and, to a lesser extent, structural cues are interpreted. Icons and symbols need to be adjustable in appearance and orientation to account for cultural or geographical differences. However, it is not always feasible to be able to rely on icons or other visual cues alone in communicating information or providing navigation guides. Different cultures also mean different aesthetic values, association with colors, typefaces, layout and orientation of course pages. Work is still needed to identify these differences so that we can more accurately adjust our designs to suit the freedom of pace, content and media.

Accessibility

Some of the approaches we have suggested are of little benefit to some learners with some disabilities. It is therefore important, wherever possible, to employ meaningful markup to provide semantic as well as visual information. Effective use of titles, block-level tags, named layers and meaningful emphases in HTML, for example, can make the techniques more accessible to all. Despite such approaches, accessibility remains an issue, especially when considering visual cues and providing media options. It is important when applying interaction design principles that not all users are operating in the same context as our own. In addition, as mobile phones and handheld computers become more diverse, compact and affordable, one cannot assume that what works and read well on a standard screen size will work across all advices. As online designers, the challenges remain that there are many different situations to consider and it is not always feasible to provide options for all learners all the time.

Achieving the right mix

It is more of an art than a science to decide at which point a learning trajectory divides, depending on both subject knowledge and pedagogical understanding. The general rule that a learning trajectory divides at a point where a choice should sensibly be made to change direction. In terms of content and pace, some such changes are very obvious and unequivocal: starting a new topic, a new course, a new sub-area, for instance. Others are harder to gauge – for example, rephrasing a point that has been misunderstood, shifting between bullet points on a PowerPoint slide, for example. Whether these constitute a change in learning trajectory is very dependent on context and our understanding of both learners and the subject to be learnt. Much empirical research remains to be done to refine our understanding of where changes do and should occur.

Conclusions and further work

Although it is generally the case that more control is better, the amount of control needed is dependent on many factors and shifts with context. In some situations it may be entirely appropriate for a learner to have limited control: some forms of training, for example, may require a proscribed sequence of activities. It is also important to observe that there is nearly always a cost associated with giving more control, if only in remembering to cater for different needs or add a small amount of emphasis here and there. On the whole, the more control we give, the greater the cost of design.

We do not wish to overstate the case that control can rest in the hands of the designer. In a modern graphic user interface (GUI), the rest of the desktop is just a mouse click away and, on the Web, there is no end to the informed choices a learner may make at any moment that will lead him or her away from the designer's path. Having said that, if we assume that a learner is making use of our materials because they have some perceived value, then we must do our best to make that value as great as possible.

All of the principles we have written of here assume a) subject knowledge and b) pedagogical knowledge on the part of the design team. To refine that knowledge and tune it to learner needs, feedback remains a vital part of the equation. A central advantage of the use of online learning is that we can gather statistics and information, both explicitly and implicitly gleaned, that will help us to inform the iterative process of design. A key requirement in making effective use of these principles is that we must constantly observe and adapt to our observations.

The next step in our research is to explore the effects of applying the principles described here with actual learners. While much of what we have to suggest is common sense, it is not yet clear which strategies will be most cost-effective nor even whether they will be used as expected. It is now necessary that we monitor and analyze usage in both real and experimental settings.

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