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Learning Experience in Dynamic and Non-Dynamic Curriculum Sequencing Systems

A thesis presented in partial fulfilment of the requirements
for the Degree of Doctor of Philosophy in Information Technology

at Massey University

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2012
Abstract

This PhD thesis presents a series of interrelated studies about computer-based learning experience with a focus on a dynamic curriculum sequencing system (DCSS). A DCSS is an adaptive computer-based system that organises learning material dynamically, based on the learners’ learning parameters such as prior knowledge, learning styles and preferences. The learning experience refers to the learners’ cognitive engagement during their interactions with computer-based systems. It is important to note that the learning experience discussed here is reviewed in the context of the flow theory. Many previous studies have claimed that learners’ psychological well-being and future use of computer-based learning are correlated with their learning experiences. Hence, this thesis provides some empirical evidence about the DCSS learning experience to complement the existing literature in the area of computer-based learning.

The thesis intends to achieve two main objectives. First, it aims to identify whether or not the DCSS learning experience is significantly different in comparison to the non-DCSS (i.e., a recommendation system). Additionally, it intends to examine whether the DCSS and the non-DCSS learning experiences change over time. It also develops and validates a new technique that can improve the DCSS learning experience, known as a skill-challenge balancing (SCB) technique. In order to achieve the first objective, two experimental studies were conducted using two types of computer-based systems (i.e., the DCSS and the non-DCSS) for teaching ‘Computer Networks’. The self-reporting technique was employed to measure the learning experiences in both studies. For the second objective, the software analysis and design tasks were performed to visualize the SCB technique conceptually and technically. It was followed by an experimental study that validates the new technique using the same methodological approach as in the first two studies.

The first two experimental studies suggested that the DCSS and the non-DCSS gave the learners different learning experiences. These studies further identified the learners’ cognitive states showing some of them suffered from boredom and anxiety in particular learning conditions. The findings of these studies emphasized that there
is a need for a novel approach to maintain learning experience in computer-based learning. For this reason, this thesis also proposes a new learning experience monitoring technique (i.e., the SCB) considering some underlying principles from the flow theory. This technique was empirically validated to be effective in improving the DCSS learning experience.

As computer-based learning is an essential tool in current higher educational settings, the outcomes of this thesis are discussed in relation to adaptive design of computer-based learning and human-computer interaction.
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# List of Abbreviations

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<tr>
<td>AI</td>
<td>Assessment Items</td>
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<tr>
<td>CLT</td>
<td>Cognitive Load Theory</td>
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<tr>
<td>CS</td>
<td>Computer Science</td>
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<tr>
<td>CSS</td>
<td>Curriculum Sequencing Systems</td>
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<td>DCSS</td>
<td>Dynamic Curriculum Sequencing Systems</td>
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<tr>
<td>DM</td>
<td>Domain Model</td>
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<tr>
<td>DSA</td>
<td>Dynamic Sequencing Approach</td>
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<td>EM</td>
<td>Engagement Model</td>
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<td>IC</td>
<td>Instructional Contents</td>
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<tr>
<td>IIMS</td>
<td>Institute of Information and Mathematical Sciences</td>
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<tr>
<td>IT</td>
<td>Information Technology</td>
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<td>ITS</td>
<td>Intelligent Tutoring Systems</td>
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<tr>
<td>K-S</td>
<td>Kolmogorov-Smirnov</td>
</tr>
<tr>
<td>LO</td>
<td>Learning Object</td>
</tr>
<tr>
<td>LOR</td>
<td>Learning Object Repository</td>
</tr>
<tr>
<td>LTM</td>
<td>Long Term Memory</td>
</tr>
<tr>
<td>NASA-TLX</td>
<td>NASA Task Load Index</td>
</tr>
<tr>
<td>QoE</td>
<td>Quality of Experience</td>
</tr>
<tr>
<td>RQ</td>
<td>Research Questions</td>
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<tr>
<td>SCB</td>
<td>Skill-Challenge Balancing</td>
</tr>
<tr>
<td>SCSS</td>
<td>Static Curriculum Sequencing Systems</td>
</tr>
<tr>
<td>SE</td>
<td>Sequencing Engine</td>
</tr>
<tr>
<td>SM</td>
<td>Student Model</td>
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This thesis presents interrelated studies about learning experiences in the dynamic curriculum sequencing system (DCSS). It primarily aims to uncover knowledge about the importance of maintaining an optimal level of computer-based learning experience. The thesis intends to offer a technique that improves the learning experience following a psychological concept known as the flow theory.

The implementation of the thesis is divided into four sections. Section I introduces the readers to the theoretical framework that guides the overall execution of the thesis. It also emphasises the importance of the optimal learning experience and techniques to achieve it through an extensive review of secondary evidence from literature.

Section II aims to explain basic DCSS concepts including the common components of the systems and existing examples of DCSS. This section also describes the design and development tasks of a DCSS named IT-Tutor. At the end of this section, a study that evaluates the usability of IT-Tutor is presented. The system has been used as the main learning tool for the empirical studies in this thesis.

Section III describes two empirical studies to investigate the DCSS learning experience which are evaluated from multiple perspectives. Firstly, it comprises of a study which intends to measure the learning experience in a DCSS with a non-DCSS. Secondly, it predicts the learners’ cognitive states while engaging with computer-based learning tasks. Thirdly, this section attempts to understand how the learning experience progresses from the beginning of an interaction with the computer-based learning towards the end. Finally, it describes the cognitive loads that the computer-based systems may impose on the learners and its relationship with the learners’ learning experiences.

Section IV proposes a technique to improve the DCSS learning experience which is fundamentally based on the flow theory, known as the skill-challenge balancing (SCB) technique. This section also presents an empirical study that evaluates the effectiveness of the proposed method in enhancing the DCSS learning experience.
First and foremost, I am very grateful to be given the opportunity to pursue a degree of Doctor of Philosophy. Thanks to God for giving me the strength to deal with the unexpected challenges during the journey of this doctoral study.

I would like to express my gratitude and appreciation to Dr. Hokyoung Ryu and Dr. Ruili Wang the primary supervisors of my doctoral study at Massey University. The first two years of the study were carried out in the Institute of Information and Mathematical Science (IIMS), where Dr. Hokyoung Ryu was the primary supervisor, and later in the School of Engineering and Advanced Technology (SEAT), where Dr. Ruili Wang was the primary supervisor. The same goes for the other co-supervisors, Dr. David Parsons and Dr. Brian Whitworth. They gave me full support and guidance in the entire process of completing the thesis.

I am heartily thankful to my best friend and my husband, Azwan Azmi whose patience, encouragement, and support; enabled me to complete the thesis. I pray to God to bestow him with a doctoral degree as well for the effort and faith he puts in his study. He deserves it too. To our son, Adam, you are the sunshine that always makes mom and dad happy. May you grow up to be a good person and successful in your life.

I would also like to thank my fellow friends: Azlina, Tingting, Lornie and Ramesh for their time in listening to my problems, difficulties and joy during the period of the study. I strongly believe that all of you will also complete your doctoral study successfully soon and will be doing well in your future career.

I gratefully acknowledge the financial support from the Malaysia Ministry of Higher Education and Universiti Utara Malaysia for undertaking this doctoral study.

Last but not least, I would like to thank everyone who had contributed to this thesis in any way either directly or indirectly. Your support and assistance are really appreciated.
Declaration

I declare that the works written in this thesis have been fully prepared and executed myself with supervision given by Dr. Hokyoung Ryu and Dr. Ruili Wang. The doctoral study was started in October 2008 and completed in December 2011. The first two years of the study were carried out in the Institute of Information and Mathematical Science (IIMS), where Dr. Hokyoung Ryu was the primary supervisor, and later in the School of Engineering and Advanced Technology (SEAT), where Dr. Ruili Wang was the primary supervisor. The following publications were published from the studies reported in this thesis. The information about the publications and its corresponding chapters are presented in the following table:

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<th>Corresponding Chapters</th>
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I also declare that the following papers were published during the early period of the doctoral study as preliminary works towards a more specialised research study; however, these papers were not very closely relevant with the theme of the thesis.

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