Learning Experience in Dynamic and Non-Dynamic Curriculum Sequencing Systems

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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

Acronyms	**Full Names**
AI	Assessment Items
CLT	Cognitive Load Theory
CS	Computer Science
CSS	Curriculum Sequencing Systems
DCSS	Dynamic Curriculum Sequencing Systems
DM	Domain Model
DSA	Dynamic Sequencing Approach
EM	Engagement Model
IC	Instructional Contents
IIMS	Institute of Information and Mathematical Sciences
IT	Information Technology
ITS	Intelligent Tutoring Systems
K-S	Kolmogorov-Smirnov
LO	Learning Object
LOR	Learning Object Repository
LTM	Long Term Memory
NASA-TLX	NASA Task Load Index
QoE	Quality of Experience
RQ	Research Questions
SCB	Skill-Challenge Balancing
SCSS	Static Curriculum Sequencing Systems
SE	Sequencing Engine
SM	Student Model

Preface

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.

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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:

Information about the publications	**Corresponding Chapters**
Katuk, N. & Ryu, H. (2010). Finding an optimal learning path in dynamic curriculum sequencing with flow experience, The 2010 International Conference on Computer Applications and Industrial Electronics (ICCAIE) 5-8 Dec. 2010, pp.227-232	Chapter 5
Katuk, N. & Ryu, H. (2011). Does a Longer Usage Mean Flow Experience? An Evaluation of Learning Experience with Curriculum Sequencing Systems (CSS), 2011 Sixth IEEE International Symposium on Electronic Design, Test and Application (DELTA) 17-19 Jan. 2011, pp.13-18	Chapter 5
Katuk, N., Wang, R., Ryu, H., & Parsons, D. (2011). The Dynamics of Computer-based Learning Experience. The Proceedings of the IIMS Postgraduate Conference, 26 October 2011, Massey University, New Zealand	Chapter 6
Katuk, N., Wang, R., & Ryu, H. (2011). Enhancement of Learning Experience Using Skill-Challenge Balancing Approach. In D. Wang & M. Reynolds (Eds.), *Lecture Notes in Computer Science*, (Vol. 7106, pp. 707-716): Springer Berlin / Heidelberg	Chapter 7

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.

Information about the publications
Katuk, N., Sarrafzadeh, A., & Dadgostar, F. (2009) "Effective ways of encouraging teachers to design and use ITS: feature analysis of intelligent tutoring systems authoring tools," *International Conference on Innovations in Information Technology, 2009 (IIT '09)* 15-17 Dec. 2009, pp.100-104
Katuk, N. & Ryu, H. (2010). Seeing is believing? Rehearsing Mayer's multimedia effects in intelligent tutoring systems. In the *Proceedings of the 11th International Conference of the NZ Chapter of the ACM Special Interest Group on Human-Computer Interaction* (CHINZ '10). ACM, New York, NY, USA, pp. 25-28