Development and Evaluation of an Adaptive Hypermedia System Based on Multiple Student Characteristics

A thesis submitted for the degree of

Doctor of Philosophy

By

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March 2006
Declaration

I hereby declare that this thesis is my own work and has not been previously submitted for a degree at any other university or institution. Information derived from the published or unpublished work of others has been acknowledged in the text and references of the thesis.

___________________________
Herman Dwi Surjono
Abstract

Adaptive Educational Hypermedia systems (AEH) are amongst the most recent types of application to provide individualised instruction to students who undertake online courses. Such systems attempt to adapt to how individuals learn by personalizing instruction for each individual student depending upon one or more “characteristics” of the student. Prior knowledge and learning style have been identified as being prominent characteristics in this process but AEH systems implemented to date have generally been limited to only employing one of these characteristics. Such systems have also been limited in that they are specific to a particular course content and cannot be easily adapted to present different learning materials.

This thesis describes the development and evaluation of a new AEH system that provides a generic template for different learning materials as well as a student model that incorporates five distinct student characteristics as an aid to learning: primary characteristics are prior knowledge, learning style and the presence or absence of animated multimedia aids (multimedia mode); secondary characteristics include page background preference and link colour preference. The use of multimedia artefacts as a student characteristic (and hence as an independent variable in this study) has not previously been implemented or evaluated. A separate non-AEH system, identical to the AEH system except for the absence of adaptation to individuals, was developed in parallel as a control.

The system development consists of a requirements analysis, design and implementation. The design models including use case diagrams, conceptual design, sequence diagrams, navigation design and presentation design are expressed using
Unified Modelling Language (UML). The AEH system which was developed in a
generic template implemented using Java Servlets, XHTML, XML, JavaScript and
HTML. The generic template is a domain-independent AEH system that has functions
of both *adaptivity* and *adaptability*.

The system was evaluated in an experimental research involving 67
undergraduate engineering students in the Department of Electronics at Yogyakarta
State University. The learning material of Analogue Electronics was implemented into
both the AEH system and non-AEH systems under seven chapter headings. The
participants were randomly divided into an experimental group and a control group.
During the 9 weeks of experimentation, the students studied the learning material in
two randomly allocated groups, an experimental group using the AEH system and a
control group using the non-AEH system. A pre-test was administered to measure
initial student knowledge. The student achievement was measured at the end of each
chapter of material using a chapter test and at the end of the experimentation as a
whole using a post-test. Basic statistical analysis of t-test and Mann-Whitney U were
conducted to investigate any difference of student achievement between the two
groups. A further detailed analysis using multilevel modelling was conducted to
investigate any possible effects of the adaptive parameters on the student achievement.

A total of 7 hypotheses were tested during data analysis. Research findings are
described as follows. Students who learned using the AEH system performed better
significantly than those who learned using the NON-AEH system. The
implementation of test repetition as a function of knowledge adaptation in the AEH
system increased student achievement significantly. This was found to be the
prominent effect. When the effect of test repetition was removed, the implementation
of learning style and multimedia mode adaptation in the AEH system was still found
to have significant effect upon student performance. Students whose learning style and multimedia preferences were matched with the system (AEH or non-AEH) achieved better results. In terms of the relative merit of each contributing factor toward a student’s achievement, the order of the effects was found to be (1) knowledge, (2) multimedia, and (3) learning style. Whilst repeated knowledge testing is an established cause of improved performance, the positive effects on student performance of using multimedia artefacts over choice of learning style is a new finding.
Acknowledgements

I would like to thank my supervisor Dr. John Maltby for his guidance, support and excellent supervision throughout the period of my study. I would like to thank Dr. Lyndon Brooks for his advice on statistical analysis. I would also like to thank Professor San Murugesan for previewing my thesis draft.

I would like to thank the Graduate Research College and staff for providing the International Postgraduate Research Scholarship, SCU Postgraduate Research Scholarship and conference support.

I would also like to thank all staff of the School of Multimedia and Information Technology and the International Office for their support.

I would also like to thank Rector of the Yogyakarta State University, Dean of the Engineering College, Head of the Electronics Department and all staff for their support.

I also thank my wife, Ida, and my son, Taufiq, for their continued encouragement, love, and understanding.
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