



# 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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## **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 Information derived from the published or unpublished work of others has been acknowledged in the text and references of the thesis.

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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.

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