Empirical Evaluation of Adaptive Educational Hypermedia

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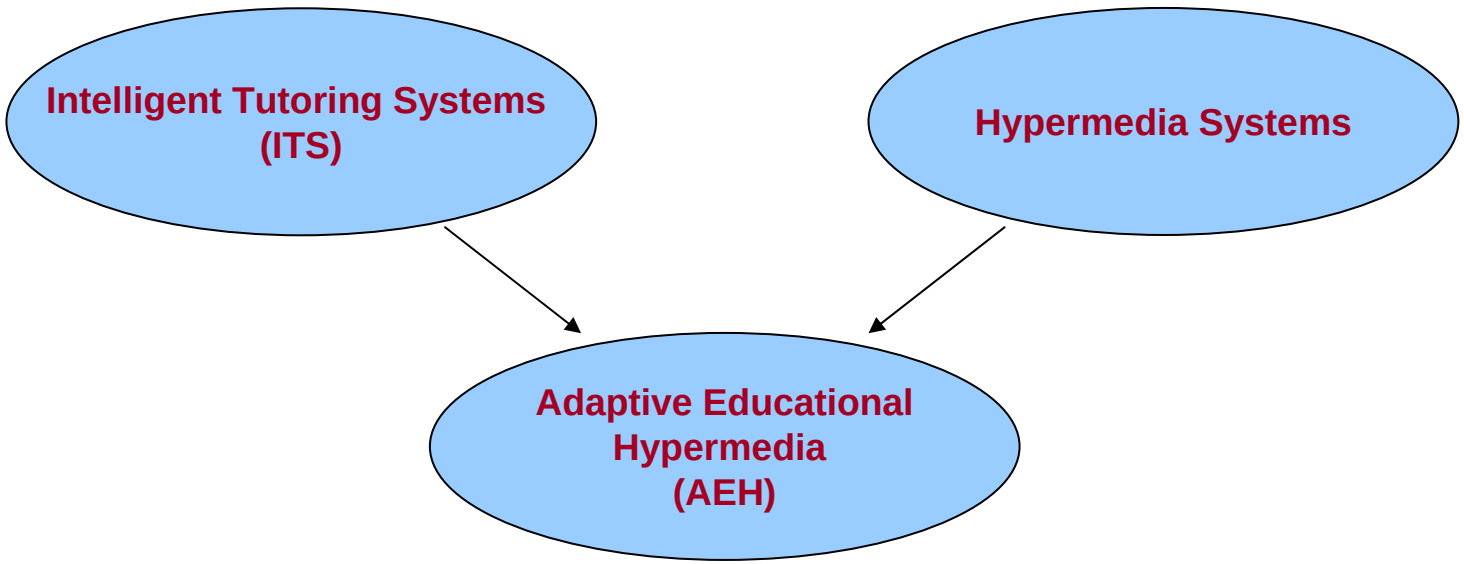
A new way to think

Introduction

- The purpose of the AEH evaluation is to evaluate the effectiveness of the AEH system for students taking an electronics course.
- A pretest-posttest two group design was undertaken with Engineering students as participants
- A basic analysis of mean difference testing and a further analysis of multilevel modelling was performed.

What is Adaptive Educational Hypermedia (AEH)?

- AEH is a combination of two technologies: intelligent tutoring systems (ITS) and hypermedia systems.



- ITS utilises a user model to adapt various visible aspect to particular user.
- Hypermedia contains information supported by different media and connected by links.

AEH Definition

- AEH system can be defined as an all hypertext and hypermedia system that accommodates some student characteristics into a student model, and then applies this model to adapt the various learning material presentations used.
- AEH system is used to enhance learning activity in web-based distance learning environment.

Compared to WBI

- AEH overcomes some problems of WBI (web-based instruction), such as:
  - providing the same information to all students, irrespective of student prior knowledge and learning style
  - assuming that all students have a homogenous ability and preference.
- AEH extends the advantages of WBI which are classroom and platform independence by offering learners personalised instruction in a distance learning setting.

Why students need AEH?

- Every student has different characteristics.
- The learning process is complex and is influenced by characteristics such as previous knowledge, learning styles, background, etc.
- Students need to use learning material and an order of presentation that depends upon their own characteristics and needs.
- AEH has the capability to adapt a presentation to an individual’s needs.

The experimental AEH system

- The experimental AEH system presents learning material of Analogue Electronics which is adapted to the following student characteristics:
  - Knowledge
  - Learning styles
  - Multimedia style
  - Background
  - Colour preferences.
- The learning material includes 7 chapters of Analogue Electronics material: Semiconductor diodes, Diode circuits, Bipolar transistor, Transistor dc biasing, BJT small-signal analysis, FET, FET analysis.

Level of adaptation in AEH

There are two level of adaptations in the AEH system depending on who takes the initiatives (system or student).

- Adaptivity

  Adaptivity refers to the AEH system that adapts its presentation using some data about the students in a system-controlled way.

- Adaptability

  Adaptability refers to the AEH system that supports end-user modifiability providing students control over several functionalities.

Functions in the AEH system

Adaptivity functions implemented:

1. The system presents a chapter depending on the knowledge level of student.
2. The system presents a chapter test depending on a percentage of pages that the student has learnt or visited.
3. The system presents set of links depending on the knowledge level of student.
4. The system presents the learning material in either global way or sequential way depending on student's learning styles tendency.
5. The system provides additional multimedia features depending on student's tendency towards visual or verbal dimensions.

Adaptability functions implemented :

1. Student can change the color preference for links in the pages.
2. Student can change the page background.
3. Student can change the password.

The NON-AEH system

- The NON-AEH system contains the same learning material of Analogue Electronic, exercises and tests as in the AEH system.
- The system provides the same page content and the same set of links to all students.
- The system presents the same static explanation and suggests the same next page to students.
- No knowledge based adaptation functions are implemented.
- No learning styles and multimedia based adaptation functions are implemented.
- Student cannot change color preference and page background.

Experimental Design

Experiment Group	R	Pre-test	Treatment of AEH System	Post-test

Control Group	R	Pre-test	Treatment of NON-AEH System	Post-test

- The experimental design was based on “pretest-postest control group design”.
- It consisted of an experimental group and a control group.
- A random assignment technique was used to assign every student into either group.

Internal Validity

Employing this design would minimize possible threats to internal validity:

- History effect was removed because the general history events which contributed between the pretest and posttest events occurred similarly in the two groups as they were run at the same time.
- Maturation effect was removed because the same amount of time passed for both groups.
- Instrumentation effect was removed because pretest and posttest questions for the experimental and control groups were the same.
- Regression and selection effects were controlled by randomization.

Subject

- Population: undergraduate students at Dept of Electronic, College of Engineering.
- Sampling method: volunteer sampling (as it is required by the HREC-SCU).
- Sample size: 67 students.
- Placement method: random assignment.
- Conditions: students were not taking or had not previously taken an electronics course. Therefore, at the beginning of the experimentation they had no knowledge of Analog Electronics.

Instrument

- The instrument in this study was an achievement test which was used to measure the level of student's knowledge of Analogue Electronics.
- The test conducted was a multiple choice format consisted of 70 items covering all learning material from the chapter 1 to chapter 7.
- The test was composed by this researcher based on a table of specifications.
- Pretest and posttest are exactly the same test except that the order of the item numbers are different.

Validity of instrument

- Content validity is primarily important in relation to the achievement test used in this study.
- This type of validity concerns the degree to which the test items represent the whole syllabus of the learning material.
- The content validity of this test was determined by:
  - judgment of researcher
  - compliance with the table of specifications
- The Table of Specifications indicates that all test items are covered in the syllabus and that all topics are associated with the test items. Therefore, this researcher assumed that the test used in this study has an acceptable content validity.

Reliability of instrument

- Reliability can be defined as the degree of internal consistency or stability of the test over time.
- Among many approaches used for estimating the degree of reliability, internal consistency is frequently used because it requires only one test administration.
- The Kuder-Richardson formula 21 (KR-21) estimates inter-item consistency or homogeneity of the items without requiring actually splitting the test.
- The calculated reliability coefficient (r_{xx}) is 0.92.

Research procedures

- The experimentation was conducted during 9 week periods from 15th of November 2004 to 30th of January 2005.
- The procedures are as follows:

  Step 1: System development

  Step 2: Administration requirement

  Step 3: Random assignment

  Step 4: Account creation

  Step 5: Pre-test administration

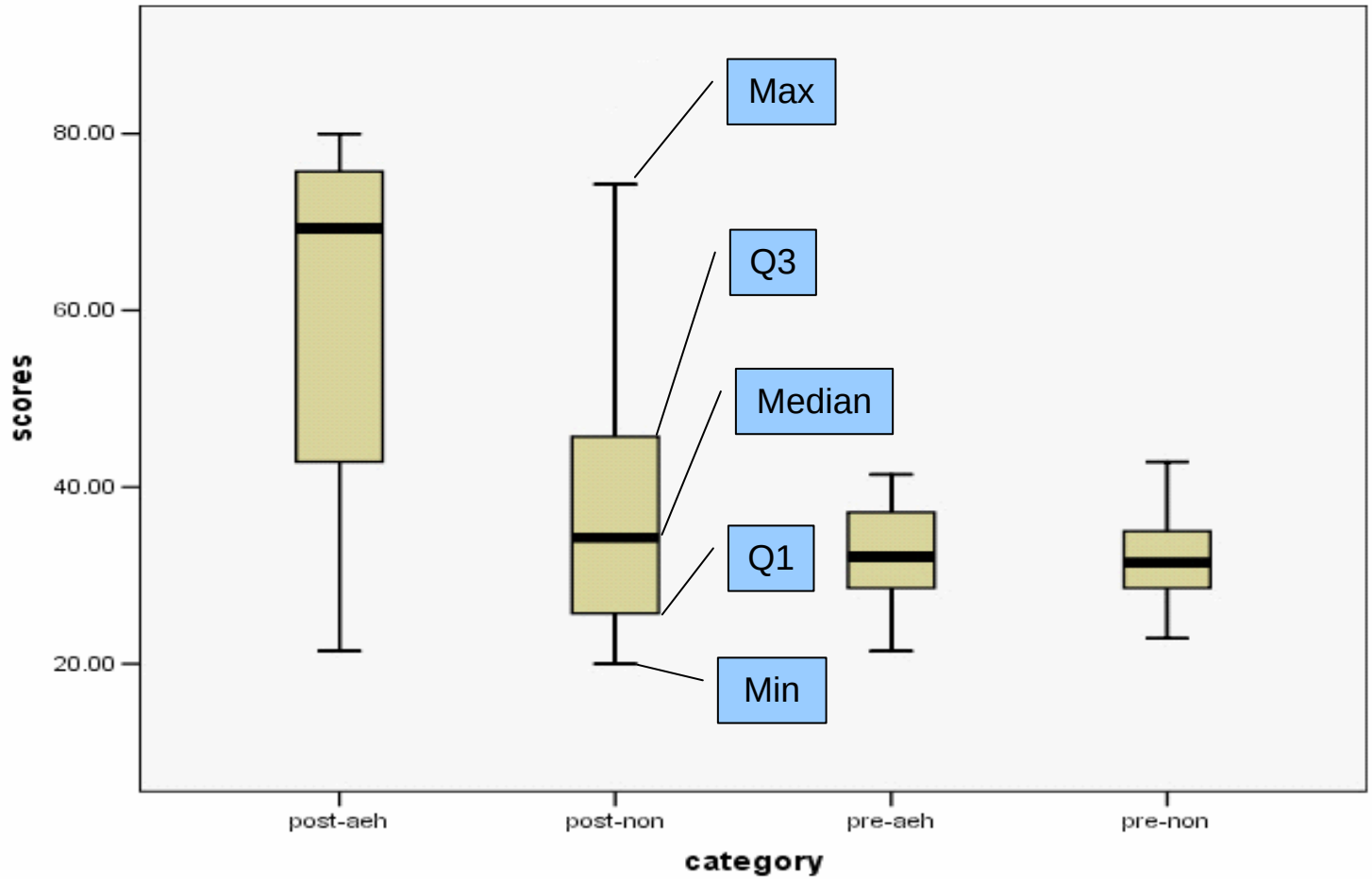
  Step 6: Experimental treatment

  Step 7: Post-test administration

  Step 8: Data collection

  Step 9: Data analysis

Box plot graph: pre-test/post-test



Post-test mean difference testing

- Hypothesis #1:

  Students who learn the learning material of Analogue Electronics in the AEH system will achieve higher post-test scores than those who learn the same material in the NON-AEH system.

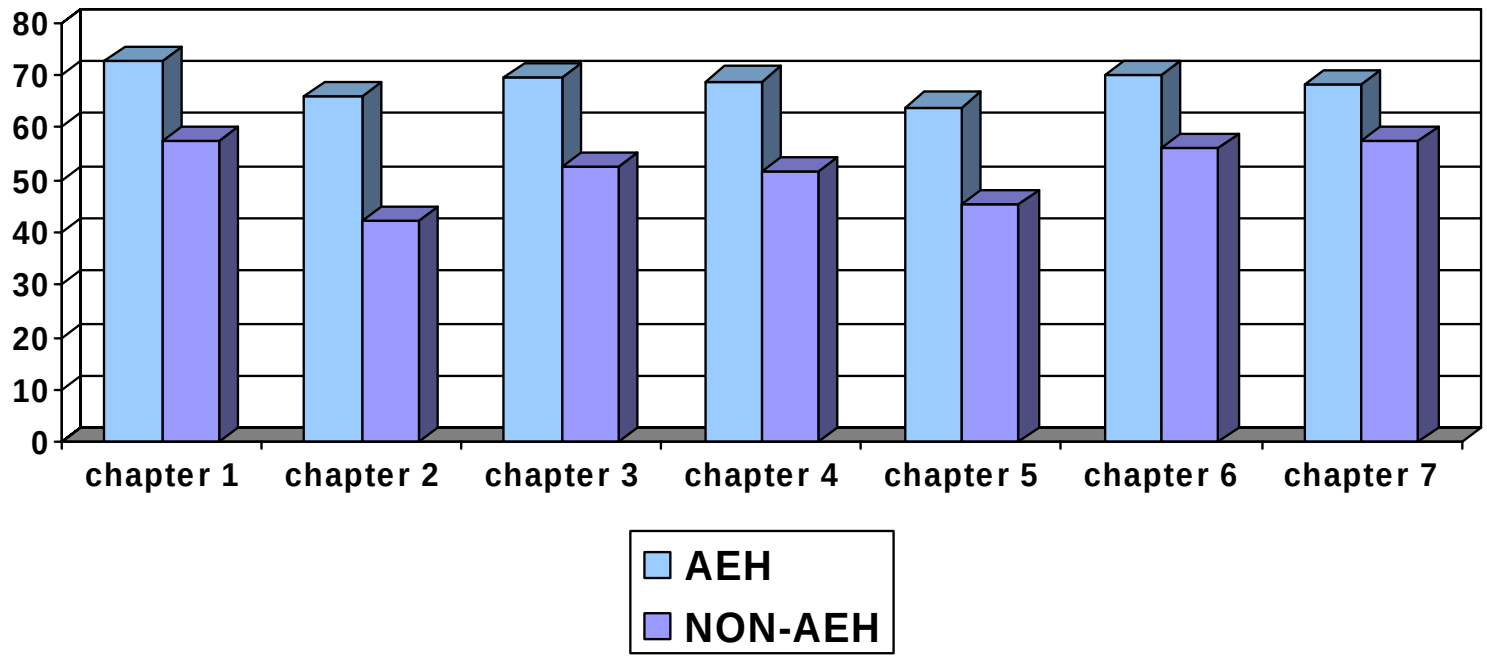
  Ha: $\mu_{\text{AEH (post-test)}} > \mu_{\text{NON-AEH (post-test)}}$

- The basic analysis results indicated that testing of hypothesis #1 was supported. Therefore, there is enough empirical data to reject the null hypothesis at the significance level of p = 0.05.

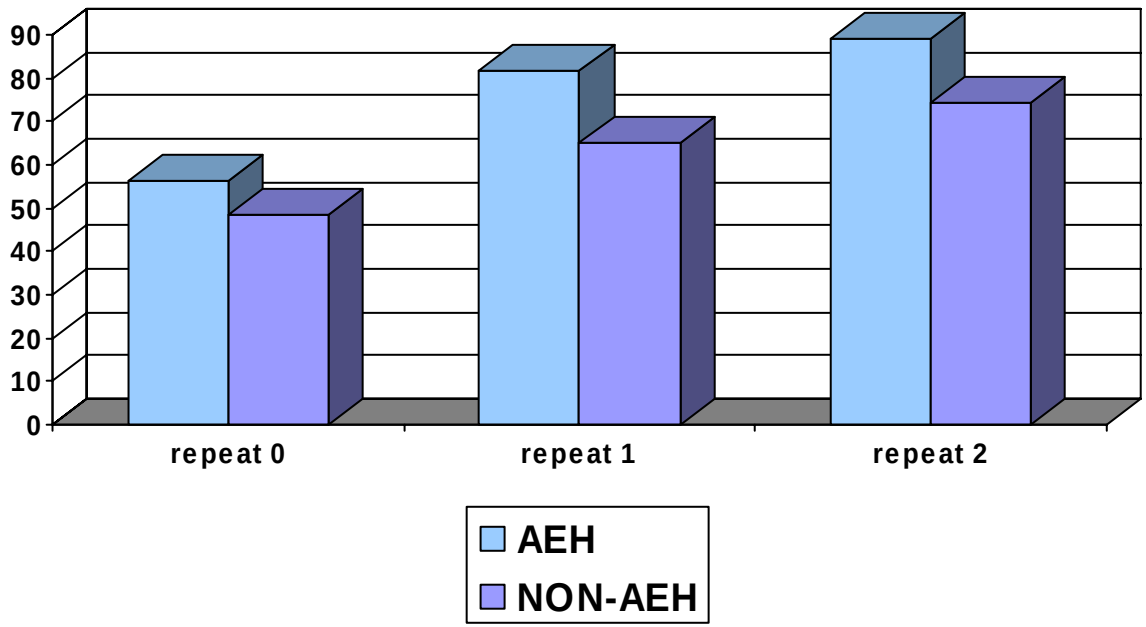
Multilevel analysis

- Multilevel analysis is a methodology for the analysis of data with complex patterns of variability with a focus on nested sources of variability.
- Multilevel analysis combines the strengths of regression and ANCOVA designs by allowing researcher to estimate outcome scores with other continuous or non-continuous variables.
- The procedure of multilevel modeling begins with the simplest model and works step by step toward the significant complex model.
- A first step in analyzing a multilevel model is to build a null model that serves as a benchmark with which other subsequent models will be compared.

Score means for each chapter



Score means for each test repetition



Multilevel: Between group analysis (knowledge adaptation)

- Hypothesis #2:

  Students who learn using the AEH system will have higher test score than students using the NON-AEH system because the AEH system adapts to knowledge as implemented in test repetition.

  Ha: $\mu_{\text{AEH (repetition)}} > \mu_{\text{NON-AEH (repetition)}}$

- According to three supporting evidences, there are significant differences at repeat_0, repeat_1, repeat_2. Therefore, there is enough empirical data to reject the null hypothesis at the significance level of p = 0.05.

Multilevel: Between group analysis (learning mode adaptation)

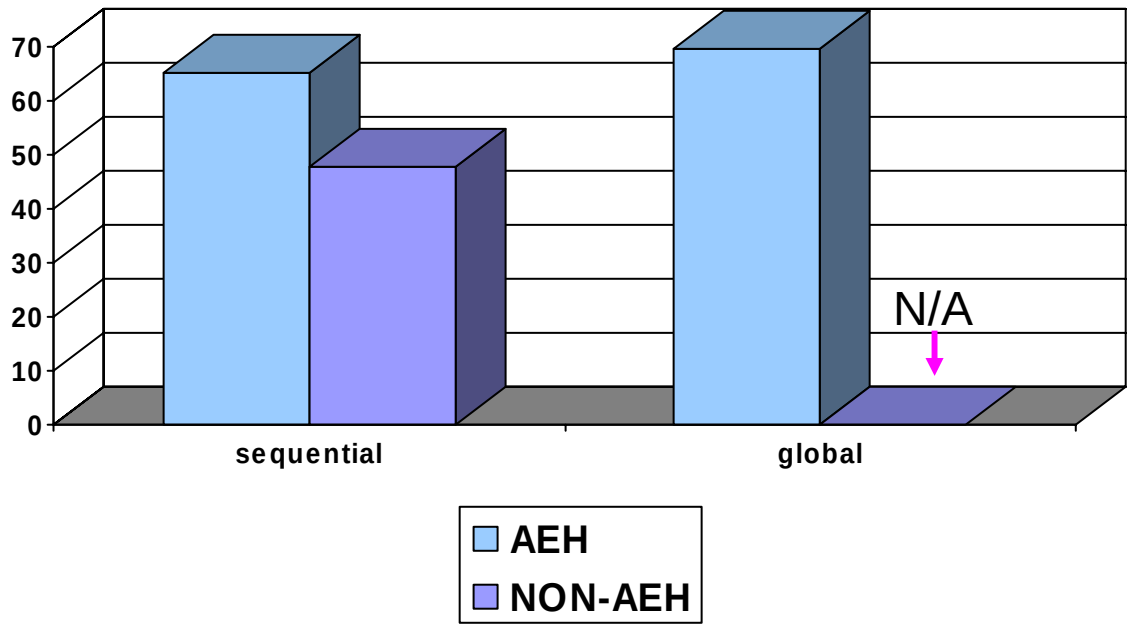
- Hypothesis #3:

  Students who learn using the AEH system with the least benefited option of learning mode (ls = 0 and ms = 0) will have higher test score than students using the NON-AEH system.

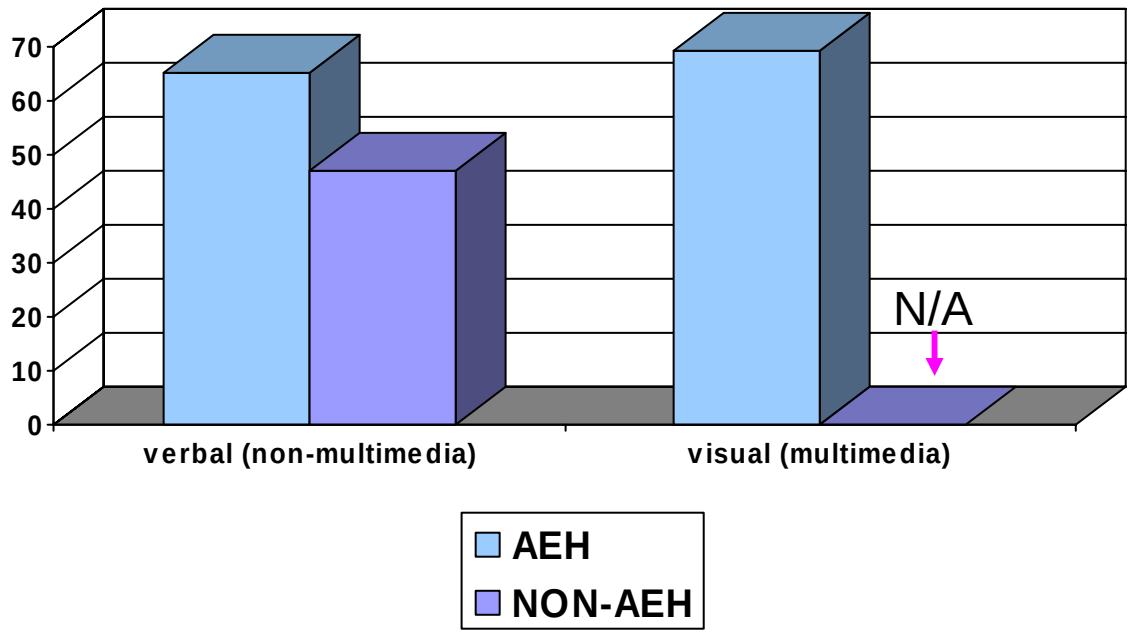
  Ha: $\mu_{\text{AEH (ls=0;ms=0)}} > \mu_{\text{NON-AEH (ls=0;ms=0)}}$

- According to multilevel analysis, there are significant differences at repeat_1, repeat_2. The null hypothesis is rejected at level of p = 0.05. At repeat_0, the AEH students still have higher test score.

Score means by learning styles



Score means by multimedia style



Multilevel: Between group analysis (for repeat 0 or first try)

- Hypothesis #4:

  Students who learn using the AEH system will have higher test score than students using the NON-AEH system when no test repetition is considered in both systems.

  Ha: $\mu_{\text{AEH (repeat\_0)}} > \mu_{\text{NON-AEH (repeat\_0)}}$

- According to multilevel analysis, there are significant differences at chapter #1, #2, #3, #4, #6. The null hypothesis is rejected at level of p = 0.05. At chapter #5 and #7, the AEH students still have higher test score.

Multilevel: Within NON-AEH analysis (suited/unsuited learning mode)

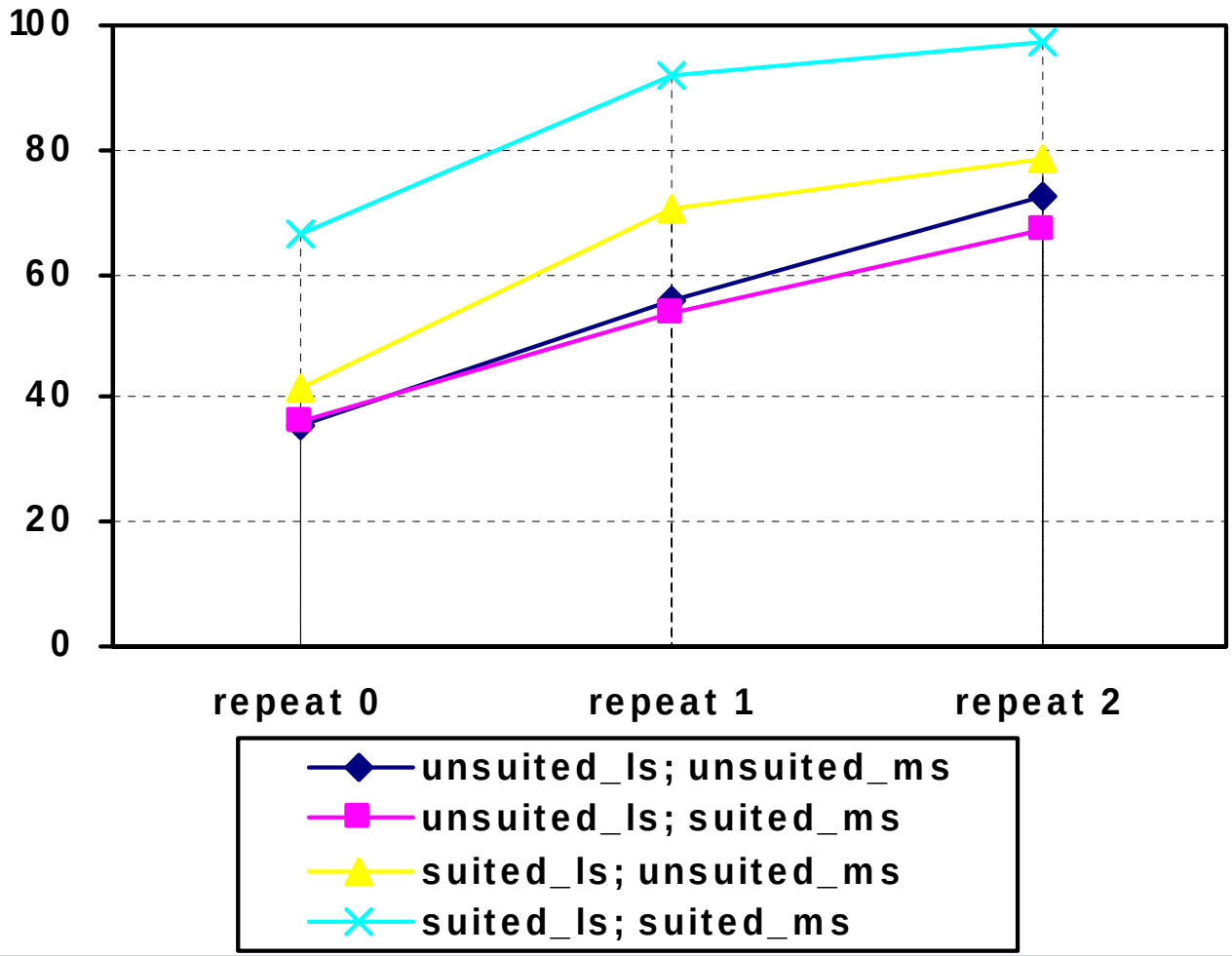
- Hypothesis #5:

  Students who learn using the NON-AEH system in which their actual learning mode preferences are suited will have higher test score than students using the same system in which their preferences are not suited

  Ha: $\mu_{\text{NON-AEH (suited ls-ms)}} > \mu_{\text{NON-AEH (unsuited ls-ms)}}$

- According to multilevel analysis, there are significant differences at repeat_0, repeat_1. The null hypothesis is rejected at level of p = 0.05. At repeat_2, the suited students still have higher test score.

Score means of NON-AEH students for each learning mode



Multilevel: Within AEH analysis (suited/unsuited learning mode)

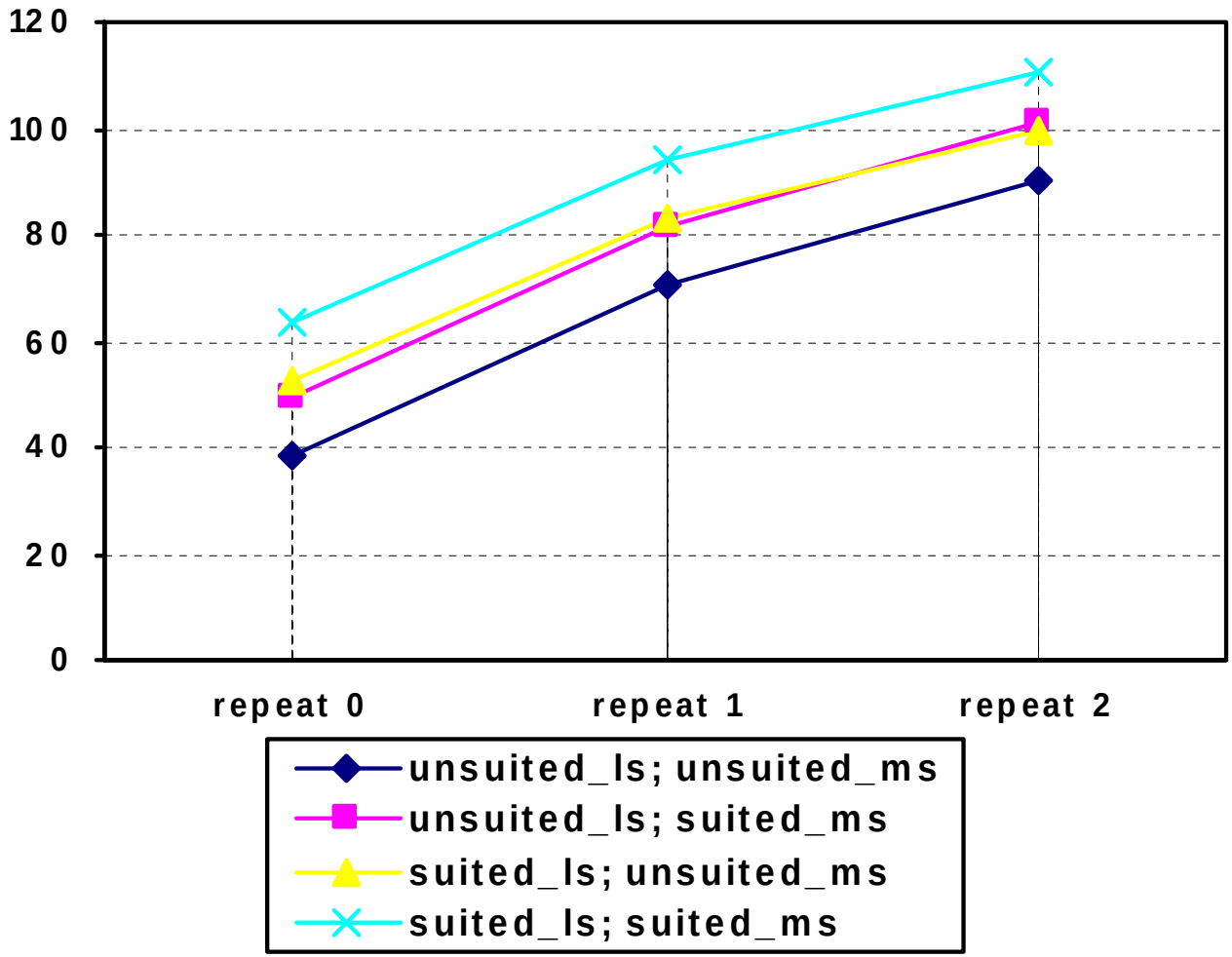
- Hypothesis #6:

  Students who learn using the AEH system in which their actual learning mode preferences are suited will have higher test score than students using the same system in which their preferences are not suited

  Ha: $\mu_{\text{AEH (suited ls-ms)}} > \mu_{\text{AEH (unsuited ls-ms)}}$

- According to multilevel analysis, there are significant differences at repeat_0, repeat_1 and repeat_2. Therefore, there is enough empirical data to reject the null hypothesis at the significance level of p = 0.05

Score means of AEH students for each learning mode



Multilevel: Between group analysis (suited learning mode)

- Hypothesis #7:

  Students who learn using the NON-AEH system in which their actual learning mode preferences are suited will have equal test score than students using the AEH system in which their preferences are suited.

  Ha: $\mu_{\text{NON-AEH (suited ls-ms)}} = \mu_{\text{AEH (suited ls-ms)}}$

- According to multilevel analysis, there no significant differences at repeat_0, repeat_1 and repeat_2. Therefore, there is enough empirical data to reject the null hypothesis at the significance level of p = 0.05

Summary-1

In general, students perform better when using the AEH than the NON-AEH system.	H1: $\mu_{\text{AEH (post-test)}} > \mu_{\text{NON-AEH (post-test)}}$
Students perform better in the AEH because it adapts to knowledge as implemented in test repetition.	H2: $\mu_{\text{AEH (repetition)}} > \mu_{\text{NON-AEH (repetition)}}$
Students perform better in the AEH because it adapts to learning style and multimedia style.	H3: $\mu_{\text{AEH (ls=0;ms=0)}} > \mu_{\text{NON-AEH (ls=0;ms=0)}}$ H4: $\mu_{\text{AEH (repeat\_0)}} > \mu_{\text{NON-AEH (repeat\_0)}}$
The learning style and multimedia style are meaningful to the AEH and NON-AEH systems.	H5: $\mu_{\text{NON-AEH (suited ls-ms)}} > \mu_{\text{NON-AEH (unsuited ls-ms)}}$ H6: $\mu_{\text{AEH (suited ls-ms)}} > \mu_{\text{AEH (unsuited ls-ms)}}$ H7: $\mu_{\text{NON-AEH (suited ls-ms)}} = \mu_{\text{AEH (suited ls-ms)}}$

Summary-2

- In terms of relative merits of each contributing factors toward student achievement, the order of the effects is as follows:
  1. knowledge adaptation
  2. multimedia style
  3. learning style
- The current findings confirm the results of other studies about educational hypermedia systems adapted to
  - knowledge (Mann: 1999, Kavcic, et al: 2002)
  - learning styles (Bajraktarevic, et al: 2003)
  - cognitive styles (Triantafillou, et al: 2004)

Summary-3

- No other adaptive system to date has been reported to accommodate up to three different characteristics simultaneously.
- Future study should not only compare the AEH and NON-AEH with more subjects and other teaching domains but also investigate the effects of various adaptation techniques on the student achievement within the AEH.