THE EFFECTS OF MULTIMEDIA AND LEARNING STYLE ON STUDENT ACHIEVEMENT IN ONLINE ELECTRONICS COURSE

Herman Dwi Surjono
hermansurjono@uny.ac.id

ABSTRACT
This experimental study investigated the effects of multimedia preferences and learning styles on undergraduate student achievement in an adaptive e-learning system for electronics course at the Yogyakarta State University Indonesia. The findings showed that students in which their multimedia preferences and learning style matched with the way the material presented in online electronics course have higher scores significantly compared to those in which their learning mode were mismatched. The difference happened both in adaptive and non-adaptive online courses.

Keywords: multimedia, learning style, adaptive, electronics course, e-learning

INTRODUCTION
Empirical studies have shown that individual one-on-one tutoring is the most effective mode of teaching. Individual tutoring allows learning to be highly individualized and consistently yields better outcomes than other methods of teaching (Hock, 2001). Because individual tutoring logistically and financially is impossible for all students in a traditional classroom situation, numerous kinds of computer programs have been developed for teaching in the form of Computer Assisted Instruction (CAI) and Computer Based Training (CBT). Students can learn individually with these computer systems. Although both CAI and CBT may be somewhat effective in teaching students, they do not provide the same kind of individualized attention that a student would receive from a human tutor. In these systems the instruction is not individualized to the student needs. They do not take into account the student's knowledge, learning style, preferences and other characteristics. The same teaching material is presented to every student in the same way regardless of his or her prior knowledge and experience.

This limitation has prompted a new generation of educational systems known as Intelligent Tutoring Systems (ITS). An important feature of ITS is their ability to adapt the presentation of material to a student's needs. They can adapt instruction dynamically to the different levels of student's knowledge. These systems obtain their intelligence and adaptivity by adopting pedagogical rules about how to teach as well as using information about the students. ITS design is founded on fundamental assumptions on learning that individualized instruction is far superior to classroom style learning because the instruction can be adapted for each student (Jerinic, 2000).

ITS have not been so popular in schools, because of problems such as high development cost, hardware dependency, installation and delivery problems. Integration of the traditional ITS and web technology has supposedly resolved these problems. Along with the advances of computer technology, more ITS researchers found it practical to develop an ITS and a learning material in electronic form. This is known as adaptive hypermedia and it has become a new field of research.

Adaptive educational hypermedia, which is a particular application of AHS in education, is a recently established area of research integrating technologies of CAI, ITS and hypermedia systems. There are at least two reasons driving the advances of educational adaptive hypermedia. First, educational hypermedia applications are typically used by much more heterogeneous users than any standalone computer-based learning application. Any web-based learning system that is designed for a specific group of users may not suit other users. Second, generally the user of web based educational hypermedia is working without any assistance from teachers, as would be the case in a traditional classroom situation.

An adaptive e-learning system (AES) has been developed for electronics course for undergraduate students in Yogyakarta State University (Surjono, 2007a), (Surjono, 2007b). The adaptivity mechanism that is used in the system to decide whether a student will get a certain learning mode is very simple. As it was described in the system design, students have to fill out the questionnaires when the first time accessing the adaptive course. The questionnaire contains questions that ask the tendency of learning styles and multimedia preferences.

It is known that a mismatch between student learning styles and the way the material is presented (as reflected by teacher teaching styles) can lead to poor student performance. A mismatch between the teacher's and learner's styles may hinder the learning process.

A number of researchers have investigated the improved performance of students whose learning styles matched the presentation mode. Ford and Chen (2001) have found significant differences in performance on conceptual knowledge for students learning in matched and mismatched conditions. Performance in matched conditions was significantly higher than that in mismatched conditions. Bajraktarevic et al. (2003) has suggested that significantly higher results were obtained for the matched session compared with the mismatched session.

This study investigated whether students in which their actual multimedia preferences and learning style (learning mode) matched with the way the material presented in online electronics course have higher achievement scores compared to those in which their learning mode were mismatched. The comparison was also made both in adaptive and non-adaptive online courses.

MULTIMEDIA PREFERENCES

There are many definitions of multimedia available. Typical examples define multimedia as “the use of multiple forms of media in a presentation” (Schwartz and Beichner, 2003), “a combination of text, graphics, animation, pictures, video, and sound to present information in a coherent manner” (Singh, 2003), and “the integration of media such as text, sound, graphics, animation, video, imaging into a computer system” (Jonasses, 2003). Vaughan (2011) defined multimedia as a class of computer-driven interactive communication systems which create, store, transmit, and receive textual, graphic and auditory networks of information. All of these definitions agree that multimedia is the integration of more than one medium in a computer system to present information.

A research study was conducted to investigate the effectiveness of multimedia instruction (Najjar, 1996). Students in the control group studied the learning materials in a classroom or lecture, combined with hands-on experiment. Students in the experimental group studied the material via multimedia-based instruction. The result indicated that student achievement was higher in the experimental group. Motion effect in animation creates illusion of movement which helps to explain abstract concepts. Computer graphics are effective for gaining attention and can encourage students to create mental images that in turn make it easier for them to learn certain types of information (Rieber, 1996).

Research conducted by Asoodeh (1993) showed that subjects who used animated visuals scored significantly higher on mental rotation tests than those who used static visuals. The use of graphics, charts and diagrams describes the relationship between pictures and words in a learning environment. Presenting learning materials in graphical form can encourage students to use mental skills in a more effective way. Arnheim (1994) suggested that visual learning can increase students understanding of abstract concepts because a student’s perception of ideas can be enriched by visual example. Therefore, visuals can promote development of perceptual thinking.

The use of multimedia in a computer based learning system is expected to increase student understanding with particular materials. However, an excessive use of multimedia may or may not improve the learning effectiveness. In order for multimedia to be effective, it should only be used in certain situations. Applying multimedia in every situation uses a lot of resources but does not necessarily provide a desirable result. Singh (2003) suggests that multimedia should be used only:

- when students have low prior knowledge;
- when students have low motivation;
- when multimedia is effectively designed.

LEARNING STYLE

There are various definitions of learning style from the literature. According to James and Blank (1993) learning style can be defined as the complex manner in which learners most efficiently and most effectively perceive, process, store and recall what they are trying to learn. McLoughlin (1999) summarizes the term of learning style as referring to adopting a habitual and distinct mode of acquiring knowledge. In addition, Honey and Mumford (1992) have defined learning style as the attitudes and behaviours which determine an individual’s preferred way of learning.

Riding and Cheema (1991) surveyed a number of learning style constructs and classified them into two broad categories: wholist-analytical and verbaliser-imager. The wholist-analytical category describes how individuals process information. Wholists prefer to learn material globally, while analysts are likely to process information in details. The verbaliser-imager describes how individuals represent information. Verbalisers prefer to present information in words, while imagers tend to present information in pictorial form. According to Felder et al. (1991), wholist and serialist are known as global and sequential; while verbalise and imager are known as verbal and visual.

There are a wide variety of instruments available for the measurement of learning styles. These include:

- Honey and Mumford's Learning Styles Questionnaire
- Grasha-Riechmann Student Learning Style Scales
- Felder's Index of Learning Styles

Honey and Mumford's Learning Styles Questionnaire is a widely used inventory learning style developed by Honey and Mumford (1992). The inventory suggests that there are four types of learner falling into two categories:

- Activists and reflectors
- Theorists and pragmatists

The Grasha-Riechmann Student Learning Style Scales (GRSLSS) were developed in the early 70's to identify and categorize the following styles of learners (2002):

- Competitive and collaborative
- Avoidant and participant
- Dependent and independent

The Felder's Index of Learning Styles focuses on aspects of learning styles significant in engineering education and has four dimensions (1991):

- Visual-verbal
- Sequential-global
- Active-reflective
- Sensing-intuitive

LEARNING MODE

Learning mode is a combination of learning style and multimedia preference that is used in the adaptive e-learning system (AE) in this study [3]. Students have their own learning styles (ls) and multimedia (mm) preferences that can be obtained through online questionnaires. Depending upon the questionnaire scores, the AES will present the learning materials with one of four possible learning modes, i.e.: *Global-Multimedia*, *Global-nonMultimedia*, *Sequential-Multimedia* and *Sequential-nonMultimedia*.

Any possible questionnaire result related to the ls dimension is shown in Table 1 (Surjono, 2006).

Table 1. Possible questionnaire results for LS dimension

Answer "a" (sequential)	Answer "b" (global)	Result (b – a)	Preference interpretation
0	11	11	Very strong preference toward global mode
1	10	9	
2	9	7	Moderate preference toward global mode
3	8	5	
4	7	3	Little preference toward global mode
5	6	1	
6	5	-1	Little preference toward sequential mode
7	4	-3	
8	3	-5	Moderate preference toward sequential mode
9	2	-7	
10	1	-9	Very strong preference toward sequential mode
11	0	-11	

There are six possibilities of the ls preference interpretation ranging from "very strong preference for global mode" to "very strong preference for sequential mode". A student who has a positive result (1 to 11) indicating that his or her learning style tendency is global will be given a presentation in global mode. On the other hand, a student who has a negative result (-1 to -11), indicating that his or her learning style tendency is sequential, will be given a presentation in sequential mode.

Any possible questionnaire result related to the mm dimension is shown in Table 2 (Surjono, 2006).

Table 1. Possible questionnaire results for MM dimension

Answer "a" (multimedia)	Answer "b" (non-multimedia)	Result (b – a)	Preference interpretation
0	11	11	Very strong preference toward non-multimedia mode
1	10	9	
2	9	7	Moderate preference toward non-multimedia mode
3	8	5	
4	7	3	Little preference toward non-multimedia mode
5	6	1	
6	5	-1	Little preference toward multimedia mode
7	4	-3	
8	3	-5	Moderate preference toward multimedia mode
9	2	-7	
10	1	-9	Very strong preference toward multimedia mode
11	0	-11	

There are six possibilities of the mm preference interpretation ranging from "very strong preference for non-multimedia mode" to "very strong preference for multimedia mode". A student who gets a positive result (1 to 11) indicating that s/he has verbal learning tendency will be given a presentation of the learning material without any additional multimedia resources. On the other hand, a student who gets a negative result (-1 to -11), indicating that s/he has a tendency towards visual learning, will be presented learning material with additional multimedia resources.

Presentation style used in the AES is a two-state variable that is defined as the way that the material is presented: this can be either sequential (where material is presented in a set unchangeable sequence) or global (where the various sections of the material are available for direct access, so that the user can pick and choose). Multimedia mode is also a two-state variable that allows material to be presented with optional multimedia artefacts in the form of film clips or animated schematics. Learning style will be referred to as ls and multimedia mode will be referred to as mm.

The additional multimedia resources are presented to the student who has a tendency of visual learning regardless of his or her ls values. The student can access navigation buttons of the multimedia features located at the bottom of the learning material page. The multimedia resources offered to the intended student include music, video clip and flash animation.

RESEARCH METHOD

The research was carried out using a randomized pretest-posttest control group experimental design. This design consisted of an experimental group and a control group. Employing this design minimized possible threats to internal validity such as history, maturation, instrumentation, regression, and selection. A total of 67 students agreed to participate voluntarily in the experimentation. The random assignment technique resulted in 34 students being in the experimental group and 33 students in the control group.

The experimental treatment used in this study was accessibility to the AES for students in the experimental group. As a comparison, students in the control group were provided accessibility to the NON-AES. The AES and NON-AES contained the same learning material, exercises and tests that are covered in an electronic course called Analogue Electronics for first-year second-semester undergraduate students at the Department of Electronics at Yogyakarta State University. The syllabus of Analogue Electronics implemented in the systems includes 7 chapters and had to be learned by the students for seven weeks with 2 hours access each week. An advanced multilevel statistical analysis was used to investigate the effects of the learning mode on student achievement.

RESULTS

In the NON-AES, students cannot change the learning mode by configuring different options of learning style and multimedia availability. The system provides a fixed default setting for the learning mode, which is a sequential and non-multimedia presentation. In order to do an analysis within the NON-AES group, additional data is required concerning actual student's preference towards the learning style and multimedia. Since the NON-AES was not designed to have questionnaires that can be accessed online, the data was collected manually through a printed version of questionnaires. The questionnaires are used to obtain the actual learning mode (ls and mm) preferences of students.

The printed questionnaires results consisting of ls and mm values were compared to the NON-AES ls and mm default values which are ls = 0 and mm = 0. Two variables were created to accommodate this comparison: suited_ls and suited_mm. The categories are as follow:

- suited_ls = 1, if their actual ls preference is equal to 0.
- suited_ls = 0, if their actual ls preference is equal to 1.
- suited_mm = 1, if their actual mm preference is equal to 0.
- suited_mm = 0, if their actual mm preference is equal to 1.

The analysis is to examine the effect of suited_ls and suited_mm variables (learning style and multimedia mode suitability) on the test scores over repeated measures within the NON-AES group only. This analysis will answer the following research question: “Do students who study using the NON-AES in which their actual learning mode preferences are suited to the system perform better than those who are not suited?”

A research hypothesis that will be tested following the analysis result can be defined as follow: “Students who study the learning material in the NON-AES in which their actual learning mode preferences are suited (suited_ls = 1 and suited_mm = 1) will achieve higher test scores than those who study the same material in the same system in which their preferences are not suited (suited_ls = 0 and suited_mm = 0).”

Using the multilevel statistical analysis, an optimum model can be plotted to illustrate the relations of each score mean corresponding to respective learning mode over the repeated measures. Figure 1 shows score mean of students among learning mode over repeated measures.

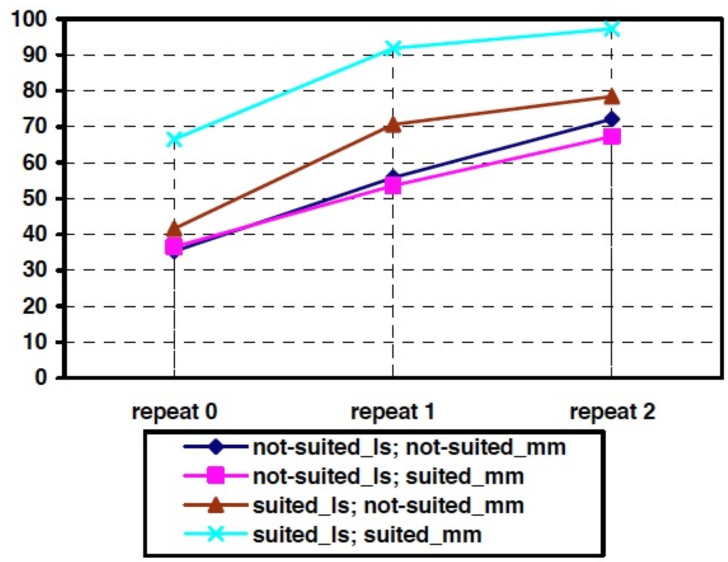

Figure 1. Comparison of score means for suited/unsuited learning mode in NON-AES

From the hypothesis testing, there is enough empirical data to reject the null hypothesis at the significance level of $p = 0.05$. It can be concluded that students who learn using the NON-AES in which their learning mode is suited have higher test score at repeat 0 and repeat 1 than students using the same system in which their learning mode is not suited.

Even though the AES allows students to change their learning mode, some students may not realize that either they need to do this or that the system can do this, because the students have only a limited on-line time during the experimentation. Consequently, the way the system presents the learning material may not match with their actual learning mode preferences. In order to reveal their actual learning mode preferences, they were asked to answer a printed version of questionnaires where the completion time was not limited.

The printed questionnaires results consisting of ls and mm values were compared to their learning mode from profile when they use the AES. Two variables were created to accommodate this comparison: suited_ls and suited_mm. The categories are as follows:

- suited_ls = 1, if their actual ls preference is equal to their ls stored in the profile.
- suited_ls = 0, if their actual ls preference is not equal to their ls stored in the profile.
- suited_mm = 1, if their actual mm preference is equal to their mm stored in the profile.
- suited_mm = 0, if their actual mm preference is not equal to their mm stored in the profile.

The analysis is to examine the effect of suited_ls and suited_mm variables (learning style and multimedia mode suitability) on the test scores over repeated measures within the AES group only. This analysis will answer the following research question: "Do students who study using the AES in which their actual learning mode preferences are suited to their profiles perform better than those who are not suited?"

A research hypothesis that will be tested following the analysis result can be defined as follow: "Students who study the learning material in the AES in which their actual learning mode preferences are suited (suited_ls = 1 and suited_mm = 1) will achieve higher test scores than those who study the same material in the same system in which their preferences are not suited (suited_ls = 0 and suited_mm = 0)."

Using the multilevel statistical analysis, an optimum model can be plotted to illustrate the relations of each score mean corresponding to respective learning mode over the repeated measures. Figure 2 shows score means of students with learning mode over repeated measures.

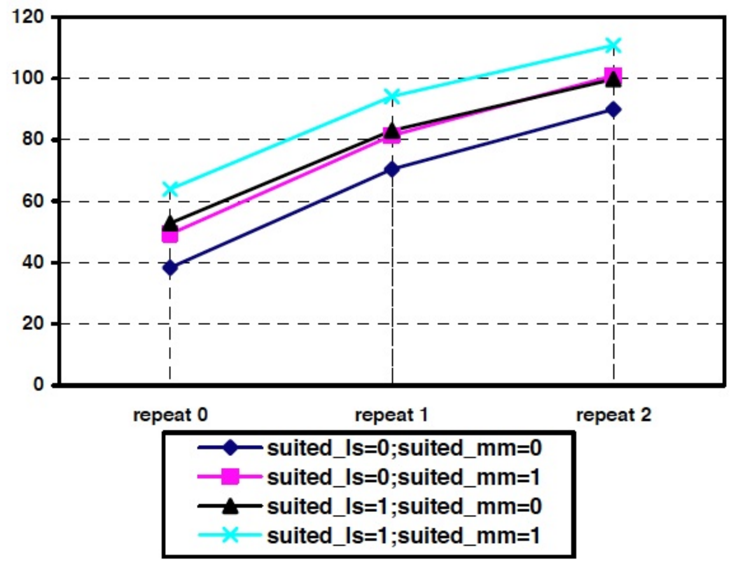

Figure 2. Comparison of score means for suited/unsuited learning mode in AES

From the hypothesis testing, there is enough empirical data to reject the null hypothesis at the significance level of $p = 0.05$. It can be concluded that students who study using the AES system in which their learning mode is suited have higher test score at repeat 0, repeat 1 and repeat 2 than students who study using the same system in which their learning mode is not suited.

CONCLUSIONS

In an non-adaptive e-learning system, students in which their actual multimedia preferences and learning style matched with the way the material presented in online electronics course have higher achievement scores compared to those in which their learning mode were mismatched.

In an adaptive e-learning system, students in which their actual multimedia preferences and learning style matched with the way the material presented in online electronics course have higher achievement scores compared to those in which their learning mode were mismatched.

REFERENCES

Arnhein. (1994). *Computers in education* (6th ed.). CT: The Dushkin Publishing Group Inc.

Asoodeh, M., M. (1993). *Static visuals Vs. computer animation used in the development of spatial visualization.* Unpublished doctoral dissertation, Texas A&M University, TX.

Bajraktarevic, N., Hall, W., & Fullick, P. (2003). *Incorporating learning styles in hypermedia environment: Empirical evaluation.* Paper presented at the AH2003: Workshop on Adaptive Hypermedia and Adaptive Web-Based Systems, Budapest, Hungary.

Felder, R. M., & Solomon, B. (1991). *Index of learning styles questionnaire*. Retrieved 9 April, 2014, from http://www4.ncsu.edu/unity/lockers/users/f/felder/public/ILSdir/ILS-nondisclosure.html

Ford, N., & Chen, S. (2001). Matching/mismatching revisited: An empirical study of learning and teaching styles. *British Journal of Educational Technology, 32*(1), 5-22.

Grasha, A. F. (2002). *Teaching with styles: A practical guide to enhancing learning by understanding teaching and learning styles*. Pittsburgh, PA: Alliance Publishers.

Hock, M. F., Pulvers, K. A., Deshler, D. D., & Schumaker, J. B. (2001). The effects of an after-school tutoring program on the academic performance of at-risk students and students with LD. *Remedial and Special Education*, *22*(3), 172-186.

Honey, P., & Mumford, A. (1992). *The Manual of Learning Styles* (3rd ed.). Maidenhead, UK: Peters Honey.

James, W. B., & Blank, W. E. (1993). Review and critique of available learning-style instruments for adults. In D. Flannery (Ed.), *Applying cognitive learning styles* (pp. 47-58). San Francisco: Jossey-Bass.

Jerinic, L., & Devedzic, V. (2000). The friendly intelligent tutoring environment teacher's approach. *SIGCHI Bulletin, 32*(1), 83-94.

Jonasses. (2000). *Computers as mindtools for schools*. Upper Saddle River, NJ: Merrill.

McLoughlin, C. (1999). The implications of research literature on learning styles for the design of instructional material. *Australian Journal of Educational Technology, 15*(3), 222-241.

Najjar. (1996). Multimedia information and learning. *Journal of Educational Multimedia and Hypermedia, 5*, 129-150.

Riding, R., & Cheema, I. (1991). Cognitive styles: An overview and integration. *Educational Psychology: An International Journal of Experimental Educational Psychology, 11*(3-4), 193-215.

Rieber, L., P. (1996). Animation as feedback in a computer based simulation: Representation matters. *Educational Technology Research & Development*, *44*(1), 5-22.

Schwartz, & Beichner. (1999). *Essentials of educational technology*. Boston: Allyn and Bacon.

Singh, V. K. (2003). *Does Multimedia really improve learning effectiveness?* Paper presented at the Asia Pacific Conference on Education, Re-envisioning Education: Innovation and Diversity, Singapore.

Surjono, H. D. (2006). *Development and Evaluation of an Adaptive Hypermedia System Based on Multiple Student Characteristics*. Unpublished doctoral dissertation, School of Multimedia and Information Technology, Southern Cross University, Australia.

Surjono, H.D. (2007a). *The design and implementation of an adaptive e-learning system.* Paper presented at the International Symposium Open, Distance, and E-learning (ISODEL 2007), Denpasar, Indonesia.

Surjono, H.D. (2007b). *Empirical evaluation of an adaptive e-learning system and the effects of knowledge, learning styles and multimedia mode on student achievement*. Paper presented at the UiTM International Conference on ELearning 2007 (UICEL), Universiti Teknologi MARA, Shah Alam, Malaysia.

Vaughan, T. (2011). *Multimedia: Making It Works*. 8th Edition. New York: McGraw Hill, 2011.