Effects of Group Problem Solving Activities on Active Learners' Performance in Online Learning

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ABSTRACT

Online learning is one of the 21st century teaching methods but researchers and practitioners face problems in applying appropriate teaching strategies to improve learners' performance. Previous studies have shown that matching learners' learning styles with appropriate teaching methods present great potential in making online learning easier and more effective as well as enhancing learners' performance. Based on that promising finding, this study aims to investigate the effects of matching teaching strategies using the group problem solving approach with active learning styles to gauge learners' achievement. The Felder and Silverman Learning Style Model and Group Problem Solving were used in this study to investigate the effects of teaching strategies on active learners' performance. Twenty-one learners enrolled in the Multimedia Interactive Application course were used as study samples. The instruments used were learners' log data, performance test results and learning activities in Moodle based LMS. The results showed that online learning utilizing the group problem solving approach on active learners improved their performance.

Keywords: learning style, problem solving, online learning

INTRODUCTION

Web-based learning facilitates online learning any time without distance and cost effect constraints in contrast to the face-to-face approach. The education community, however, is faced with the challenge to exploit the innovative characteristics of online learning in order to produce a flexible education system that meets the needs of different individuals and also to encourage learner participation during the learning processes (Huang, Lin & Huang, 2011). The pedagogical aspect is related to the quality of online learning and has become the focus of researchers as teaching and learning is very challenging and complex especially for online learning where the instructor merely functions as a facilitator and learning focuses more on the learners as the main agent for the implementation of the learning processes. This is made more complex as each learner has different characteristics and learning needs. These individual characteristics are the variables frequently forecast as the contributing factor for the success of online learning (Lim, Morris & Yoon, 2006).

Teaching practitioners believe that one of the individual characteristics that needs to be given due consideration when developing online learning is learning styles. They believe that learning styles can improve the performance of the learners by matching their learning styles with the appropriate teaching method; more popularly known as adaptive learning (Gilbert & Han, 1999). Adaptive learning has the potential to make the learning processes easier and more effective (Graf, Liu & Kinshuk, 2010). However, earlier researchers faced problems looking for the appropriate mechanism to match the teaching method with learning styles that was able to optimize learner achievement. Thus, this paper aims to investigate the effects of matching one of the teaching methods, i.e. Group Problem Solving with Active Learning Style in an online learning environment.

BACKGROUND OF PROBLEM

According to James and Blank (1993), learning style is defined as 'the complex manner in which, and the conditions under which, learners most efficiently and most effectively perceive, process, store and recall what they are attempting to learn'. For instance, some learners learn easily when it

involves visuals such as, diagrams, graphs, images and videos. This type of learner operates in the visual learning style dimension. On the other hand, if the learner is more comfortable with verbal form of learning, they are categorized as having a verbal learning style.

Kolb, Myer, Mumford, and Felder and Silverman have come up with a few learning style models (Coffield et al., 2004). Kolb categorized learning styles based on learning choices; accommodating, converging, diverging and assimilating while Myer focused more on personality stability choice; extroversion / introversion, sensing / intuition, thinking / feeling, and judging/perceiving. There are two methods to determine learning styles, i.e. using questionnaire and automatic behaviour detection in online learning. However, the Felder and Silverman learning style model has received greater attention as it implements a reliable and valid questionnaire (Litzinger, Lee & Wise, 2005) and the automatic detection based on online learning behaviour. Furthermore, this model provides a clear and detailed dimension of learning styles based on a scale ranging between +11 to -11. The added value of the Felder and Silverman model has been recognized by Kuljis and Liu (2005) who adopted this model for online learning usage.

Active Learning Style is one of the learning style dimensions in the Felder and Silverman model (Felder & Silverman, 1988)others demonstrate or discuss; some focus on principles and others on applications; some emphasize memory and others understanding. How much a given student learns in a class is governed in part by that student\u2019s native ability and prior preparation but also by the compatibility of his or her learning style and the instructor\u2019s teaching style. Mismatches exist between common learning styles of engineering students and traditional teaching styles of engineering professors. In consequence, students become bored and inattentive in class, do poorly on tests, get discouraged about the courses, the curriculum, and themselves, and in some cases change to other curricula or drop out of school. Professors, confronted by low test grades, unresponsive or hostile classes, poor attendance and dropouts, know something is not working; they may become overly critical of their students (making things even worse. In this dimension, a learner who possesses an active learning style tends to use an active physical approach to gather certain information. An active learner can learn effectively if their learning situations give them the opportunity to play around with the learning material such as executing

an experiment or debating or conducting a discussion in groups. In defining a learning style, two approaches can be utilized, which are the collaborative and automatic approaches. In case of the collaborative approach which uses a questionnaire as a tool to identify learning styles, it is observed that the results from this approach are inaccurate, caused by self-conceptions (Graf, Kinshuk & Liu, 2008) or perfunctory answers by the respondents (Garcıa et al., 2007). Thus, the results do not reflect the actual learning styles which potentially give a negative effect on adaptive learning.

In order to overcome this problem, an automatic approach is suggested to identify the learning styles. The automatic approach is based on the actual behaviour patterns during online learning process. The assessment of the behaviour pattern can be done via two approaches; namely, data driven method and literature based method (Garcia et al., 2007; Graf et al., 2008). The former method uses sample data of behaviour that matches the questionnaire in model development to infer the learning style. Neural networks, Decision trees, Hidden Markov model, Fuzzy Clustering and Bayesian Networks are among the techniques used on the data driven Approach (Garcia et al., 2007). The literature based method on the other hand, uses behaviour patterns acquired and aligns them with the Felder-Silverman learning style model (Graf et al., 2008).

The main aim of matching teaching methods with learning styles is to overcome the 'one-size-fits-all' approach that is commonly used to design the learning materials and activities for online learning (Brown et al., 2005). The 'one-size-fits-all' is a teaching approach that does not take into consideration the different characteristics of individual learners and thus only uses a single method for all. The 'one-size-fits-all' approach may result in some learners having learning difficulties (Felder & Brent, 2005).

Felder and Brent's (2005) statement is supported by teaching practitioners who believe in the need to consider individual differences to develop effective online learning activities. An online learning system that does not emphasize individual differences could demotivate learners and thus affect their academic achievement (Aviram et al., 2008). Research has shown that online learning systems that practice the 'one-size-fits-all' approach is not successful (Despotovic-Zrakic et al., 2012). This statement is supported by a few other researchers (Felder & Brent, 2005) who claimed

that this issue has caused a significant reduction in the use of online learning systems because learners are not satisfied with the static form of learning that uses a single method for every learner.

The matching of teaching methods and learning styles approach is an adaptation technique. A few adaptation techniques exist such as matching learning styles with curriculum arrangements, presentation of learning materials and navigation adaptation. However, empirical studies have not proven that the adaptation technique has been widely accepted, as the results of such studies are inconsistent (Brown et al., 2005). The adaptation technique which matches teaching methods with learning styles has the potential to make the learning processes more convenient (Felder & Silverman, 1988; Graf et al.,2010), reduce effort and learning time (Graf et al., 2010) and improve learner performance (Akdemir & Koszalka, 2008). The adaptation technique is still understudied and needs thorough research especially to determine the learning styles utilizing automatic detection (Garcia et al., 2007).

Franzoni and Assar (2008) have come up with a Learning Style Matching Taxonomy based on the Felder and Silverman (1988) learning style model and teaching method. Franzoni and Assar (2008) claim that the taxonomy is developed based on the classification of teaching methods according to the Felder and Silverman (1988) learning style model. This taxonomy has passed through a verification process by a panel of experts using the Delphi method during The III Congreso de Estilos de Aprendizaje di Cáceres Spain in July 2008 (Franzoni and Assar, 2008). One of the taxonomies is matching teaching method based on problem solving with active learning style.

Problem solving refers to the integration of concept and skills to solve an incomplete situation (Lester, Stone & Stelling, 1999). The Problem Solving Technique is a teaching strategy that can improve learner thinking enabling them to become more critical, logical and creative (Dogru, 2008). It is a teaching and learning approach developed from John Dewey's theory. According to John Dewey, a good way of thinking is deep thought utilizing fuzzy situation, doubt, conflict and disruption of clear, coherent, complete and harmonious situations. Problem based learning is a learning technique to strengthen the learners by carrying out research, integrating

theory and practice, and using knowledge and skills to develop solutions to problems. Problem Solving Learning refers to the method commonly used by instructors, that is giving lectures or reading materials to the learners and then presenting the learners with problems referring to the given lectures and reading materials.

According to Franzoni and Assar (2008), this teaching method is suitable for learners with sensory and active learning styles as both facilitate learning when presented with problems. They prefer facts, procedures and practical activities and these elements are needed for problem solving (Felder & Silverman, 1988; Franzoni and Assar, 2008). A few past researches had studied the effect of matching teaching method with learning style on learner achievement but the results are inconsistent. Therefore, an indepth study which is realistic and practical to overcome certain problems such as the development of sophisticated learner's model (Garcia et al., 2007), a complex learning adaptation mechanism (Brown et al., 2005) as well as a study on the comprehensive effect of learning adaptation, needed to be conducted.

RESEARCH METHODOLOGY

This study was conducted over a 15 week duration in a selected polytechnic. The duration of this study was divided into 4 main timeframes. In the first week, a pre-achievement test was executed. Meanwhile, in the second time frame which was 8 weeks consecutively, a learner was observed to determine his/her online learning style in the LMS environment. The literature based method was used to measure the online learning style pattern in this environment (Graf et al., 2008). The third frame consisted of the remaining 6 weeks, where active learners were exposed to the LMS environment with active learning techniques consisting of group problem solving activities using forum. Finally, in the final week, a post-achievement test was executed.

Samples in this study were fifth semester diploma in engineering learners who were enrolled in the Multimedia Interactive Application (MIA) course. The 21 learners were purposely selected to be the samples in the study based on their online learning style. Automatic detection as

active learner is based on actual learning behavior in online learning. The sample was further classified into 4 female and 17 male learners. The total population sample was 130 electrical engineering students from one of the Malaysian polytechnics.

The instrument used in this study is divided into two. The first part of the instrument is used to identify the online learning style using an activity and resources available in the LMS. The activity and resources include notes in the form of SCORM package, quizzes, forum and journal. The second part of the instrument was an add-on of a group problem solving activity. A forum for the online group problem solving learning activity was created for this purpose.

In order to identify the learning style based on log data, 10 learning behavior patterns were used in determining the learners' online learning style. This log data was analyzed using a literature based method (Graf et al., 2008) from weeks 2 until 8. Table 1 shows the details of the online learning behavior pattern under study.

Table 1: Patern Of Online Behavior

Features	Pattern of Online Learning Behavior
Content	Content_visit, Content_stay,
Exercise	Exercise_visit, Exercise_stay,
forum	Forum_visit, Forum_stay, Forum_post
Journal	Journal_visit, Journal_stay, Journal_post

Meanwhile, for problem solving activities, each group of active learners was given 3 topics related to the content of the course to carry out the online learning problem solving activity for a duration of two weeks for each topic. A total of 6 weeks of discussions were carried out using online discussion forum. Throughout the process, the learners were assisted by the instructor with feedback, encouragement, as well as provision of clues to scaffold learners' discussions.

Achievement tests were developed to measure the effectiveness of adaptive learning based on group problem solving activities for active learners. There were two achievement tests involved in this study; pre-

achievement test and post-achievement test. The tests were arranged into two sections namely, Section A and Section B. Section A consisted of 5 short essay questions at Bloom Taxonomy's knowledge and comprehension levels while Section B consisted of 5 questions at the application and analysis levels. The pre-achievement test was given in week 1 while a post-achievement test was executed at week 15.

The discussion topics and achievement tests were validated by an instructional expert with more than 5 years of research background on online problem solving and a content expert with more than 5 years of experience in teaching the subject. The reliability of the achievement tests were established through repeated test with Pearson correlation value of 0.763.

DATA ANALYSIS

The learners online learning style is formulated in Eq. (1) (Graf et al., 2008), with (denoting an online learning style, ($h_{dim,\ i}$) indicating each learning style dimension (*dim*), value of behavior pattern score (*i*), and accumulated behavior pattern score behavior (P_{dim}). (1)

The next step is to normalize the online style value (into 0 to 1 range of value using Eq. (2). The output of learning style after normalization is further categorized into four classes as shown in Table 2. (2)

Table 2: Category of Processing Information Learning Style

Normalization value	Learning Style Preferences
nls_{dim}>0.75	Strong active
0.5 < nls_{dim}≤0.75	Balance active

In addition to that, a paired-samples *t*-test was used to compare the mean value from pre- and post-scores at 0.05 confidence level. This test was carried out to investigate any significant effect of adaptive learning based on learning style towards active learners' performance in tests. The hypotheses set are as follows:

H_o: There is no significant difference in active learners' academic performance before and after using adaptive learning based on learning style.

H_1: There is significant difference in active learners' academic performance before and after using adaptive learning based on learning style

Consequently, meta-analysis on the t test, related to the effect size of the given treatment is calculated to obtain Cohen *d* value. Finally, to estimate the exact sample size and the power value for the effect size value being previously obtained is analyzed using power analysis.

RESULTS

Results from the analysis of the log data shows that 2 learners possess a strong online learning style and the remaining 19 learners have a balanced score. Upon finding the active learners' score to be normally distributed ($p>0.05$) when conducting a Shapiro-Wilk normality test, a paired-samples t-test was implemented. The results of the t-test indicate that adaptive learning using learning strategy based on group problem solving activities contribute a significant achievement on the active learner score that is equivalent to $p=0.000$ and $p<0.05$ as shown in Table 3. This highlights that matching teaching strategy based on group problem solving could improve active learners' achievement in tests.

Table 3: T-Test Result on Active Learners' Performance

	Paired Differences				
	Mean	Std. Deviation	t	df	Sig. (2-tailed)
Post-test –Pre-test	43.357	20.88	9.555	20	0.000

In view of the analyses in Table 4 below, outcomes from post hoc analysis show an effect of size the power of value 2.714 is 1.00 ($p>.05$). This confirms that the value is the biggest size effect that has been suggested.

Table 4: Comparing Performance

	Mean, *M*	Standard Deviation, *SD*	Effect size, *d*	Power *(1-β)*
Post-test	47.623	22.370	2.714	1.00
Pre-test	4.266	3.158		

Meanwhile, Table 5 illustrates the result from priori analysis that show a usage of 10 samples is enough to give size effect of 2.714. Thus, the size of sample used in this study (n=21) achieves a significant level (p>.05) with power of (1-β=1.00) needed.

Table 5: Power Analysis Results

Effect Size, *d*	Power	Critical *t* (16)	Delta	Minimum Sample size, *n*	Degree of freedom, *df*
2.714	1.00	2.306	4.050	10	8

DISCUSSION

This study presents and evaluates the effect of group problem solving activities on active learners' learning performance in an online learning environment. The study used matching teaching method (group problem solving activities) with learning style (active learning style from the Felder and Silverman Learning Style Model) in order to study its learning effectiveness. The main findings and their reasons are discussed below.

Based on the finding, this study proves the research hypothesis that learning activities with adaptive learning using group problem solving is able to improve the active learners' performance significantly. This result is consistent with the findings by Franzoni and Assar (2008) who claimed that the learners' performance can be enhanced when the appropriate teaching method was matched with the learners' learning style. Besides that, previous studies (Despotovic-Zrakic et al., 2012; Graf & Kinshuk, 2007) also revealed that learners whose learning styles were perfectly matched with the appropriate teaching method gained a significant score compared to unmatched ones.

The group problem solving method has been acknowledged to increase learners' learning performance without considering their differences (Shukor et al., 2014). Yet, the learning process will be far more effective if it is applied to learners who are interested in problem solving learning or active learning, compared to those who lack interest. When this learning style is matched with group problem solving teaching method, it can make the active learner's learning process easier and more efficient (Graf, Liu & Kinshuk, 2010). This is due to the role of group problem solving technique becoming the catalyst to trigger a more meaningful discussion in an effort to understand and use all concepts learned in solving the given problem (Felder & Silverman, 1988). A study conducted by Popescu (2009) showed that the implementation of the learning style matched with adaptation was more beneficial to learners in terms of learning gain, enjoyment, motivation, increased overall satisfaction and shorter learning time compared to learners who had to go through a mismatched course.

Besides the selection of matching learning style and teaching method in order to increase learner performance, the selection of learning style models used are also considered a critical issue influencing the effect of matching learning style and teaching method (Papanikolaou & Grigoriadou, 2004). It covers the selection of learning style models and the diagnosis of learners' learning styles. There are many models of learning styles (Coffield et al., 2004), but a model that can characterize the learning style dimensions in detail with valid and reliable instruments as adopted in the Felder and Silverman learning style model should be given due consideration (Papanikolaou & Grigoriadou, 2004). Hence, this study used the Felder and Silverman's active learning style dimension model and found that it has given a positive impact to the chosen teaching method. The result is probably due to the use of the Felder and Silverman model that is able to analyze clearly the dimensions of learning styles based on a scale range of between +11 to -11 (Felder & Brent, 2005). In addition, the Felder and Silverman model's questionnaire also has acceptable reliability and validity (Felder & Brent, 2005). In addition, previous research using Felder and Silverman model showed a positive effect of matching the appropriate learning style with the teaching method (Despotovic-Zrakic et al., 2012).

Apart from the selection of the learning style model, the automatic approach adopted to determine the learning style also plays a vital role

as it is more accurate compared to the collaborative approach (Graf et al., 2008). The automatic approach is based on the actual behavior of learners while doing online learning and is not solely based on perception. Previous researches have shown that the impact of the achievement of learning adjustments could potentially be more optimal if personal parameters used for the adjustment are based on actual learner behavior (Graf et al., 2008), compared to the determination of learning styles using a questionnaire that is solely based on perception. The combination of the Felder and Silverman learning style model and the automatic approach adopted to create a unique adaptive learning style and matched with appropriate teaching method has probably increased learners' achievement in this study.

CONCLUSION

In short, this research proves that three elements have to be considered in determining the effect of matching teaching method with learning styles to improve learners' performance. Firstly, the selection of teaching method needs to be matched with the learning style. Next, is the selection of learning style models which can range from Felder and Silverman's Model, Myers-Briggs Type Indicator, Kolb's model or any other models. Thirdly, is the method used to determine the learning styles, either collaborative or automatic. For future work, the researchers propose using the teaching method matching technique on other active learners as suggested in the taxonomy of matching teaching method with learning styles by Franzoni and Assar (2008) such as question and answer, games and simulation, etc. On the other hand, studies utilizing other learning dimensions as stated in Felder and Silverman learning styles model such as reflective, visual and others are also suggested for future research in order to uncover the effects of matching teaching method with other learning styles.

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