Effects of an Online Interactive Multimedia System on Cognitive and Affective Learning

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Abstract—**This study examines the effects of an online interactive multimedia system on the cognitive and affective learning of some issues related to road safety. It employed a quasi-experimental design with two experimental modes: multimedia learning and text-based learning. This study design enables both multimedia and text-based to be compared in order to determine the differences on the learning effects of these two learning modes. The pretest and posttest scores were analyzed using Mann-Whitney U Test to compare the variances between the multimedia and text-based groups and K-means cluster analysis was used to find out whether two distinct clusters exist to represent the two learning modes. Results show that for cognitive learning, positive gain scores are obtained for both the multimedia and text-based groups but there is no significant difference on the gain scores between these two groups. On the other hand, results of affective learning show significantly higher gain scores for students using multimedia learning than students using text-based learning. Thus, it can be concluded that the online interactive multimedia system can produce desirable effects, particularly for affective learning.**

Index Terms—**Affective; Cognitive; Online Interactive Multimedia System.**

I. INTRODUCTION

Over the decades, there are numerous studies that focus on the use of multimedia for cognitive learning or learning in the cognitive domain. For example, Beerman [1] shows that instruction through computers produced higher test scores than conventional methods and learners were also reported to have better long-term retention. Moreno and Mayer [2] who introduced cognitive principles in multimedia learning conclude that in computer-based instruction, students learn better when both verbal and visual materials are used. Alkhasawneh et al. [3] who developed multimedia text for reading comprehension based on the cognitive theory of multimedia shows that student achievement in reading comprehension increased when both channels (verbal and pictorial) were used in reading the comprehension text. Moreover, the study by Liu [4] that examines the effects of multimedia design on cognitive skills shows that multimedia tools can afford students' learning of design skills. Mechling et al. [5] further shows the successful used of a multimedia program to teach the procedure of operating an automated payment machine with a debit card. More recent studies such as Yeh and Wang [6] examined the effects of different types of vocabulary annotations on vocabulary learning and found that the combination of text and pictures is the most effective.

According to Goldfayl [7], affect and cognition are indistinguishably tangled in a learning process; hence design and development that only focus on one of these two aspects will abandon the primary mechanism of success in the learning process. Comparing with the number of studies that focus on cognitive learning, the number of studies that focus on affective learning or learning in the affective domain is significantly lesser. Moneta and Kekkonen-Moneta [8] compared the effects of using an online multimedia and the corresponding lecture version on students' affective learning of an introductory computing course. This study found that multimedia benefits affective learning but lecture produces both positive and negative consequences to affective learning.

There are also studies that focus on using the affective aspect to influence cognitive learning. For example, Um et al. [9] who investigated the emotional design in multimedia learning reveal that positive emotions can assist learning and thus, should be deliberately incorporated into the instructional design of a multimedia learning environment. Taylor and Galligan [10] used an interactive multimedia mathematics system, which consisted of video, animation, audio, interactive examples and self-assessment for tertiary students with mathematics anxiety to develop both cognitive and affective learning. Students were inspired to feel as part of a group and express their feelings and opinions towards mathematics. They were also exposed to real world problem solving, practices and self-assessment to develop their confidence and were encouraged to appreciate their own mathematical ability as well as build confidence while developing mathematical problem skills.

Liew and Tan [11] who examined the effects of positive and negative mood on cognition and motivation in multimedia learning environment found that negative mood reduces learning transfer. On the other hand, positive mood produces favorable effect on germane load, extraneous load, and intrinsic motivation. Recognising the effects of the affective aspect on learning, Ray and Chakrabarti [12] implemented an affective computing module into an e-Learning system to capture learners' emotional state with the aim to improve their learning experience. Such studies focus on the influence of the affective aspect, particularly in terms of learners' emotion and attitude during the learning process rather than the affective learning that focuses on changes to learners' attitude and values with regard to the learning content as defined by Krathwohl, Bloom and Masia [13].

II. PROBLEM STATEMENT

As mentioned earlier, many studies focus on examining

the effects of multimedia on cognitive learning. Comparing to studies that focus on cognitive learning, the number of studies that focus on examining the effects of multimedia on affective learning is still rather minimal. Fuller [14] highlights the lack of assessment done for the affective domain due to several reasons, which include the difficulties to measure performance in the affective domain because very few validated assessment instruments are available; values and attitude are seen as private matters and affective behavior changes at a rate than that is much slower than cognitive behavior. Much research that grounded on the cognitive theory of multimedia learning emphasis on cognitive learning but much remains undone [15]. Hence, it would be insightful to examine the effects of multimedia on affective learning to gain more understanding of the role of multimedia in the affective domain.

Existing studies [9, 10, 11] show that positive emotions and attitude afford cognitive processes and also affective practices in multimedia-based learning environment can enrich learning. While there are considerably number of studies that focus on the use of the affective aspect to influence cognitive learning, studies that focus on affective learning that involves changes to learners' attitude and values due to the learning content are still rather minimal. Indeed, affective learning has often been neglected [16]. Thus, besides focusing on the cognitive learning aspect, this study also focuses on the effects of multimedia on affective learning as defined by Krathwohl et al. [13] to add to the limited literature available on this aspect.

III. AIM

The aim of the study is to investigate the effects of using an online interactive multimedia system on cognitive and affective learning.

IV. RESEARCH QUESTIONS

R01: How to design an online interactive multimedia system to deliver the learning content?

R02: What is the effect of using the online interactive multimedia system on cognitive learning when compared with the printed text-based learning material?

R03: What is the effect of using the online interactive multimedia system on affective learning when compared with the printed text-based learning material?

V. HYPOTHESES

The following are the hypotheses:

H01: There is no significant difference on the gain scores of the cognitive learning between multimedia and text-based learning modes.

H02: There is no significant difference on the gain scores of the affective learning between multimedia and text-based learning modes.

VI. METHOD

The following subsections describe the multimedia system used, participants involved in the experiment, instruments, ways to improve the internal validity, pilot study and experimental procedure of the study.

A. Online Interactive Multimedia

The online interactive multimedia system that focused on both cognitive and affective learning was designed and developed to deliver the learning content about road safety (i.e. distraction and speeding). Learners responded to reflection questions, forums, read related articles and news, as well as viewed related videos in the learning system. The system was designed based on the Design Principles of Multimedia Instruction as recommended by Mayer [17]. Table 1 shows the specific principles used.

Table 1
Design Principles Used

Design Principles	Description
Coherence Principle (Reducing Extraneous Processing)	Multimedia message will allow people to learn more deeply when unnecessary materials are removed instead of included as those materials might divert them [17]. For example, in the online multimedia system, background music, non-related content and irrelevant graphic were not added, instead simple, basic as well as concise on-screen text were used to avoid extraneous cognitive load.
Signaling Principle (Reducing Extraneous Processing)	Multimedia message will allow people to learn more deeply as cues are added to emphasize on the organization of the important materials [17]. In this online multimedia system, bold fonts and headings as well as subheadings with different colors were used to direct learners' attention.
Redundancy Principle (Reducing Extraneous Processing)	People will learn more deeply through narration and graphics instead of narration, graphics and on-screen text [17]. For example, a documentary that consisted of graphics and narration was obtained via YouTube to educate learners on the risk of texting behind the wheel.
Spatial Contiguity Principle (Reducing Extraneous Processing)	People will learn more deeply when related printed words and graphics are presented near rather than far apart on the page or screen [17]. For example, in the online multimedia system, printed words were placed near to the related graphics.
Temporal Contiguity Principle (Reducing Extraneous Processing)	People will learn more deeply when multimedia message are presented concurrently instead of consecutively [17]. For example, in the online multimedia system, learners were able to simultaneously listen to the narration and view the related pictures.
The Segmentation Principle (Managing Essential Processing)	People will learn better when a multimedia lesson is presented in user-paced segments rather than as a continuous unit [17]. For example, in the online multimedia system, the quick links to the different parts of the learning content make it easier for user to navigate the learning system.
The Pre-training Principle (Managing Essential Processing)	People will learn more deeply from multimedia message when they understand the names and characteristics of the main concepts [17]. For example, in the online multimedia system, the meanings of the different icons were introduced to learners to enable them to recognize the various components of the learning system.
The Modality Principle (Managing Essential Processing)	People will learn more deeply graphics and narrations instead of animation and on-screen text [17]. The video used in this learning system supports this principle.
The Personalization Principle (Fostering Generative Processing)	People learn more deeply when words of multimedia are in conversational style instead of formal style [17]. For example, in the online multimedia system, most messages were written in conversational tone to encourage learners to communicate with each other in an informal way and a sharing platform that allowed learners to post their individual opinions also served to support this principle.
The Image Principle (Fostering Generative Processing)	People do not necessary learn better from a multimedia lesson when the speaker's image is added to the screen [17]. In this learning system, the speaker's image was not added to the screen.

B. Participants

In Malaysia, the minimum age to own a driving license and drive a car is 17 years old and above. The targeted population of this study was undergraduate students as they were over the minimum age to qualify for driving license. This study involved 81 participants from two intact classes of an undergraduate course. The first intact class that consisted of 41 students was assigned to the multimedia learning mode and the second intact class of 40 students was assigned to the text-based learning mode.

C. Instruments

The instruments used to measure the effect of the interactive multimedia system on cognitive and affective learning were pretest and posttest. There instruments were administered to both multimedia and text-based groups. Both tests were divided into two sections, namely cognitive and affective, with each section consisted of 11 questions. The questions were designed based on the Krathwohl Taxonomy for both cognitive and affective domains. Related questions were derived for the five levels of the cognitive domain, which are remembering, understanding, applying, analyzing and evaluating as well as the first five levels of the affective domain which are receiving, responding, valuing, organization and characterization. The maximum score for the cognitive section was 11 points and the maximum score for the affective section was 41 points. These scores were then converted into 100% respectively in the analysis of the results.

D. Threats to Internal Validity

Threat to maturation: It involves the process that leads individuals to change the dependence measure (i.e. getting older, better educated, more experienced) and this might affect the performance of participants in their posttest. Thus, in this study, the posttest was administered right after the treatment to minimize this threat.

Threat to mortality: It involves participants' attrition, dropouts or withdrawals during the experimental study caused by certain reasons and this might be problematic to researcher as this will result in the loss of participants and create unequal numbers of participants at the end of the study. As to reduce the threat of maturation, the experiment was carried out with a larger sample size in the circumstance of students' withdrawals during the study. Both confidentiality and the purpose of this project were explained to students before participating in the study to obtain better commitment.

Threat to instrumentation: It is an improvement or decline that is caused by the measure itself and it usually happened due to inappropriate pretest and posttest or the researcher using the instrument in an unusual way. To prevent this situation, the instrument was examined by a subject matter expert and similar instruction was given during the administration of the tests to both groups.

Threat to testing: It is a threat that causes an improvement in scores of the participants' posttest due to the experience gained from the pre-test. As to prevent the threat to testing, the researcher administered the pre-test a week before the actual experiment to avoid an improvement in scores of the participants' posttest due to prior experience of taking the pre-test.

E. Pilot Study

A pilot study was conducted to verify the experimental procedure and examine the reliability of the instrument. A group of 40 students were selected to participate in the pilot study. They were given 30 minutes for the pre-test. Then, each of them was assigned to a computer and required to go through the online learning system. They were given one hour for this treatment session and finally, another 30 minutes for the posttest. The pilot study revealed that the participants did not require 30 minutes to complete both pre-test and posttest. Thus, participants in the actual experiment were given a shorter duration to complete these tasks. The duration for the treatment had also been shortened to only 30 minutes.

The reliability of the test was measured using the Cronbach alpha's procedure. The Cronbach alpha coefficient is 0.754 for the cognitive section and 0.846 for the affective section, which indicate that the test is reliable.

F. Procedure

Two experimental groups were involved and all participants were informed about the purpose of the study before the experiment began. The first experimental group, which involved an intact class of 40 students who took course in Computer Graphic during the study, was requested to read the text-based learning materials. Each participant of the second group, which involved an intact class of 41 students who also took the similar course, was assigned with a computer and was requested to read and interact with the online interactive multimedia learning system. The pre-test was carried out a week before both interventions and the posttest was carried out immediately after each intervention. Data from pretest and posttest for both text-based and multimedia groups were collected and further analyzed using the Statistical Package for Service Solution (SPSS).

VII. Testing of Hypotheses

The Mann-Whitney U Test was used to compare the variances between the two independent groups (multimedia and text-based) because the dependent variable was continuous but not normally distributed or in other words, the results did not meet the requirement for parametric test.

A. Testing Assumptions of Mann-Whitney U Test

According to Lund Research Ltd [18], in order to conduct Mann-Whitney U Test, four assumptions must be fulfilled with the first three assumptions relate to the study design meanwhile the fourth reflects the nature of the data.

Assumption 1

There must be at least one dependent variable that is measured at the continuous or ordinal level [18]. In this study, the dependent variable (gain scores) was continuous in nature.

Assumption 2

There is an independent variable that consists of at least two categorical, independent groups [18]. In this study, the independent variable was the learning mode and it consisted of two levels, multimedia and text-based.

Assumption 3

According to Lund Research Ltd [18], this assumption requires independence of observations, in which there is no connection among the observations in each group of the independent variable or among the group themselves. Thus in this study, students were divided into two groups (multimedia and text-based) and each student was only allowed to participate in either one of these groups.

Assumption 4

One must determine either the distribution of scores for both groups of the independent variable have the same or different shape [18]. This is the most critical assumption in SPSS and data were generated as below for both affective and cognitive. Figure 1 and Figure 2 show the distribution of gain scores for cognitive and affective learning respectively.

Based on the population pyramids (Figure 1 and 2), it can be concluded that through visual inspection the distributions of scores for multimedia and text-based for both affective and cognitive are dissimilar. As the distributions are dissimilar, the mean ranks of the gain scores for both learning modes were compared.
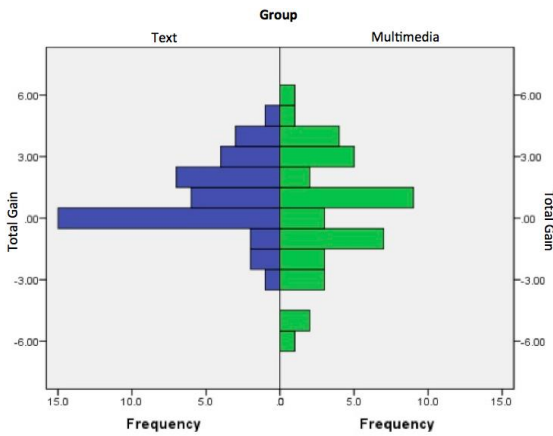

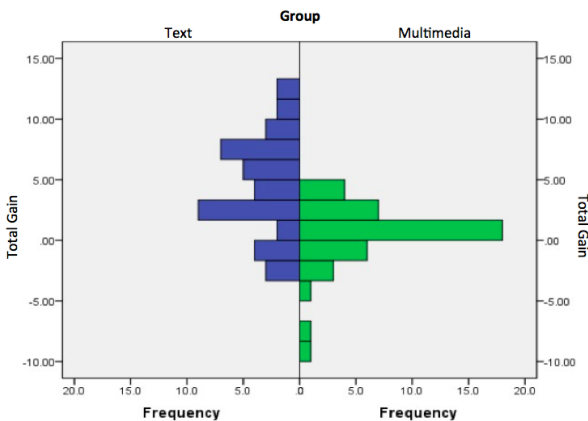Figure 1: Distribution of scores for cognitive learning

Figure 2: Distribution of scores for affective learning

B. Mann-Whitney U Test

The Mann-Whitney U Test was conducted for both groups to analyze the effects on cognitive learning and results are shown in Table 2 and Table 3.

Table 2
Mann-Whitney U test (rank) for the cognitive gain scores

Groups	N	Mean Rank	Sum of Ranks
Gain 1(Multimedia)	41	41.85	1716.00
2 (Text-based)	40	40.12	1605.00
Total	81		

Table 1 shows that the multimedia group has higher mean rank of 41.85 when compared with the mean rank of 40.12 for the text-based group.

Table 3
Mann-Whitney U Test (test statistics) for the cognitive gain scores

	Gain
Mann-Whitney U	785.00
Wilcoxon W	1605.00
Z	-.335
Asymp. Sig (2 tailed)	.738

From the analysis in Table 3, it can be concluded that the gain scores of the multimedia group was not statistically significantly different from the text-based group (U=785.000, p=738).

The analysis for affective learning was performed using the Mann-Whitney U test for both groups and results are shown in Table 4 and Table 5.

Table 4
Mann-Whitney U Test (rank) for the affective gain scores

Groups	N	Mean Rank	Sum of Ranks
Gain 1(Multimedia)	41	53.21	2181.50
2 (Text-based)	40	28.49	1139.50
Total	81		

Table 3 shows that the multimedia group has higher mean rank of 53.21 when compared with the mean rank of 28.49 for the text-based group.

Table 5
Mann-Whitney U test (fest statistics) for the affective group

	Gain
Mann-Whitney U	319.50
Wilcoxon W	1139.50
Z	-4.750
Asymp. Sig (2 tailed)	.000

Based on the analysis in Table 5, it can be concluded that the gain scores of the multimedia group was statistically significantly higher than the text-based group (U=319.500, p=0).

C. Clustering Analysis

The purpose of clustering is to organize data into clusters such that there is high intra cluster similarity. Clustering helps to informally find the natural groupings among objects. Clustering analysis was employed in this study to examine whether the gain scores for the two groups can be clustered accordingly to the learning modes. This study employed the K-means clustering technique as it is one of the most widely used and effective clustering algorithms [19].

D. K-Means Analysis

In this K-means cluster analysis, the researcher wanted to find out whether there were two distinct clusters existed to

represent the two learning modes for both cognitive and affective learning. Table 6 provides a summary of this membership for cognitive learning.

Table 6
Distribution of membership in the two clusters for cognitive learning

Learning Mode	Cluster 1 (%)	Cluster 2 (%)
Multimedia	15 (48%)	26 (52%)
Text-based	16 (52%)	24 (48%)
Total member:	31	50
Member mean score:	2.87	-0.62

Two clusters existed. Table 6 shows that the membership of participants for both multimedia and text-based learning modes was almost equivalent for both clusters. Thus for cognitive learning, the analysis shows that there is no distinct clusters based on learning modes, which is consistent with the earlier Mann-Whitney results that show no significant difference in the gain scores of cognitive learning between the two learning modes.

Table 7
Distribution of membership in the two clusters for affective learning

Learning Mode	Cluster 1 (%)	Cluster 2 (%)
Multimedia	19 (35%)	22 (85%)
Text-based	36 (65%)	4 (15%)
Total member:	55	26
Member mean score:	0.65	7.03

In Table 7, the mean of gain score for Cluster 2 (7.03), which comprised mostly participants from multimedia learning mode (85%), was higher than those in Cluster 1 (0.65), which comprised mostly participants from text-based learning mode (65%). Thus, for affective learning, the analysis shows that there are distinct clusters based on learning modes, which is consistent with the earlier Mann-Whitney results that show a significant difference in the gain scores of affective learning between the two learning modes.

VIII. DISCUSSION

The following two subsection provide the discussion for the results of this study.

A. Cognitive Learning – Positive Effects But No Significant Difference

Generally, the study shows that positive gain scores are obtained for both groups of students, indicating that both learning modes contribute positively towards cognitive learning. Many studies have shown that multimedia produces positive effects. For example, Mayer [15] supported that computer-based multimedia learning environments serve as a great mean to enlighten student understanding. Kim and Gilman [20] who studied the use of multimedia mechanisms such as spoken text, graphics and visual text through a Web-based self-instruction program for English vocabulary learning found that an effective technique to improve English vocabulary is via the use of graphics. Arguel and Jamet [21] revealed that video and static pictures improve the learning of procedural contents. The result of this study is consistent with many existing studies as the online interactive multimedia system used in this study also contributes positively towards the learning of various facts and issues on road safety.

The study also found that there is no significant difference on the gain scores between students using multimedia and text-based for cognitive learning. Schneiderman et al. [22] demonstrated the effectiveness of an online computer-based learning module for arterial blood gas analysis in which nurses' understanding improved significantly after using it compared with the text-based version. The learning module allowed learners to represent and express their knowledge (e.g. discuss about their sharing experience) and provide experiential learning through both video and audio to replicate real-life scenarios. The results of Schneiderman et al.'s [22] study is however not in line with the results of this study in which both multimedia and text-based learning modes did not provide significant difference in cognitive learning. The nature of the subject matter chosen may possibly explain the equivalent positive effects of the two learning modes. Learners may already have some existing knowledge on road safety issues and the content presented is mostly common knowledge that maybe easily grasped by the learners even without the use of a variety types of media.

B. Affective Learning – Positive Effects But With Significant Difference

As for the online interactive multimedia for affective learning, results show that there is a significant positive effect when compared with the text-based learning. Kalmbach [23] mentioned that whatever words can do, it can be performed even better with the combination of words, pictures and sounds whereas it is specifically beneficial in affective learning. Chen and Sun [24] investigated how different multimedia materials affect learning performance and the emotions of learners with visual and verbal cognitive styles. Three different materials: static text and image-based material, video-based multimedia material, and animated interactive multimedia material were examined and their experimental results show that video-based multimedia material generates the best learning performance and most positive emotions for verbalizers. Moreover, dynamic multimedia materials containing video and animation are more appropriate for visualizers than static multimedia materials containing text and image. Generally, their study shows that multimedia produces positive emotions. As emotions are affective expressions [25], Chen and Sun [24] highlights the potential of multimedia in yielding positive affect that lead to improved learning performance. The multimedia elements used in this study, particularly video and colored graphics, have most probably yielded positive emotions that eventually lead to more changes in attitudes and values (as self-reported by the participants in posttest) when driving on the road.

In addition to the variety of multimedia elements used in the multimedia learning system used in this study, the availability of interaction channels such as discussion forum, experience sharing board and self-test that allow interaction between instructor and learner, learner and their peers as well as learner and the system, may also explain the significant positive effects of this system on affective learning. Mazer et al. [26] examined the effects of computer-mediated teacher self-disclosure on student motivation, affective learning, and classroom climate. Their study found that learners who accessed the Facebook websites of educators with high level of self-disclosure showed greater levels of enthusiasm, affective learning and

positive classroom climate. Mazer et al. [26] implies that the opportunity to communicate in more relaxed, social situations influence affective learning. In another study by Russo and Benson [26], the presence of an instructor and other students in an online learning environment correlated positively to affective learning. Baker [28] found that the linear combination of instructor immediacy and presence is a statistically significant predictor of online student affective learning. All these studies support the importance of interaction in affective learning.

Learners are also prompted to provide their reflections on various road safety issues raised in the online interactive multimedia system of this study. As pointed out by Ong [29], reflection and learning are closely interconnected. Reflection links existing understanding with new information and facilitate meaning-making in a learning process [29]. According to Andrusyszyn [30], reflection is a deliberate cognitive activity where learners connect thoughts, feelings, and experiences related to the learning activity in which they are involved in. Reflection is often regarded as an appropriate learning activity to foster affective learning [31, 32, 33]. In this study, the online interactive multimedia system provides opportunities for reflection that afford learners to clarify their thoughts, gain insights into road safety matters and eventually, affect their decisions, values and attitudes on the road. Reflection will increase learners' knowledge, awareness and control in practice [34]. Furthermore, reflection allows learner to examine ideas, assess experiences and form thoughts. Thus, the availability of channels for reflection in the online multimedia system is seen as contributing to the significant positive effects for affective learning in this study.

IX. CONCLUSION

As with many other existing studies, this study provides additional evidence on the effectiveness of using multimedia learning for cognitive learning. This study also contributes to the existing literature on the effects of multimedia on affective learning as to date, there is only a handful of studies that look into this aspect. The use of variety of media types and the affordance of interactive and reflective activities are hypothesized as the contributing factors towards positive affective learning. Further experimental studies may be designed to examine the main factors that affect learning, particularly in the affective domain. The study also provides evidence on the appropriateness to employ an online interactive multimedia system to provide road safety education because it is able to produce positive cognitive and affective learning outcomes as both domains are crucial to nurture courteous drivers.

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