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The use of augmented reality application in a large-enrolment class for increasing students' attention

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ABSTRACT

Maintaining students' attention is difficult to gain in a traditional lecture centred class with high number of students. The objective of this study is to develop and evaluate an augmented reality (AR) based application that can be used to engage students' attention in a large-enrolment class. The application can incorporate the view of real objects such as a memory stick and digital information together. This integrated view can be displayed on a projector in a lecture class. This approach is to gain students' attention towards important learning objects so that it will help them to further concentrate on the details to attain in-depth understanding. The attention items in the Instructional Materials Motivation Survey were used to identify the impact of an augmented reality system on students' attention for a largeenrolment class. The survey shows that the students' attention in an AR based learning environment was better rated than those obtained in a slides-based learning environment. This shows that AR has a positive impact on the attention of computer science students in a large lecture class.

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INTRODUCTION

Large class size increases faculty reliance on the lecture method of instruction. This is the first finding listed by Cuseo in his article (Cuseo 2007). This finding matches with the teaching activities for course computer organization and operating system for 79 first year computer science students. During one semester, the lecture for the class held in a large lecture hall. This didactic (teacher-centred) lecture is required for a number of reasons including to explain difficult contents elements, help the students integrate previously learned information, and contextualise the specific content of the lecture within the broader field of study (Geoff 2011) . One of the students wrote in the evaluation form that the lecture hall is not suitable for them. This might be related to the size of the class that causes problems such as student–instructor disconnect in large-enrolment classes and limitation of the lecture approach (Meltzer and Manivannan 2002). Furthermore, based on a learning pyramid that suggests certain teaching methods are connected with a corresponding hierarchy of student retention, retention rates of a typical lecture are only 5% (Lalley and Miller 2007). Therefore, engaging students' attention in a large class is critical because of the strong relationship between attention and working memory (ability to retain information in an accessible state) (Daryl 2008).

Augmented reality (AR) is a viable option for attention engagement that is suitable for technical and abstract subject with a large number of students. AR is one part of the general area of mixed reality (Milgram, Takemura *et al*. 1994) that can be used to model a mixed reality situation using a tracking object. When the tracking object has been recognised by an AR model, virtual (computer-generated) object will supplements the real world of the tracking object. In fact, this combines real and virtual objects in a real environments (Azuma, Baillot *et al*. 2001) so that the perception of the students towards the tracking objects will be enhanced. This ability has attracted many researchers to apply this technology in education in order to get one of these benefits as listed by Wu, Lee, Chang, & Liang (2013): to develop important practices and literacies that cannot be developed and enacted in other technology-enhanced learning environments (Squire and Jan 2007; Squire and Klopfer 2007) and to visualize complex spatial relationships and abstract concepts (Arvanitis, Petrou *et al*. 2007). The aim of this study

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is to demonstrate the use of AR based applications has a positive impact on students' attention in a large enrolment class. The objective of this study is to develop and evaluate an AR based application that can be used to engage students' attention. The integrated view of real and virtual information of this application can be used to gain students' attention towards important learning objects so that it will help them to further concentrate on the details to attain in-depth understanding.

Literature Review:

AR is a novel human-computer interaction tool that overlays computer-generated information on a realworld environment (Nee, Ong *et al*. 2012). AR is a potential technique that can be used as an additional tool for engaging students' attention in learning complex materials. This is because one of the benefits of AR is that it can enhance a user's perception of the real world with virtual objects (Azuma 1997). AR can be used to improve the explanation of a complex concept by overlaying related information on the real object. Projector, head-mounted display and hand-held devices such as tablet, mobile phone can be used as a tool to view the information overlay. The use of AR in education has been extended and practical, for example, as shown in Table 1 and the usage can be divided into three approaches: (1) emphasizing the roles, (2) emphasizing the locations and (3) emphasizing the tasks. In terms of level, it covers school and university (Wu, Lee *et al*. 2013).

Table 1: AR based education applications

No	Application	Environment	Approach	Level	Tool
1	Alien Contact! (Dunleavy, Dede et al.2009)	Outdoor	Role based	School	Handheld devices
2	ACCampus (De Lucia, Francese et al. 2012)	Outdoor	Location based	University	Handhelddevices
3	EULER (Liu andSociety)	Outdoor	Task based	School	Handheld devices
4	AR-Dehaes toolkit (Martín-Gutiérrez,Saorín et al. 2010)	Indoor	Task based	University	Desktop

Since there is limited amount of studies investigating student motivation with use of AR, Di Serio *et al*. (2013) had explored the impact of AR on motivation including attention. However, the potential of AR in engaging student's attention in a large enrolment class during didactic lecture remains unexplored. This study analyses the impact of using AR applications on students' attention while learning in a largeenrolment class. In this study, during the didactic lecture, a system (Figure 1) composed of a computer in the lecture hall, a webcam, an AR application, a projector, projector screens and learning objects, will be used. Learning objects such as a memory stick is one of the target references that need to be captured by the camera in this study. When the camera successfully tracks the target, digital information about the memory will be added in order to mix the digital and reality environment. This integrated view can be seen by the students on the big screen in the class.

Fig. 1: A system for AR based learning in a lecture hall

Methodology:

Case study:

In this research, case study was applied. This study examined how the impact of an AR based application towards students' attention is in a lecture method of instruction. An AR based application was designed to engage students' attention in learning complex materials in a computer organisation course. This study was conducted on a lecture session at a public university in Malaysia. The experiment was

performed on a two-sessions-module on the computer's components. The first module (TS1) comprised the study of computer's component based on power point slides. The second module (TS2) also focused on the same subject but based on augmented reality technology. The experiment also partly followed the format of the fully interactive lecture class by Meltzer & Manivannan (2002) that contains a mini-lecture, a sequence of questions, and follow-up activities. Figure 2 shows a situation for TS2 in the class where a memory stick (RAM) was used as the target reference and the integrated view was shown on the screen.

Fig. 2: A situation in TS2 module, teaching using AR technology

Research questions The aim of this study was to demonstrate the use of AR based applications has a positive impact on students' attention in a large enrolment class. Therefore, two teaching scenarios: TS1 (based on slides) and TS2 (based on augmented reality technology) were investigated. Attention factor was selected in this case study because this is one of the critical features that needs to be emphasized during a didactic lecture in a big hall. The study also determines the preference of student in learning a complex subject, whether with or without AR technology. The research questions were:

Is there any difference in the students' attention depending on which of the two teaching scenarios proposed they used?

Which teaching scenario is preferred by students in learning computer organisation and operating system?

Procedure:

The procedure in this study is based on the procedure by Di Serio *et al*. (2013) where all the students participated in both learning scenarios (TS1 and TS2). Quantitative data was collected in two steps. After the first part of the module (TS1), the attentions item in the motivational measurement instrument (Keller, 2010) modified by Di Serio *et al*. (2013) was used to evaluate students' attention. The same questionnaire was given after students finished the second part of the module (TS2). Paired-sample ttests were carried out to compare attention between the two teaching scenarios.

Participant and instrument:

In this study, 63 first year students from a computer science course were surveyed. Eight participants declared having previous contact with the AR technology. The modified IMMS questionnaire for item attention as in Di Serio *et al*. (2013) was used and it contains 12 questions with 5-point Likert-scale items.

RESULTS AND DISCUSSION

Research questions 1:

Is there any difference in students' attention depending on which of the two teaching scenarios proposed they used?

A paired-sample t-test was conducted to compare attention. Result indicates a statistically significant difference in attention between students following the course within TS2 ($M = 3.239$, $SD = 0.162$) and the same students following the course within TS1 ($M = 3.015$, $SD = 0.123$), $t(63) = 4.4392$, $p = 0.000$. The minimum and maximum scores of the instrument IMMS are 12 and 60 since the response scale ranges from 1 to 5. The total scores in TS1 ranged from 135 to 227 and the scores in TS2 ranged from 108 to 267. These results indicate that students were moderately in giving attention when the module was taught within the slides-based learning environment and giving more attention when it was taught within the augmented reality learning environment.

Table 2: Survey statements and the received responses

No	Statement Total response for	1	2	3	4	5	Mean	STD
1	There was something interesting at the beginning of the AR lesson that caught my attention	0	2	8	26	27	4.24	0.80
2	Augmented reality technology is attentiongrabbing	0	1	11	24	27	4.22	0.79
3	The quality of the augmented reality material helped to hold my attention	0	3	16	21	23	4.02	0.91
4	The material is so abstract that it was hard to keep my attention on it (Reversed)	14	25	13	8	3	2.38	1.11
5	The images, videos and text that I discovered through the lesson are unappealing (Reversed)	15	20	20	7	1	2.35	1.02
6	The way the information is arranged using this technology helped keep my attention	1	0	15	31	16	3.97	0.80
7	The information discovered through the experience stimulated my curiosity	2	1	16	28	16	3.87	0.92

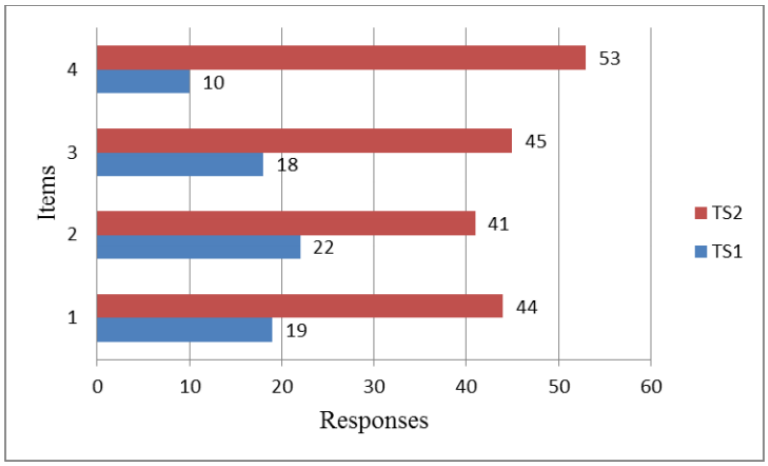

Fig. 3: The results of students' preference toward TS1 (slides) and TS2 (AR)

As it was previously stated, students were highly had more attention when using augmented reality teaching material. Table 2's two rightmost columns display descriptive statistics for each item that describe attention factor. The highest mean scores were yielded by item 1 (M = 4.24) and item 2 (M = 4.22). The lowest mean value was obtained by the reversed item number 12 (M = 1.71). The highest mean score corresponds to item 1 which states that there was something interesting at the beginning of the AR lesson that caught my attention. 53 out of 63 students thought that it was mostly true or very true that AR lesson caught their attention. Meanwhile, 51 out 63 of the respondents indicated that it was mostly true or very true that AR was attention-grabbing (item 2). 49 out of 63 students responded that it was mostly true or very true that I learned some things from the augmented reality that were surprising or unexpected (item 9).

Research questions 2:

Which teaching scenario is preferred by students in learning computer organisation and operating system?

Teaching scenario based on AR (TS2) is preferred by students in learning computer organisation and operating system as shown in Figure 3. There are four items have been asked to the students. The highest number is item 4 where 53 out of 63 students selected TS2 for question: In the future, would you like using TS1 or TS2? In terms of understanding, 45 out of 63 students selected TS2 for item 3 which is: Which session that helps you more understanding the contents? Whereas 44 students selected TS2 for item 1: Would you prefer this exercise to have been on slides (TS1) or AR (TS2). For item 2, 41 students selected TS2 for this question: Which session that helps you more in doing the exercise? Slides (TS1) or AR (TS2). Overall, TS2 had been selected for a total of 183, 69 more than TS1.

Engaging students' attention in a large class using AR:

AR application can be used to engage students' attention in a large class based on the results in the case study. Since subject computer organization for the first year students was 60% relied on the lecture method of instruction, the results indicate a positive impact of AR application toward students' motivation. There is a statistically significant difference using a paired-sample t test when comparing both scenarios, with and without AR. Students were moderately engaged by the traditional way of teaching the course and slightly more engaged when augmented reality technology was

used. These results also support the need for innovative idea for engaging students' attention in a didactic lecture. Richard and Anne (2012) proposed Open Web Lecture (OWL) in order to increase student engagement in a didactic lecture where OWL is designed to promote interactive lecture. The experiment in this research was also done in an interactive format as in Meltzer & Manivannan (2002) where after a mini lecture that ended by showing the AR based application, students had do to exercise that only can be answered based on the digital information overlaid on the real objects. The combination of the real objects and digital information can help the students to hold their attention in learning difficult contents elements.

This AR application also considers important elements that can hold the students' attention. These elements are using real objects as the reality resources and designing the application using multiple tracking methods, nature and image tracking. This is also support the finding that AR is effective here because the learning method was developed by considering the mixed between reality and digital world (e.g. Abd. Majid (2013); Azuma, *et al*. (2001); De Lucia, Francese, Passero, & Tortora (2012); Di Serio, *et al*. (2013); Heen *et al*. (2011); Kaufmann & Schmalstieg (2003); Martín-Gutiérrez, *et al*. (2010); Milgram, *et al*. (1994); Nee, *et al*. (2012); Wu, *et al*. (2013)). The positive impact of AR technology on students' attention can be extended to cover a different learning and cognitive tool. For example, an AR application can be developed based on constructive pedagogy for doing assignment. In this assignment, students can be instructed to construct their own AR based application and share it with their classmate as an exercise. This can be done because the tools to develop an AR based application are become easier to use which is based on drag and drop concept such as Metaio Creator software.

Preference of students toward AR based learning in a didactic lecture:

Overall, the results show the ability of the developed AR application to influence students to select AR as a complement to the didactic lecture of a large-enrolment class, thus addressing the second research questions. The reasons of selecting AR given by the students can be divided into four factors:

1) Attention: e.g.:

"It attracts student attentions and can prevent us from being sleepy in lecture" "Because it is completely grabbing my attention with the augmented reality technology" "Using TS2, the lesson become interesting and can hold my attention longer than usual" "It is fun and it is not boring and also grabs my attentions to look/study

2) Interesting: e.g.:

"It seems more interesting and attractive" "Cause it generate my interest" "Because it catches my interest during lecture sessions" "Very interesting and learn something new"

3) Increase understanding: e.g.:

"Easy to understand about component of computers" "Because it is interesting and make me more understand" "The image from augmented reality seems more interesting to watch and understand" "Learn better about the content and interesting"

4) New technology: e.g.:

"Because it is an advanced and new technology" "Curiosity to learn new technology" "Because the technology is very excellent"

Attention is one of factors given by the students in justifying why they selected AR. This result supports the finding that attention received higher ratings in results presented by Di Serio, *et al*., 2013 in their study about the impact of AR on students' motivation for a visual art course.

However, there were students selected TS1 (slides) as their preferred method. These are comments given by the students:

"TS1 is more efficient than TS2 because TS1 does not have lighting problem"

"TS2 quite wasting time when computer (AR) can't detect the component"

These comments show that there was dissatisfaction among the students about the use of AR. One of problems in using real objects as the tracking object is the lighting. The AR application needs to have enough lights in order to detect clearly the objects. However, the light in the lecture hall is not very bright. The solution during the experiment was to use an additional source of light. Therefore, these were suggestion given by the students for how learning using AR can be improved:

"If the program can detect AR more efficiently, thus AR can be very fun and interesting"

"By improving it sensitivity of detecting objects"

"Detections of image tracking with a good lighting or dim lighting"

"Using tablet"

"Make it more flexible in other situation"

The last two comments related to the issue of flexibility of the application. The AR application in this work was designed for a concept learning in a didactic lecture that using projector as the display device. However, the application can be designed for a situated learning where one of the best options to support this learning is by using hand-held devices such as mobile phone and tablet. Furthermore, mobile AR has gained increased attention from academia and industry, due to the portability of mobile phones and the ubiquitous nature of camera

phones (Nee, *et al*., 2012). This will address the issue related to flexibility.

Conclusion:

The problem in didactic lecture for a large-enrolment class was addressed by designing an application with AR module. Real object can be tracked by the application in order to mix digital information and the learning object so that this might enhance the students' perception about the objects. The results show that the students' attention in an augmented-reality-based learning environment was better rated than those obtained in a slides-based learning environment. This approach can be used to assist in gaining students' attention towards important learning objects so that it will help them to further concentrate on the details to attain in-depth understanding. This study also show that there are four main reasons given by students in using AR which are attention, interesting, increase understanding and new technology. This system is expected to assist instructor in higher education who teach complex subject or largeenrolment class in preparing an interactive environment so that the percentage of low attention or motivation among the students can be reduced. However, the results also show the need for a mature AR based system in order to overcome the dissatisfaction among the students towards this new technology.

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