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TIME ON TASK FOR COLLABORATIVE AUGMENTED REALITY IN SCIENCE EXPERIMENT

Wannisa Matcha*, Dayang Rohaya Awang Rambli

Computer and Information Sciences Department, Universiti Teknologi PETRONAS Perak, Malaysia

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*Corresponding author
wannisa21@gmail.com

Graphical abstract

Abstract

This paper reports on a study findings on the time participants spend engaged doing task while interacting with Augmented Reality (AR) based system in collaborative learning environment. Engaged time is an important factor in any learning approaches as it is the actual time that participants pay attention and acquire knowledge. In the present study, time-on task and time off task were used to investigate the student level of engagement in learning activities. Data was collected from an observation study using video recording approach. Result showed that participants spend more than ninety percent concentrating on task related activities. Result from a survey questionnaire following the study revealed that participants enjoy group learning using AR as a tool. These findings further indicate that fun learning environment offered by augmented reality technology has the potential to grab learner's attention and motivate them to stay focus on the learning activities.

Keywords: Augmented Reality, Education, Computer-Supported Collaborative Learning, Time-On Task, Engagement

Abstrak

Artikel ini melaporkan keputusan kajian ke atas masa yang digunakan oleh peserta dalam penglibatan sesuatu tugas disamping berinteraksi dengan aplikasi AR di dalam persekitaran pembelajaran secara kolaboratif. Masa penglibatan adalah faktor terpenting dalam apa jua proses pembelajaran kerana ianya masa sebenar peserta menumpukan perhatian dan mendapat pengetahuan. Dalam kajian yang telah dilaksanakan, masa ketika melaksanakan tugas dan masa tidak melaksanakan tugas telah digunakan untuk mengkaji tahap penglibatan pelajar dalam aktiviti pembelajaran. Data telah dikumpul melalui pemerhatian menggunakan rakaman video. Keputusan telah menunjukkan peserta meluangkan lebih dari sembilan puluh peratus masa dalam menumpukan aktiviti yang berkaitan dengan tugas. Manakala, keputusan dari soal kaji selidik menunjukkan peserta lebih gemar untuk belajar secara berkumpulan menggunakan AR sebagai alat sokongan pembelajaran. Keputusan-keputusan hasil dari kajian ini, menandakan persekitaran pembelajaran yang menyeronokkan beserta dengan teknologi AR berpotensi untuk menarik perhatian pelajar dan menggalakkan mereka untuk terus kekal fokus di dalam aktiviti pembelajaran.

Kata kunci: Augmented reality, Pendidikan, Pembelajaran Kolaboratif Berkomputer, Masa ketika melakukan tugas, Penglibatan

1.0 INTRODUCTION

Augmented Reality (AR) is a technology which has a unique interface whereby physical object is enhanced by adding virtual information onto it [1, 2]. It allows the invisible object to be observable. In this context, physical objects are used for interaction in real time. Thus it offers more kinesthetic style of learning rather than using mouse alone [3]. Collaborative AR refers to the use of AR technology to support group activities both in working and learning environment. Despite the noticeable advantages offered by AR technology to support learning e.g. in [3, 4, 5, 6], exploration on the use of AR to support group learning is relatively few [7]. This research aims to fulfill that gap. Multiple research areas on education were explored in order to accomplish this goal.

Many researchers claimed that in group learning environment whereby technology is used as a mediate between group members also known as Computer-Supported Collaborative Learning (CSCL), learning occurs through interaction and time participants spend engaged on the learning task [8, 9, 10, 11, 12]. Therefore, exploring the time that participants spends engaged on learning the related tasks is important in order to explore the effectiveness of learning in collaborative AR based system. Engagement refers to the involvement or interest of learning in the content or activities [13]. It is vital in learning as it could sustain the attention of participants to focus on the learning task [14]. Engaged time refers to the time participants spend, interact, and communicate with group members on the related learning task [15]. This is also referred to as time-on task. In contrast, the disengaged time or time off task refers to the time participants spend unfocused on the task given [15, 16]. As such, these two characteristics are considered as better suited as potential variables to investigate engagement offered in learning environment [15, 16].

This paper explores the use of AR to facilitate group learning by examining the time participants spend engaging on task related work versus non related work. The next section presents the related work in this area of research. In Section III, the methodology used in collecting and analyzing the data are described, follow by the result and discussion in section IV. Finally, the paper will conclude the findings in section V.

2.0 BACKGROUND OF STUDY

This section presents the concept behind which draw the boundary of this research paper. Two learning concepts are reviewed in order to discuss the potential of AR in learning: the concept of engagement in group learning or CSCL and the concept of AR in supporting learning.

2.1 Engagement in CSCL

Engagement is considered to be one of the important factors in group learning as had been highlighted by many researchers. Based on Kreijns *et al.*, (2003), collaboration refers to *"...mutual engagement of participants in a coordinated effort to solve the problem together"* [17]. The application of collaboration in learning environment involves the mutual engagement of group members in social interaction in which they combine all their skills and knowledge to solve the problem together [8, 9, 10, 11, 12].

A study done by Dillenbourg *et al.*, (2009) revealed that learning will be effective if students are engaged in rich interactions [9]. According to Bryan-Kinns *et al.*, (2007) participants need to be mutually engaged in both the activities and with their collaborators [18]. Unquestionably, engagement is one of the most essential factors that affects and motivates teaching and learning [19]. Multimedia elements such as graphics, text, audio, animation and video have been shown to create an engaging, and interesting learning environment [19]. Various technologies are available to create and integrate these features in a application and augmented reality is one of the emerging technologies.

The term engagement itself was used in many different contexts. Hijzen defined engagement as the intensity and quality of students' involvement in initiating and carrying out learning activities [20]. Similarly, Daggett, (2008) defined engagement as the extent to which students are motivated and committed to learning, have a sense of belonging and accomplishment, and have relationships with peers that support learning [21]. According to Bryan-Kinns *et al.*, (2007) participants need to be mutually engaged in the task activities as well as with the collaborators [18]. Crook further characterized collaboration as certain forms of productive joint engagement [22]. A more complete description of engagement in collaborative learning environment is outlined by Piki, (2011), and Hawryszkiewycz (2007) [23, 24]:

1.) Engagement of learner with the learning content e.g. materials used in learning, case study or problem solving.

2.) Engaging in collaborative activities e.g. participate and contribute in discussion, work and jointly construct the learning outcome.

3.) Engaging with other group members e.g. negotiate and share meaning.

Despite the various definitions, generally engagement refers to the learners' activities within the learning environment and time spend on these activities is of essence as it refers to the level of engagement.

Engagement is vital in learning as it could sustain the motivation, attention and maximize students' time-on-task during learning activity [14]. The exploration on the engagement itself requires deeper investigation. Many theories were drawn upon the engagement and motivation. Attention and enjoyment are some of the

engagement factors explored in this study. Various researchers claimed that engaged in collaborative learning means that participants were involved and participated in group discussion, engaging with the shared objects and peers, having hands-on and problem solving activities [14, 15, 16, 20, 21, 23]. These tasks are identified as tasks related. The time that participants spend engaged in task related activities is known as time-on-task or engaged time.

In contrast, participants might also exhibit some of the disengaging behaviors which known as off-task behavior [15, 16]. In general, off-task behavior was reported to have negative effects on learning [15]. Based on Greenwood, (2002), students who appear to spend too much time on off-task will not be able to effectively respond to academic activity [14]. Off-task behavior is also related to emotional states of participants such as boredom [15], annoyance [16], distracted or exhausted [25]. Some of the off-task behaviors as had been studied are such as talking about unrelated subjects [26] day dreaming, looking around [27].

2.2 Augmented Reality

Many of AR related papers explore engagement in various perspectives such as user attention, motivation and encouragement or intention in learning. Such as the work of Oh and Woo (2008); the authors developed a system called AR Garden as an edutainment learning tool to teach children on growing the plant. The purpose of the observation study was to explore the engagement and motivation of participants in the presence of AR learning companion agent. The engagement was identified by the interaction and emotion of participants to the pedagogical agents. Their study showed that participants interacted with AR system and the pedagogical agents and participants showed positive response encouraging towards the system [28].

Dow *et al*., (2007) conducted a comparative study between AR and desktop based application to investigate presence and engagement of students in role playing. The study was conducted in an uncontrolled setting; this is due to the intention of researchers to elicit rich player feedbacks on the complex scenario. Qualitative data were used in this study through in-depth interview with participants. They found that AR increase the sense of presence, however, the increase in presence interfered with participants' engagement [13].

Di Serio *et al*., (2012) explored learners' motivation after using mobile AR system to support learning in class as compared to traditional (slide-based) learning style. Survey questionnaire was used to collect the data. The result showed that in an AR learning environment, learning was more attractive and lessons were easier to be understood compared to the traditional approach. Furthermore, learners showed more desire to discuss and share their idea in AR based learning environment. This was due to the ability of navigation and interaction with learning material supported in AR based system which offered more learner-center environment [29].

Generally, survey and observation approach were employed as data gathering techniques to investigate engagement and users' perception. Our study follows a similar approach. The focus of prior researchers was more on learners' motivation that drive the intention to use and learn using AR as well as on learners' performance. However, variables such as actual time, behavior and interaction that participants spend on task are still left largely unexplored, especially, in the context of collaborative learning. Thus, the focus of our study is examine engagement based on observation of learners' behavior with respect to time spend doing related tasks.

3.0 METHODOLOGY

In this observation study, video recording was used to collect data. The research was carried out by using electricity topic as a case study. Relationship between resistance and current is one of the sub-topics in electricity used in this study. The prototype system (AR Circuit) was developed based on ARwithWPF framework. With the system, it is possible to imitate the experiment scenario realistically. For example, the brightness of a virtual light bulb will be different upon different amount of resistance being applied in the circuits. This difference is further reflected by a virtual ammeter's readings. Students can interact with the system through pattern markers, a set of black and white square shaped paper. Figure 1 presents the setting up of the system used in this study.

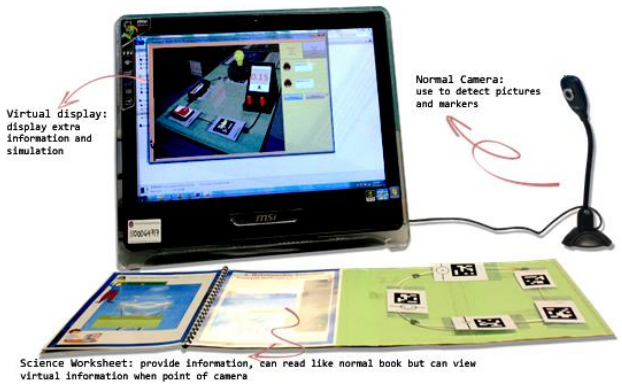

Figure 1 AR Circuit system

Eight pairs of students participated in this study: five pairs from foundation year students who were required to take fundamental Physics course and three pairs from secondary schools.

Data were analyzed using Actogram2, software which could be used to annotate the video. Annotation is the process whereby the states of the activities were stamped to the time in the video. Prior to the analysis of the video, a coding scheme to refer to the state of the activities need to be first created.

These activities or behavior are later categorized as on-task and off-task.

As has been highlighted earlier in Section II, the amounts of time spend on on-task or off-tasks reflect the attention and engagement of participants in learning in 2 opposite ways. In this study, the amount of on-task behavior and off-task behavior are observed and coded. Table 1 presents the coded tasks related behavior.

Table 1 On-task and off-task behavior

Behavior	On-task	Off-task
Talking	Related to the experiment or the system e.g. discussion on the experiment	Not related to experiment and the system e.g. discussion on other thing
Gaze	focused on workbook, markers, monitor or partners	Staring somewhere else unfocused
Interaction	Interact with the system or partners	Interact with something else beside the system and partner
Others	Other action related to the experimentation e.g. read, write etc.	Other unrelated action e.g. walking out, singing etc.

The recorded video was annotated and analyzed based on the presented behaviors in Table 1.
Open-ended questions were also used in this experiment to uncover the rationale and richness of information behind the fixed subjective view of users.

4.0 RESULT AND DISCUSSION

The following section presents the result based on the video annotation on the engaged time participants spend during the experiment.

4.1 Engaged Time

The engaged time or time on task and time off-task or disengaged time were observed and presented in figure 2. Any action identified as off-task behavior by any group members was stamped as disengaged time.

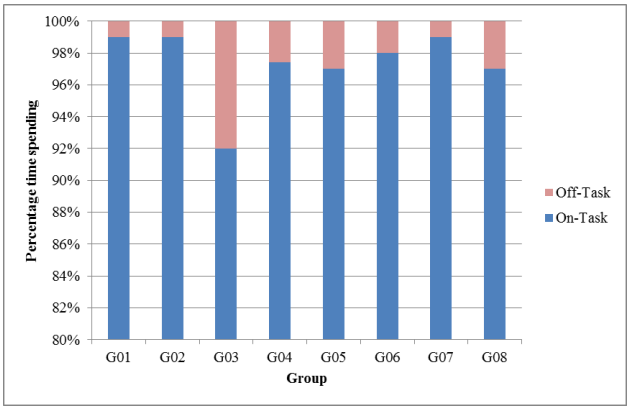

Figure 2 Percentage of time participants spends on/off task for each group

Figure 2 shows that most groups spend at least 92 percent of their time concentrating on the given tasks. In particular, G01 and G02 spent 99 percent concentrate on the task given, meanwhile, G03 showed the least amount of time focusing on the task (92 percent). G04 and G05 spent 97.50 and 97 percent respectively. G06 used 98 percent whereas G07 showed slightly higher at 99 percent and G08 showed 97 percent of the time spends on the task. On average about 97 percent of time spend is participants as being focused on the activities. This high number shows positive feedback towards learners' motivation in using AR in collaborative learning activities.

Participants exhibited various types of interaction and communication during their engaged time in the experiment. This includes verbal communication as well as non-verbal communication e.g. gaze, gestures etc. Figure 3 presents the actual situation whereby participants engaged in discussion on the experiment.

Figure 3 Participants discussed on the experiment

For off-task behaviors, in most groups it is common to see one participant exhibited off-task behavior during their idle time when other group member was recording or writing down the answer. Most exhibited off-task behavior observed in this study is gaze action, that is, when one of the group members spent their time looking around. However, when the other active partners start talking or asking question, the attention of idle group member was shifted back to the conversation and task at hand. Other types of off-task behavior observed were conversation on other topics beside the experiment. For example, G05 and G08 spent some time making the conversation with the instructor on the technology used in this experiment.

G03 exhibited the highest percentage of time off-task behavior; this might be due to level of prior knowledge. Based on G03's pre-test questions which were taken before the actual experiment, the group scored relatively low on the prior knowledge of the topic. One participant spent off-task behavior by getting out of his seat. It appears that he was off to seek help from another friend on the task. However, their group result after experiment's test showed some improvement.

4.2 Survey

Survey was used to gather the participants' perception towards the use of AR to support group learning. Table 2 presents the set of question which were used to evaluate the perception of participants in using the AR based application. Participants were asked to rate if they agree with the statements from 1-strongly disagree to 5-strongly agree.

Table 2 Survey question on user's perception in using AR

No.	Question
Q1	I feel comfortable using an Augmented Reality application in group learning.
Q2	I enjoy group learning using Augmented Reality application.
Q3	I enjoy lessons on the Augmented Reality application.
Q4	I will be able to concentrate better in class when Augmented Reality application is used.
Q5	I can learn more from books if it includes Augmented Reality application.
Q6	Augmented Reality application are not difficult to use
Q7	I do not get a sinking feeling when I think of trying to use Augmented Reality application.

This survey is mainly aim to assess the perception of how participants feel towards learning by using AR as a medium which was adopted from the work of Puckdeepun [30]. The first question begin by investigate if participants feel comfortable in using the application followed by the enjoyment of using AR in learning as a group learning and toward the application itself in question 2 and 3. Question 4 and 5 are intended to measure whether participants think that they could concentrate better in learning by using AR and they could learn more from the book if AR application is included. Finally, the last two questions (Q6 and Q7) aim the measure the difficulty and sinking feeling of learning how to handle experiment by using AR.

Figure 4 presents the results of the survey questionnaire. Generally, the result showed that participants feel comfortable using the system (Q1) to support their group learning (mean score: 4.32). Overall, the result shows that the students found that group learning using the AR application is enjoyable (Q2). Most expressed that they enjoyed their AR based lesson (means score: 4.5). This is due to the usage AR which allowed various multimedia applications to be attached to its the physical object such as 3D and animation which offer the interactivity and entertainment [19, 29, 31]. Besides that AR offer the interaction with 3D itself such as user can view and navigate the object in different view point creating the "playful" environment [32]. Participants expect themselves to be able to concentrate better when AR application is used to support learning (Q4). This result suggested the willingness to use AR and it also showed that participants feel that they can learn and concentrate better if AR application is used to support their group learning. Towards the question on learning from AR book, despite being the lowest score, an average score 4.05 is relatively high (Q5). As explored by many researchers, AR could engage participants to the learning [28, 29, 35] which allow participants to concentrate better.

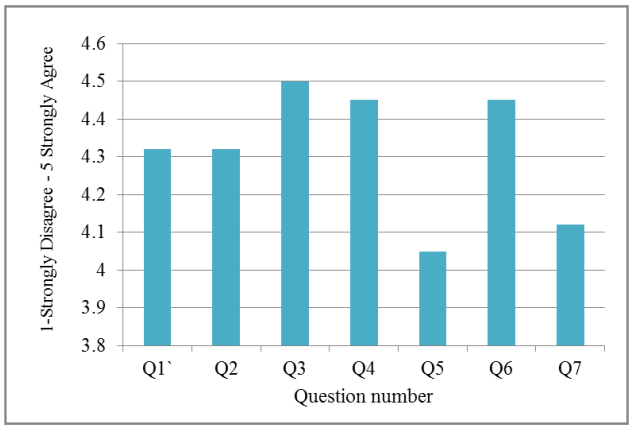

Figure 4 Survey result of user perception in using AR

On the ease of use of the system itself (Q6), participants feel that this system is easy to use, with relatively high score of 4.45, and they do not get the sinking feeling or frustrating when using the application (Q7). Based on comments from the user, this is because they were using natural action such as pick up and put down to interact with the system, which make it easier to do the task and the use of AR support diverse range of action, ease the sharing [33] and turn taking between partners. Besides that, the setting of AR application itself also offers the ease of communication between group members. This is inline with the work of Kiyokawa *et al*., which stated that the use of single display of AR ease the collaboration and communication between group members [34].

This set of questionnaire strengthens the observation result on engagement in collaborative learning. The result showed that AR based application has great potential to create an enjoyable learning environment and grab the attention of learners. Most students feel they could perform better in learning if they were given the opportunities to use the application.

4.3 Open-Ended Comments from Participants

Some of the comments from participants were gathered during the experiment section.

Based on the participants' comments after the experimentation, AR technology appears to be one of the interesting tools in learning for students. Comments from participants who had played with the system includes AR application is attractive and interesting. Furthermore, they also commented that this application will make learning become more enjoyable and not boring. The following are some comments from the participants:

"I believe it makes learning become more interesting as I am feeling very excited to see this AR myself."

"Students will be more focus and enjoy their learning process".

The students feel motivated to use the system. These results strengthen and provide evidence to support the use of AR technology in learning. The participants are free to navigate and interact with the system.

"It is really interesting and engaging. And nowadays students are more technologist, they will be interested in this kind of thing. It makes learning become more fun"

"The system can be used to provide assistance in my study in the near future. So it could be very helpful."

Towards the difficulty in using AR application, most participants agreed that it is very easy to handle. Positive feedbacks were given toward the use of the system, such as the system give accurate result in real time. The use of visual information and real time interaction is one of the main features which draw the participants' attention.

Overall, the AR system creates learners' engagement by offering the user a shared space for collaborative activities in which participants spends most of their time engaged on the intended learning activities. The survey results further revealed that most participants enjoyed learning collaboratively using the AR system

5.0 CONCLUSION

This paper presented the result of an exploratory study on engaged time participants spend while interacting with AR based application in collaborative learning environment. The results showed that participants spend more than ninety percent (90%) engaged in the learning task. This result highlighted the significant potential of applying AR to support learning especially, in handling experiment due to its ability to provide countless number of practices. Whereas, it also engages the students to the lesson by attaching various types of multimedia applications such as audio, 3D model, animation, video and other graphics. Moreover, the usage of physical object such as book and markers also provide the shared space where students are freely taking turn to handle the task and easily navigate from the task on hand to their partners to exchange the communication both verbally and non-verbally such as gaze, gesture etc. Additionally, the result from a survey questionnaire taken after the experiment positively supports this finding. Participants were motivated and most expressed that they enjoyed learning using AR based application. Some even stated that if the AR technology is used in the classroom they will perform and concentrate better.

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