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# An Emic Perspective on Students' Learning Experiences Using Augmented Reality

**Fariza KHALID[a*] & Su Luan WONG[b]**
[a]*Universiti Kebangsaan Malaysia, Malaysia*
[b]*University Putra Malaysia, Malaysia*
*fariza.khalid@ukm.edu.my

**Abstract:** The existence of technology has helped learning activities to become more exciting and more meaningful. Augmented reality (AR) is one of the emerging technologies that has gained attention from educators, as it provides unique learning experiences to learners. This study seeks to understand learners' experiences in using AR as part of their learning activities. Using a qualitative research approach, this study involved 24 university students who were enrolled on an Educational Technology course. The students were exposed to the use of AR so as to drive their motivation, and were required to develop their own AR projects as part of the course assessment. Data were generated through one-to-one interviews, which were later analysed using thematic analysis. The findings indicate that students valued the use of AR as a tool that stimulated their creativity and critical thinking. Although students found their group AR task challenging, they agreed that the task fostered collaborative values in themselves and helped them expand their communication skills. This paper also discusses the potential of AR in developing the twenty-first century skills.

**Keywords:** augmented reality, AR, education, motivation, twenty-first century skills

## 1. Introduction

With the assistance of technology, teaching and learning activities are made more interesting and meaningful. The emergence of new technology offers wider opportunities for educators to design fun and engaging teaching and learning activities. Digital media, for example, has increasingly made its way into educational settings, providing students with learning opportunities around interactive simulations and educational games. Augmented reality (AR) is an emerging technology that has gained wider attention from educators for its benefits in strengthening learning experiences and helping learners to develop a better conception of certain topics (Danakorn et al., 2013). AR refers to "human-computer-interaction, which adds virtual objects to real senses that are provided by a video camera in real time" (Ludwig & Reimann, 2005, p. 4); in other words, AR is a technology that "allows computer generated virtual imagery to exactly overlay physical objects in real time" (Zhou, Doh & Billinghurst, 2008, p. 193).

For teaching purposes, AR can be seen as a tool that has vast potential in taking technology-integrated learning processes to the next level (Dunleavy & Dede, 2014; Vincenzi et al., 2003). AR has been reported to have many advantages to spur learning. Hamilton & Olenawa (2010) note that AR can provide more contextual learning, enabling the acquisition of certain skills through the simulation of students' cognitive thinking. It has been shown in many studies that learners learned better when they used AR materials, as compared to other methods such as slide presentations or text materials (Hedley, 2003; Sin & Zaman, 2010; Seo et al., 2006; Nischelwitzer et al., 2007). Using AR, learners can also learn at their own pace, as they can re-scan the overlay as many times as they wish until they reach a solid understanding to conceptualise the content given (Wei et al., 2015). This can in turn help develop learners' long-term memory retention (Vincenzi et al., 2003; Valimont et al., 2002).

Kaufmann et al. (2000) in their research report that students learning using AR demonstrated significant satisfaction with their learning. They were also found to be more motivated to explore more things using the technology. Similar findings were reported by Juan et al. (2008) and Liu et al.

(2009), who posit that learners see AR as fun, which makes them willing to experience it again. In studying an alternate reality game, Liu et al. (2009) found that the GPS-based game increased students' motivation, creativity and exploration more than its paper-based counterpart. The use of AR was found to be more suited to individual exploration or learning. However, this might not always be the case, as Radu (2014) notes that students showed a greater sense of collaboration in shared meanings with their peers when they learn using AR. This is also supported by Freitas and Campos (2008), who observed that class collaboration increased when students used a shared display for observing AR experiences.

The past research has undeniably demonstrated the benefits of AR, especially in the education sector. It can be concluded that, through the integration of AR as a learning medium, learners will benefit more – they will be more motivated, gain a deeper understanding and memorise better. Using AR as a medium, collaborative work can also be cultivated. Previous research, however, has focused on how the use of AR, which was provided by educators or researchers, benefitted students' learning. Very little research has looked at how students learn when they are involved not only as the end users of an AR product, but also when they take a role in developing AR products themselves. This research, therefore, aims to gain insights into students' learning when they both use AR and develop their own AR projects.

## 2. Methodology

This research employed a qualitative approach, which aimed to focus on the understanding of learners' experiences in learning with and about AR. An interpretivist methodology aims to provide "contextual understanding on the basis of rich and detailed data" (Mason, 2002, p. 3). The study participants were second-year 24 (6 male and 18 female) students who were enrolled on an Educational Technology course. These students were a subset of the overall 121 students who took this course. All of the students had some skills in developing videos and multimedia stuffs during their first year when they took Computer in Education course. However, none of them had prior experience in using AR, or developing AR material. For the purposes of this study, a tutorial group was chosen based on volunteerism.

The course provides skills related to the domains of educational technology which involves design, development, implementation as well as evaluation of learning materials. Throughout the semester, students were also exposed to current topics related to the use of technology for teaching and learning purposes, e.g., Web 2.0, communities of practice, cybersecurity, MOOCs, augmented reality, eLearning, m-learning and micro-learning. There were AR materials developed for certain topics i.e., MOOC, communities of practice and domains of educational technology. AR cards were also used to spur students' motivation in starting their group projects.


Figure 1: Examples of AR cards used to present the steps in developing a CoP


Figure 2: Examples of AR cards used to trigger students' motivation in group work

In addition to being end-users of AR, students were given a group task to create their own AR materials. The group-based work took four weeks to complete, and at the end of the semester all groups presented their projects through by talking about their research. Six topics were assigned to the students which were: cybersecurity, MOOCs, augmented reality, eLearning, m-learning, and micro-learning.

Figure 3: Students presenting their AR projects

Data collection was done using one-to-one interviews, which were conducted during the final week of the semester. Interview data was transcribed and coded using Nvivo using a thematic analysis (Braun & Clarke, 2006). After the coding was completed, codes were classified into categories (Miles & Huberman, 1994). In doing this, we made the 'link' between the data (Denscombe, 2010). As a result, several categories emerged as presented in the findings section.

## 3. Research Findings

The objective of this study was to explore learners' experiences in using AR as part of their learning activities and assessment. The two research questions that we tried to answer are: a) How did students view the use of AR in their learning activities?; and b) What kind of learning did students experience when they developed their own AR projects?

### *3.1. Students' views of the use of AR in their learning activities*

Several themes emerged through the analysis, as indicated in Table 1.

Table 1: Students' views of the use of AR

| Themes | Number of respondents | Percentage |
|---|---|---|
| Fun activity | 20 | 83.33% |
| Convenience of AR | 18 | 75.0% |
| Interest in learning new topics | 15 | 62.5% |
| Easy to memorise | 15 | 62.5% |
| Self-paced/directed | 11 | 45.83% |
| Ubiquity of AR | 10 | 41.66% |
| Authentic activity | 9 | 37.5% |
| Challenging | 8 | 33.3% |

The analysis shows that participants mentioned that the use of AR had motivated them to learn about the new topic and new technology. They were surprised when they used AR for the first time. The excitement of explore a new thing made the task more interesting for them. For example, one of the participants said:

> When I was first exposed to AR, I was surprised and stunned. How come a piece of paper can project a moving video? I thought it was magic, seriously. And it makes me so excited to know more about AR. I am sure that AR can be a motivating factor for other learners. (Aryan)

The use of AR also developed their interest in exploring the topic given for their group task. This was due to the requirement for them to gather related information and then turn it into a sequence, using trigger images and overlay videos. For instance, Denise said:

> The use of AR definitely stimulates students' interest to learn about the topic. Not only I experienced the feeling, I am sure that others are feeling the same too. I will definitely use AR in my classes or perhaps in my presentations in different classes next semester! (Denise)

The mobile app that was used for these activities was Aurasma. To be able to scan the trigger images, students had to install the app on their mobile phones. Since all the students were using a smartphone, they had no problem in accessing the app. The convenience of using their own smartphones made the activities smooth and easy:

> What is beautiful about AR is that it uses mobile phones to scan. It is handy, everybody has got their own device so I think it is quite convenient, and motivating too. (Umar)

Furthermore, students also found AR was fun to use. Moreover, the overlay videos used were short in length but full of important points, and that made their learning more meaningful. One participant said:

> When I was using AR, I can say that I learned better because we have a lot of videos to

> scan but in smaller chunks. It is easy to digest in a very short period of time. And what's more, it is fun! It brings the learning process to the next level of motivation. (Fara)

Shorter videos seemed not only to help students to pay more attention to each piece of content, but also to memorise better. This can be seen from the response below:

> The use of multimedia actually helps me to memorise the content better. I do not like to read too many words actually. And what's more, I can re-scan the trigger image as many times as I wish. (Atia)

Another opinion on AR was that it allows students to spend their own time to digest the information presented in each AR material provided. The promotion of self-directed learning can be seen from participants' answers. The use of this approach seemed to be appreciated by the students, as an alternative to open discussions or lectures. Anne, for example, elaborated on how she views AR:

> It [AR] is interactive, and gives us the freedom to spend our own time to watch all the multimedia given. I love it because it is something new to me. I mean Aurasma is like magic. It integrates a photo and a video and your mobile phone becomes the medium to make it happen! (Anne)

> Using AR can actually fulfill our individual needs. We have different paces or speeds of learning. (Zurani)

Meaningful learning can be achieved through satisfying activities and when learners experience the process themselves. While learning to use the Aurasma app, students were also given a chance to do a hands-on activity in which they created their own trigger images and videos as overlays prior to developing their actual projects. All the students had to demonstrate their Auras (videos overlayyed on trigger images created using Aurasma software) in one of the tutorial classes. Hands-on activities were mentioned by the students as what made AR interesting and satisfying, for example:

> The most important impact on me when I learn to create AR is the fact that we had to experience a hands-on activity. We needed to do everything from scratch, from planning to developing and uploading. The best feeling is when the product runs well. That is the highest satisfaction [laughs]. I think there should be more projects like this using AR. (Aryan)

Another feature of AR is its ubiquity, which was mentioned by 41.66% of the participants. They appeared to appreciate the fact that they can use AR anytime and anywhere they wished. For example:

> Because AR uses mobile apps, it can be used anywhere, anytime. Ubiquitous, that's the word! (Amirul)

> AR in a way can replace a one-way teaching and learning process. No boredom. (Iza)

Although students found the use of AR motivating, interesting and beneficial for learning, a few students mentioned that AR was also challenging. For example:

> Developing an AR product means we have to do lots of things. First, we have to decide on a topic. Once we have the topic, we then search for related information. Our group project is on social media. So it is quite a tricky process. We hardly sleep at night. The main challenge for me is to be creative in making our videos, and at the same time we have to design the trigger images. If it is not interesting enough, people might not want to scan it. But after we manage to complete the work, it is really satisfying. (Noni)

### *3.2. Students' experiences in developing their own AR projects*

In addition to exploring students' views of AR, this paper also seeks to study students' experiences in developing their own AR projects. As mentioned above, students in this study were required to develop their own AR projects as part of their course assessment. None of the students involved were aware of the existence of AR prior to this course, and none had experienced using the application before. So as to accomplish their group task, all the students had to do a hands-on activity to create their own Aura. They were given four weeks to develop their AR project. Throughout the process, they had to work closely in their group and reflect on their own work. The process required them to brainstorm ideas, discuss their work and find the best solution to any problems that developed. As indicated in Table 2, four main themes emerged: collaboration, creativity, critical thinking and communication.

Table 2: Students' experiences in developing their own AR projects

| Themes | Sub-themes | Number of respondents | Percentage |
|---|---|---|---|
| Collaboration | Consensus on what to do | 23 | 95.83% |
| | Allocating tasks | 15 | 62.5% |
| | Editing work | 9 | 37.5% |
| Communication | Giving and taking | 24 | 100.0% |
| | Brainstorming | 15 | 62.5% |
| | Communicating ideas to the audience | 9 | 37.5% |
| Creativity | Exploring new approaches | 23 | 95.83% |
| | Selecting themes | 7 | 29.16% |
| | Learning from others' examples | 5 | 20.83% |
| Critical thinking | Being critical and reflective on what they had done | 19 | 79.16% |
| | Problem solving | 18 | 75.0% |
| | Arranging ideas / content | 10 | 41.66% |

#### *3.2.1. Collaboration*

The overall process of developing an AR project required collaborative effort. 95.88% of the participants found that a lot of collaborative elements were present. Once they received their topic, the students had to brainstorm their ideas and agree on certain things before they proceeded with the next stage of development. Based on the responses given, the students were aware that they were involved in teamwork from the beginning of the process to the very end. For example, after deciding on a certain theme, they had to create trigger images and videos before being able to upload them to Aurasma. The collaboration occurred during all phases, from forming brief ideas, selecting designs, developing videos, to editing. Some responses included:

> Obviously, this activity [the development of AR] requires collaborative work among us. We started with brainstorming ideas, selecting a suitable theme, and deciding who was going to do this and that. (Zaidan)

> We really learned through trial and error. But it did not demotivate us. I myself became more eager to make sure that our AR works! (Zuraida)

> What is exciting about the AR project is that we worked in a team. Everybody was so excited about AR and that made us want to give our best to produce a satisfying product! We split our tasks according to the storyboard. We were lucky that Google Presentation is there! So we didn't have to meet up physically to complete the storyboard [students used Google Presentation to create their storyboards] (Hanif)

### *3.2.2. Communication*

Another theme that emerged from the analysis was communication. Connected closely with collaboration, students mentioned how they were engaged in communication activities with their peers. When they talked about communication, it did not only involve the skill of expressing ideas effectively to others, but the students also mentioned give and take processes as part of their communication:

> We communicate a lot about AR. I would say that this project not only scaffolds our communication skills among the group members, but also how to communicate out ideas to our users. That part is more challenging I think. (Zuraida)

> This task is meaningful to me personally. As a pre-service teacher, I have to master communication skills. I mean, how to explain concepts in a very accurate and effective way. I am in love with AR. I will surely use it as part of my teaching materials. (Noni)

Nine students also highlighted communication skills with audiences, in the form of video and animation. For example:

> AR is like a medium of communication. You provide the videos in a sequence and the users will go through them one by one. I wish that we had had more time to create an online quiz, but we had no time for it. (Dahlia)

### *3.2.3. Creativity*

It is undeniable that the development of AR requires creativity, not only in designing the illustration for trigger images, but more importantly in video production. The creativity aspect was mentioned many times by the participants. In the process of completing their group task, students were given the freedom to think of the theme of their product, as well as the depth of the content they would cover. This task was challenging for them as they needed to conceptualise their product and think of its possibilities. These aspects can be seen in the following example responses:

> Creating AR really challenges our creativity. We explored many potential approaches actually, and finally we decided to use the one we have presented today. Infographics are the best way to convince users as it takes less time, but the video is something that we think makes the difference. (Mike)

> The AR presentation was something that we were looking forward to, although I cannot deny that we were so nervous … we were not that confident whether the overlay videos would play accordingly when others scanned [the images]! But the most important thing that I experienced through this task is … it taught me to think more creatively. (Azura)

> This is the best project we have ever had since we become students here! I think AR requires not only ICT skills but more on how to be creative and selective, but at the same time we also have to be precise in selecting which points to be highlighted in sequence. (Dahlia)

To overcome a lack of creativity, students cited learning from others' examples, such as watching videos via YouTube:

> What was the most challenging aspect in developing AR was creativity. As we could not think of many creative ways, we decided to view videos on YouTube and learn from those examples. We chose the best and then we tried to produce a somewhat similar video. (Mimi)

### *3.2.4. Critical thinking*

Critical thinking is defined as a cognitive process, a purposeful self-regulatory judgment that includes cognitive skills such as interpretation, analysis, inference, evaluation, explanation, logical thinking and problem solving (Perry, 1981). The analysis shows that the students also talked about how they learned to develop their critical thinking throughout the process of completing their AR projects, and this involved their judgments about their own work, for example:

> It is a process in which we need to 'judge' our product critically. Is it understandable? Is it interesting enough for users? Does it achieve our objectives? Those are the things that we have to critically think about. (Hanif)

> It is like 'what if' thinking … you know what I mean … we have to wear that kind of 'hat'. (Zuraida)

Students mentioned that they learned through trial and error, through which they developed better skills in AR development:

> We really learned through trial and error. But it did not demotivate us. I myself became more eager to make sure that our AR works! (Mimi)

In addition, the students mentioned how they had to be problem-solvers and to work with objectives - a good characteristic of an instructional designer. For example:

> This project helps me to be more objective. Our lecturer also reminds us that we have to always go back to our objective. We are taught how to identify problems, and what needs to be done to solve the existing problem. We learned how to fix things on our own. (Mahadi)

41.66% of participants mentioned that they learned to use their cognitive skills more effectively to arrange the content so that the information related to their topic would help their audience to grasp the concept more meaningfully:

> It's not only about creating a good design for trigger images, but also the skills to arrange the content so that it will ease our users to follow the idea, and at the end of it they will learn something about the topic (Dahlia)

> There are many things that need to be explained, but you have to do it in chunks. We are used to developing a long video, like 15 minutes or so … but for this project we have to split them into shorter videos. We have to think carefully about the content and the arrangement of the videos themselves. (Suraya)

## 4. Discussion and Conclusions

The overall findings show that students had positive views of the use of AR as part of their learning. Using AR was valued as a fun activity and one that helped learners to memorise better. These findings are in line with Vincenzi et al. (2003) and Valimont et al. (2002). Students also reported to that they were motivated and interested to learn about new topics using AR. These findings are consistent with Juan et al. (2008) and Liu et al. (2009). With the use of their own smartphones to access to the overlay videos, students saw how convenient it is to learn using AR. In addition, they could use their own time to re-scan the overlay videos as frequently as they wished. This is also mentioned in Wei et al. (2015). Nevertheless, despite the fact that students demonstrated positive views of the use of AR for

learning, when they had to develop their own AR projects, many of them saw it as a challenging task. However, the challenges they faced did not demotivate them from their tasks.

When asked about their learning experiences throughout the process of developing their AR projects, students gave varying answers. It was clear that the process of developing an AR project had built their collaborative skills, as working in a team needed such skills to make the project successful. It seemed that the students not only learned collaboratively when they used AR materials together, as found in the research of Freitas and Campos (2008) and Radu (2014), but also that they worked collaboratively when they developed the AR material themselves. It was also revealed that in addition to collaborative skills, the students also experienced an increase in their communication skills and creativity.

The low ability of students, particularly in higher education settings, to demonstrate critical thinking has been identified as an issue (Khalid et al., 2015; 2016). This has been believed to be due to a lack of tasks that stimulate their critical thinking. The findings from this study indicate that the task of developing an AR project can inculcate students with critical thinking abilities, including the cognitive ability to interpret, analyse, evaluate, explain things effectively (Perry, 1981), reflect, criticise (Khalid et al., 2015; 2016) and solve problems (Rimiene, 2016).

The emerging themes of collaboration, communication, creativity and critical thinking are dimensions of twenty-first century skills. From the findings of this study, it can be concluded that the integration of AR elements into learning activities can promote these skills among students, and leverage educational experiences, particularly when they are asked to develop AR materials. The findings also suggest that the use of AR should be encouraged among tertiary students as an effective way to construct learning experiences (Radu, 2014), as they will experience a new way of learning that is dynamic, interactive, and allows them to control their education (Chen, 2006). This study also contributes to suggesting how educators can maximise the potential learning benefits of and generate guidelines for designing effective educational AR experiences.

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