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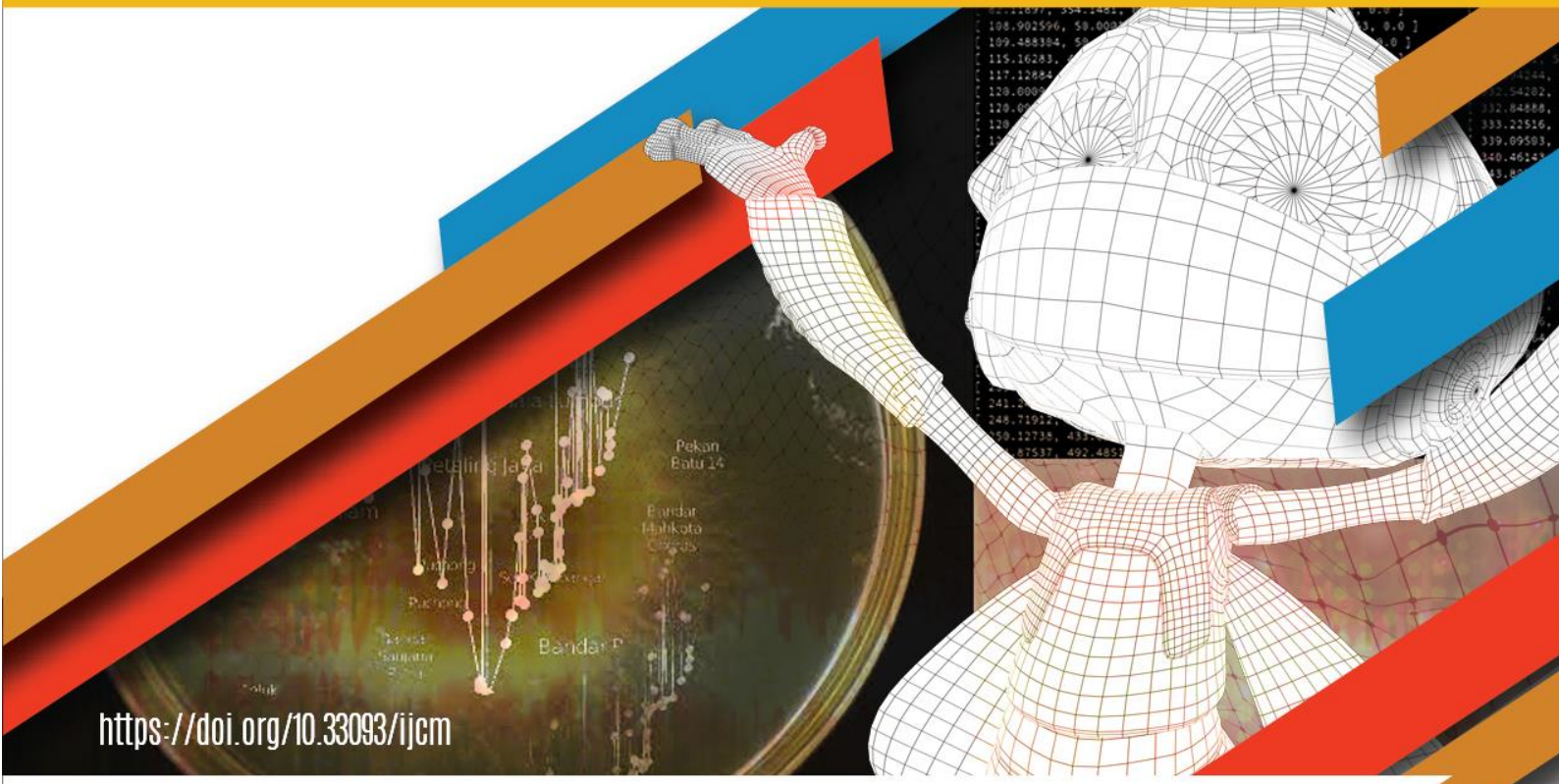

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The DARE Project: Exploring Creative Multimedia Students' Acceptance Towards Augmented Reality-enhanced Learning Environments

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Abstract

In an effort to prepare graduates for the onset of Industry 4.0, higher education institutions in Malaysia have been heeding the call by the Malaysian Ministry of Education to look into the utilization of technology to digitize learning materials and bring classrooms online. However, the physical learning space or classroom has largely remained the same. Hence there is a growing need to ensure that the physical learning environments are as engaging and immersive as online learning environments. Augmented Reality (AR) emerges as one of the key technologies that educators can use to "augment" the physical learning space. This paper presents a study that looked into the use of AR technology with Authentic Learning elements to develop AR-enhanced learning materials that can be used in a classroom. Students' perceptions and attitudes towards AR-enhanced learning were investigated through the use of a Technology Acceptance Model questionnaire. Results provide encouraging support for further research and development of AR-enhanced learning materials to create physical learning environments as students were positive towards the use of the AR learning app and showed a positive intention to use similar AR applications in the near future.

Keywords Augmented reality; Authentic learning; Technology-enhanced learning

Introduction

The onset of the fourth industrial revolution (Industry 4.0) brings to the fore artificial intelligence and automation that will transform the workplace, in particular jobs that are task or knowledge based (Xing & Marwala, 2017). Whilst it's been noted that there is still an on-going debate about the global impact of

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Industry 4.0 (Morrar, Arman, & Mousa, 2017), the World Economic Forum (2016) in their "Future Jobs Report" identified complex problem solving, critical thinking and creativity as the top three skills workers will need to succeed in Industry 4.0 and emphasizes a need to revolutionize learning (Kang, 2019). As such the Ministry of Education through the "Malaysian Education Blueprint 2015-2025" has embarked on various key initiatives in an effort to transform the higher education landscape, in particular by changing the teaching and learning approaches. The Ministry of Education emphasized that educational institutions must innovate the delivery of knowledge through the use of technology in hopes of creating engaging learning environments that produce graduates who are innovative, creative and able to think critically (Ministry of Education, 2015). Similarly, on a global scale, educators have been looking at innovative ways to create engaging and interactive online learning environments (Gillett-Swan, 2017). However, the physical classroom has essentially remained status quo with lecture style seating and not much room for collaboration and group activities (Yee, Sim, Ng, Low, & Chong, 2017). Whilst there is a lack of research into the impact of the physical classroom environment on student learning (Han, Kiatkawsin, Kim, & Hong, 2018), educators have begun noticing the gap between the online learning environment and the physical learning environment. Hence the education landscape is now moving towards encouraging more "Makerspace" types of learning environment that facilitate group activities, project-based learning and encourage creativity (Saorín, Melian-Diaz, Bonnet, Carrera, Meier, & De La Torre-Cantero, 2017).

Research has shown that learning environments that are immersive are able to better engage learners in the content through increased interactivity (Webster, 2016; Parong & Mayer, 2018). Augmented Reality (AR) technology has since emerged as one of the key players towards the design and development of learning environments that are more immersive (Xing & Marwala, 2017). Azuma, Baillot, Behringer, Feiner, Julier, and MacIntyre (2001) defines AR as having the following characteristics:

1. The virtual environment is "blended" into a real environment
2. There is "real-time" interactivity involved
3. By accurately aligning the virtual object with real objects, it creates a realistic visual of a 3-Dimensional (3D) object existing in an actual environment.

Azuma et. al. (2001) claims that the fundamental intention of Augmented Reality is to enhance the way users perceive and interact with the real world by augmenting the physical world with virtually created 3D entities to create the illusion that the 3D virtual object exists in the same physical space. While

Azuma et al. (2001) have noted that AR has been applied with favourable results in different disciplines, it is not without its own set of challenges when it comes to usability (Akçayır & Akçayır, 2017). In order to allow AR technology to reach its potential in creating immersive and engaging experiences, the graphical user interface, content, and technology need to be synthesized in a meaningful way (Enrique, Rutledge, & Neal, 2012). Hence, this study sought to explore this research question: What are the perceptions and attitudes of Malaysian creative multimedia students towards Augmented Reality-enhanced learning applications?

Creating an Authentic and Relevant Learning Experience

Authentic Learning emerges as a potential solution to address the need for an effective pedagogical framework when it comes to the application of Augmented Reality in enhancing the field of education. Authentic Learning is underpinned by constructivism and focuses on creating learning environments that facilitate the solving of complex real-world problems (Herrington, Reeves, & Oliver, 2014). Authentic learning is often described as a learning that is seamlessly placed into a real-world situation where students are actively engaged in solving complex problems that allow them to see meaning in what they are learning (Howland, Jonassen, Marra, 2012). Authentic learning activities allow students to apply theory to practice (Lindsay & Wood, 2014) and are able to address the learning styles of the new generation of students (Gen Z). Generation Z is the generation after Millennials who are often labelled as "Digital Natives" (Mohr & Mohr, 2017). This generation of students want relevance and practicality in what they are learning and prefer lecturers to facilitate engagement with the content rather than merely presenting the content (Seemiller & Grace, 2017).

In recent years, authentic learning has begun to be incorporated into different types of emerging technologies to uplift academic results at all stages of education (Bhagat & Huang, 2018). Cai (2018) found that an authentic learning environment supported by AR technology was able to encourage natural interactions among students thanks to AR not requiring input devices like a mouse or a keyboard. This allowed the experience to feel real with the additional benefit of being able to access items that are harder to access under normal circumstances due to cost or danger. AR technology provides one possible solution to designing a learning experience that is authentic and relevant as it creates a learning environment that allows students to explore the application of theoretical knowledge through a secure and controlled environment (i.e. a classroom) (Le, Pedro, Lim, Park, Park, & Kim, 2015).

The DARE Project

The DARE Project, which is an acronym for "Digital Augmented Reality Environments" is a pilot project to develop an Augmented Reality (AR)-enhanced learning environment through the development of a mobile learning application using Augmented Reality (AR) technology with Authentic Learning elements (Herrington, Reeves, & Oliver, 2014) as a pedagogical framework.

The DARE Project is an extension of The MILE Project which was a multiple award-winning project where an online learning environment was developed to house multimedia interactive learning content, lecture slides, notes, video conferencing, learning journals (blogs), and an e-Portfolio. As the MILE Project had successfully made the online learning environment robust and engaging, the key focus of the DARE Project was to bridge the gap between the online learning environment and the physical learning space by augmenting the physical learning space using AR technology. Through the incorporation of AR-enhanced learning materials, the physical learning space could potentially be just as immersive and engaging as the online learning environment.

Therefore, in The DARE Project, an AR-enhanced mobile application called "DARE" was designed and created through the use of UNITY and Vuforia software. Development of the content for the DARE app focused on three fundamental design element topics: 1) Colour, 2) Shape, 3) Texture. These topics were chosen from the actual Design Fundamental class syllabus and since they are fundamental topics the content would not need to be frequently updated. This was an important criterion for the selection of topics to be developed as the AR development process is complex and takes time, therefore topics or content that need to be frequently updated would not be as suitable. Furthermore, the application was meant to be a supportive learning tool in the classroom to help students increase engagement and connect the physical learning and online learning. To illustrate this, in the topic of Shape (3D) students would normally transition straight away from physical 3D objects to building virtual 3D objects. It would take students some time to familiarize themselves with how virtual 3D objects are built as they try to imagine the digital building blocks (vertices, lines, and faces) that would create a digital 3D object that looks exactly like the physical object. The DARE mobile application would help to ease the transition as students can see the components that make up a virtual 3D shape overlaid on a physical 3D object. The application and its intended use was designed to incorporate the 9 Authentic Learning elements by Herrington, Reeves, and Oliver (2014) to ensure the application was pedagogically sound and to allow learning to be authentic and relevant to students. The 9 elements of Authentic Learning, guidelines for implementation into a

technology-supported learning environment as suggested by Herrington and Kervin (2007), and how they were adapted towards the design and usage of the DARE application are as follows:

1. **Authentic Context**

   Guideline: Providing authentic context to learning is about creating a meaningful setting or situation that shows students how knowledge that they are being taught in class is actually used in real life.

   Adaptation to the DARE app: The content chosen for the development of the DARE app was theoretical design knowledge taken from an actual subject's curriculum of which the practical application could be demonstrated through the use of AR.

2. **Authentic Activity**

   Guideline: The learning environment should provide complex, real-world task that are relevant.

   Adaptation to the DARE app: Within the mobile app, AR was used as a method to provide students with an immersive activity that would allow them to see the practical application of the concepts and theoretical knowledge they learn in class. In addition to that, the DARE app as a whole is designed to help support and enable students in their process of completing a complex group project.

3. **Expert Performances**

   Guideline: Students should be given access to variety of experts on the topic, and be able to watch an expert complete a task before attempting it on their own.

   Adaptation to the DARE app: The "experts" in this learning environment were the lecturers who guided the students. Within the DARE app, subject matter experts prepared content for the videos.

4. **Multiple Perspectives**

   Guideline: The learning environment should provide students with access to multiple views of the topic, not just a singular view based on a textbook.

Adaptation to the DARE app: The DARE app supported classroom learning through the addition of videos in the "Learn" section, offering students more perspectives outside their lecture notes.

5. **Collaboration**

Guideline: The learning environment should encourage students to jointly solve problem in a social context.

Adaptation to the DARE app: In addition to being a method of enhancing the physical classroom environment, the DARE app was designed to also be used by students as a supplementary learning tool while working on their group projects. As the class would be designed to center around a group-based project, students could easily use the DARE app as a reference while working collaboratively to complete the project.

6. **Reflection**

Guideline: Reflection is about providing a learning environment that gives learners a chance to think, reflect, and discuss.

Adaptation to the DARE app: The DARE app allowed students to stop and continue at any time of their learning process; thus, students were able to think and reflect on what they were learning. The short micro learning-style videos allowed students to recall the topics learnt.

7. **Articulation**

Guideline: Encouraging students to express their understanding.

Adaptation to the DARE app: The increased engagement while using the DARE app, in particular the AR "Explore" function of the app encouraged students to articulate their thoughts and understanding to each other.

8. **Coaching & Scaffolding**

Guideline: Lecturer supports learning through facilitation.

Adaptation to the DARE app: The lecturer took up the role of coach and facilitator, providing students with guidance as and when necessary.

9. Authentic Assessment

Guideline: Assessment should be part of the project rather than a separate test.

Adaptation to the DARE app: The DARE app can be used as a supportive learning tool, therefore assessments were integrated in to the group project that students worked on solving together.

As the DARE app was designed to be a supportive learning tool to enhance the physical classroom, each topic within the application contained a "Learn" section and an "Explore" section. In the "Learn" section, short micro learning-style videos that were no longer than 1 minute each were created as a way for students to informally learn the content "on the go". The main topic was broken down to sub-topics/areas that allowed students to quickly recall key points on the topics. The videos were graphically designed using an infographic style of visual communication as infographics have been found to be a memorable way to deliver information when designed to be colorful and visually appealing (Harrison, Reinecke, Chang, 2015). The idea was that if students were in the classroom working on a project and they need to recall key concepts pertaining to their project, they can quickly refer to the "Learn" section of the app. Figure 1 shows a screenshot from a sample video that can be found in the "Learn" section of the topic on Shapes.

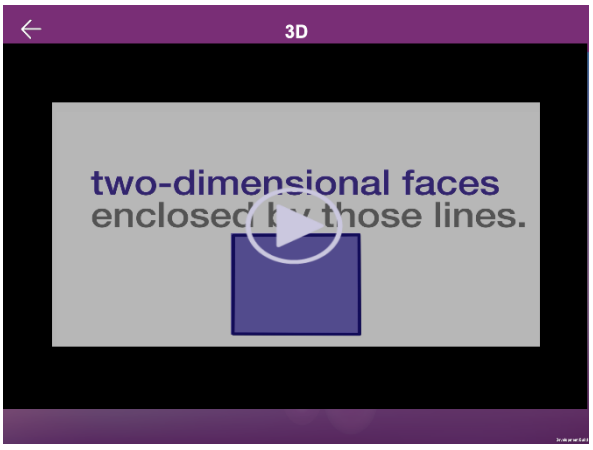

Figure 1 Infographic Style Video about 3D Shapes

Whereas in the "Explore" section, students could then explore the topic further through the use of AR technology as shown in Figure 2. The "Explore" section was designed to give students a better

understanding of how design element concepts are practiced or applied in a real-world setting. Tactile learning materials were also created to be used together with the DARE app as AR markers and would be overlaid with the virtual entities. Figure 2 shows how students would use the "Explore" section of the DARE app for the topic "Shapes". A real physical object is placed on the table and the DARE app is used to scan the object. When the app recognizes the object as a "cube", it then overlays the cube with some menu options. Clicking on these options, students can see how a real-life 3D object is made up of lines, vertices and faces. This is important because these students go on to learn how to use 3D software to recreate real objects in a virtual environment. Understanding how to build 3D models using lines, vertices, and faces is a basic fundamental knowledge that students need to have. In the example shown in Figure 2, students can physically rotate or angle the cube to see how many vertices (as illustrated by the colorful spheres) a cube would have if it were to be recreated as a 3D model.

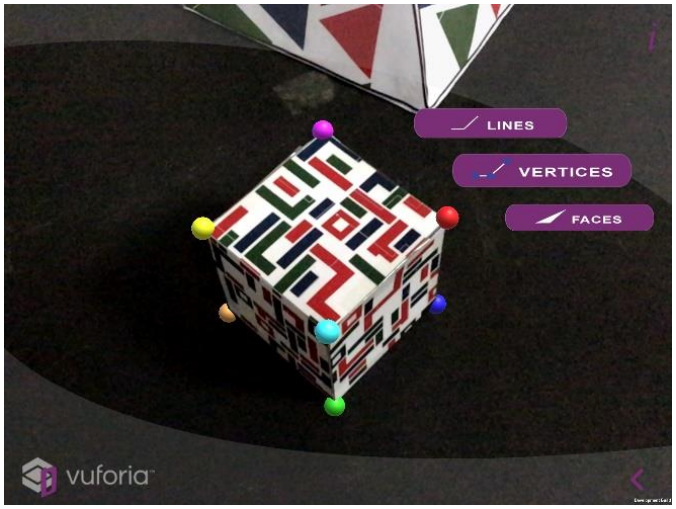

Figure 2 Exploring 3D Shapes using AR Technology

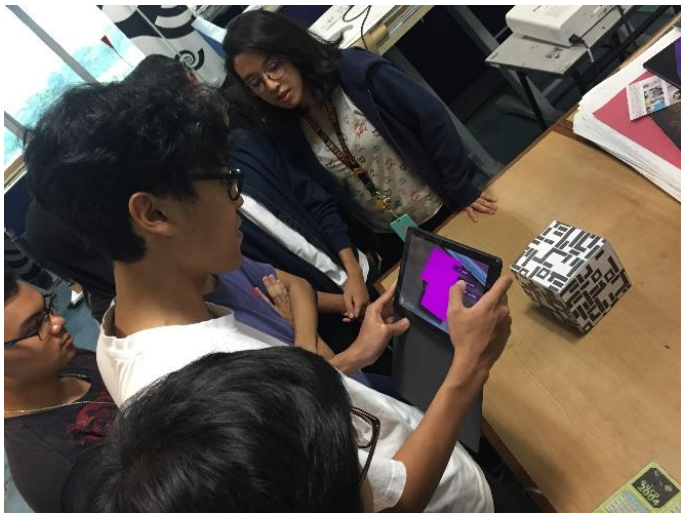

Figure 3 Students Learning about 3D Shapes Using the DARE App

A cohort of fifty-five students from the Faculty of Creative Multimedia at Multimedia University voluntarily participated in this study. These were students from the Foundation in Creative Multimedia course and were taking a class on Design Fundamentals which is a core subject. The class was selected as the topics found within the DARE mobile application were adapted from topics found in the class syllabus hence students would be able to provide feedback on whether they would like to learn these topics through AR. While class was in session, students were introduced to the DARE mobile application and were briefly introduced to the features of the application. Students were then given fifteen minutes to explore the DARE mobile application in groups of 4 - 5. Facilitators were on standby to assist students should they require help navigating and using the application, or if they faced any technical difficulties. Students were instructed to go through each topic within the DARE mobile application, watching the videos in the "Learn" sections followed by trying the AR feature in the "Explore" section. Figure 3 shows a group of students exploring the DARE app. After exploring the application, students were given a Technology Acceptance Model (TAM) survey questionnaire to fill up and provide their feedback on the DARE app.

Findings

The research design used in this study was a mixed-method research design using a combination of qualitative and quantitative data, to provide a deeper indicator of how undergraduate students in a Malaysian local private university perceive learning with Augmented Reality mobile applications, as well as their attitudes towards it. The Technology Acceptance Model (TAM) survey by Davis (1989) and Rasimah, Ahmad, and Zaman (2011) were adapted for the survey questionnaire used in this study. The questionnaire was used in this study to gather feedback on student perceptions towards learning with AR-enhanced learning materials as this was their first exposure to AR learning applications. The TAM survey also facilitated the identification of factors that would influence student's acceptance and likelihood to use these learning materials. The TAM survey items were measured on a 5-point Likert scale where "1 = Strongly Disagree" and "5 = Strongly Agree". Results of the TAM survey are listed in Table 1, organized according to the TAM constructs and in order of descending means. The survey yielded a Cronbach Alpha of 0.933, which according to Gliem & Gliem (2003) indicates the survey is reliable.

Table 1 TAM survey items

Perceived usefulness			
Items	**Mean**	**Std. Dev.**	**%**
1. Learning was made enjoyable	4.04	.719	83.6
2. Learning was enhanced	3.96	.637	85.5
3. App found to be useful for learning	3.93	.604	81.8
4. Helped to improve learning	3.91	.823	74.5
5. Increased understanding of design concepts	3.55	.741	50.9
Perceived Ease of Use			
Items	**Mean**	**Std. Dev.**	**%**
6. Felt the app was user friendly	4.02	.490	92.7
7. Learning how to use the app was simple	4.00	.577	83.6
8. Clear and understandable UI	3.80	.848	72.7
9. UI was flexible to interact with	3.67	.862	61.8
10. Was easy to skillfully use the app	3.51	.635	52.7
Attitude Towards Usage			
Items	**Mean**	**Std. Dev.**	**%**
11. Overall found app enjoying to use	4.09	.674	90.9
12. Believe use of app in classes is a good idea	4.07	.604	85.5
13. Like the concept of using the app	4.07	.634	87.3
14. The app was fun to use	3.87	.695	76.4
15. Generally in favor	3.73	.651	70.9
Behavioral Intention to Use			
Items	**Mean**	**Std. Dev.**	**%**
16. Expect to use the app next time	3.82	.796	70.9
17. Would use the app in class if available	3.73	.781	60.0
18. Would like to use AR apps for learning	3.71	.737	58.2
19. Intend to use AR apps frequently for coursework	3.62	.782	50.9
20. Plan use it as often as possible	3.29	.712	32.7

Results from the TAM survey as shown in Table 1 indicate that student attitudes and perceptions towards the DARE mobile application was generally positive. Overall, almost all survey items had a mean above 3.5. Students responded positively to the "Perceived Use" and "Perceived Ease of Use" of the app. 83.6% of students agreed that learning became an enjoyable process through the use of the app (m=4.04)

and felt their learning was enhanced (m=3.96). Students found the app user friendly (92.7%, m=4.02) as they had no trouble using the app (m=4.00). They felt the app was both useful (m=3.93) and was able to improve their learning (m=3.91). Students also reported an overall positive "Attitude Towards Usage" and positive "Behavioural Intention to Use" the learning application. 90.9% of students felt the app was enjoyable (m=4.09) and 85.5% of students believed that using the app in their classes is a good idea (m=4.07). Majority of students believe they would continue to use the app in time to come (70.9 %, m=3.82), whilst students also positively indicated that they would like to use AR applications for their classes if it was available to them (60%, m=3.73). Some of the "Behavioural Intention to Use" items had a lower percentage of students (30% to 58.2%, Items 20, 19, & 18) who agreed with the statements and it was found that students' responses were mostly undecided as learning with AR technology was still a very new experience for them.

Students were also asked to provide some comments and feedback through open-ended questions that were given after the questionnaire. When students were asked what they found favourable about using the DARE app, students said it was interesting, interactive, enjoyable, and would make learning the subject better. Examples of student comments taken verbatim are as follows:

1. *"Because it makes learning easier especially the 3D section. I can find the lines and edges easier with the app."*
2. *"The 3D part is cool when I could see the vertices and lines even though they were at the back back of the shape"*
3. *"I like how it is very easy to use. Also, it makes learning fun"*
4. *"On the 3D mode, it had a feature to make the outlines of the box. That was impressive."*
5. *"It was convenient for the studies of shapes"*

Students were also asked if they would like to see more AR learning applications used in their classes. Most students commented positively saying it will help improve their understanding of the design concepts. Some students also commented they would like more AR technology in their classes as it would make the classes more engaging. Samples of student comments are quoted verbatim as follows:

1. *"… because AR would definitely broaden my imagination and helps me to understand a concept better."*

2. *"Yes, for me to be more anticipated in class and for me to not get easily boring in class"*
3. *"Yes. For the complicated objects that need to use imagination"*
4. *"Design idea. Because we can have some ideas through the app to produce a better works"*
5. *"…it'll be more interactive among classmates"*

As this was a pilot project, students were also asked to provide some input on how the DARE app could be further enhanced or improved. Students commented that future versions of the app could be improved in terms of technical functionality (accuracy reading the marker and app stability), adding more interactive features, and expanding the topics available in the app. Student's overall positive comments support the results found through the TAM survey.

Discussion and Conclusion

Based on the results of the TAM survey and through a discourse analysis of the student comments, three key themes emerged: 1. Engagement was an important element when learning with AR technology, 2. Authenticity and relevancy of the learning materials played a key role in perceived usefulness of the AR-enhanced learning material, and 3. Technical stability and application usability was an important factor in the intention to continue using AR apps.

Engagement was a key factor that influenced the perception and attitude of students towards AR-enhanced learning materials as students found the DARE app to be an interesting and enjoyable way to learn. This supports Parong & Mayer (2018)'s findings that students who learn with immersive learning materials have higher motivation, interest and engagement. Usefulness of the app towards illustrating key concepts was also important to the students as they were able to better relate to the topic when they could see it applied into a real-world setting via the AR app. The learning experience become more authentic and relevant to them as a result of this, supporting what was noted by Cai (2018). Usability was also a key factor that influenced student's perception of AR-enhance learning materials as students had no problems using the DARE app and were able to navigate the app, but highlighted that app stability and marker scanning accuracy should be improved. As noted in the review done by Akçayır and Akçayır (2017), technical usability is one of the prevalent challenges when using AR for education.

Moving forward future iterations of the DARE app will look at expanding the topics with different levels of interactivity to suit different learner needs, as well as focus on improving the technical usability of

the AR portion of the app. In conclusion, the encouraging results from this study provide support for educators and researchers to delve deeper into the use of AR technologies with Authentic Learning elements as a pedagogical framework to create enhanced learning materials or learning spaces.

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Authors' Bio

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