



## **Examining Students' Intention to Use Augmented Reality in a Project-Based Geometry Learning Environment**

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The aim of this study is to examine factors that affect secondary students' behavioural intention to use GeoGebra Augmented Reality to support a project-based geometry learning environment. To achieve this purpose, we adopted technology acceptance model (TAM). A total of 54 students from two lower secondary schools in Indonesia were involved in this study. The students enrolled in secondary mathematics classes and attended six lessons of a project-based geometry learning assisted with GeoGebra Augmented Reality. Descriptive analysis, multiple regression and independent T-test were employed to analysed data. The findings of this study suggested that GeoGebra Augmented Reality was well accepted by the secondary school students. It was found that perceived of usefulness (PU) is the strongest factor of students' behavioural intention (BI). Contrary to the previous studies, this study showed that attitude toward using (AT) has no direct effect on behaviour intention (BI). We elaborate how the findings of this study could improve the understanding of AR acceptance by students and highlight important guideline for educational AR developers, researchers, and educators.

Keywords: augmented reality, geogebra, technology acceptance model, project based learning, learning geometry

### **INTRODUCTION**

This paper examines factors that affect secondary school students' behavioral intention to use GeoGebra Augmented Reality for a project-based geometry learning environment. GeoGebra is a Dynamic Mathematics Software (DMS) for teaching and learning mathematics from secondary school through college level. The software provides features of Dynamic Geometry Software (DGS), Computer Algebra Systems (CAS) to bridge some gaps between geometry, algebra, and calculus. It consists of

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several different types; one of them is GeoGebra Augmented Reality which is the latest type of the software.

Augmented Reality (AR) is a real-time display from a physical real object by adding objects from the virtual world to add information on an existing real object. This digital technology can combine real objects and virtual objects that exist and displayed on digital devices. AR is one of the most rapidly growing technologies and has changed since 2010. Early AR used expensive technology while most recent one uses tablets and smartphones, enabling this technology to become accessible by teachers and students (Garzon & Acevedo, 2019).

According to Saidin, Halim, and Yahaya (2015), AR leads to learning becomes more dynamic and has a potential and advantages that can be adapted in education (Saidin et al., 2015). This potential can be exploited for improving quality of mathematics teaching and learning as well as it is also an important tool to improve the experience of interacting with reality (Garzon & Acevedo, 2019). This technology makes it possible to provide interactive experience by enriching the real world with virtual items (Höllerer & Feiner, 2004). It provides a landscape that enables children to engage with concepts that are not accessible in real life (Fotaris, Pella, Kazanidis, & Smith, 2017) and enables students to see the world around them and engage with realistic issues in context with which the students are already connected (Klopfer & Sheldon, 2010). Furthermore, AR is very potential in teaching and learning of the subjects that requires students to visualize (Saidin et al., 2015). Thus, it is widely believed that Geometry is one of mathematical subjects that requires students to visualize.

According to Mills and Treagust (2003), project-based learning (PBL) is a teacher-led practices which focuses on the application of previously acquired knowledge. It is often composed of several problems that students will need to solve. Furthermore, PBL provides the contextualized and authentic experience which are necessary for students to build meaningful mathematical concepts (Capraro & Slough, 2013). The use of technology is important when designing a project-based learning (Duch, Groh, & Allen, 2001). In addition, Augmented reality is suitable to enhance the implementation of project-based learning (Luis, Mellado, & Díaz, 2013).

Educational value of Augmented Reality depends on how this technology is integrated into teaching and learning. Therefore, researchers have examined AR integrated inquiry-based learning (Efstathiou, Kyza, & Georgiou, 2018; Martín-Gutiérrez, Fabiani, Benesova, Meneses, & Mora, 2015), collaborative learning (Ke & Carafano, 2016; Martín-Gutiérrez et al., 2015), and discovery learning (Ibanez, Di-Serio, Villaran-Molina, & Delgado-Kloos, 2015). However, little research has been conducted in the use of AR in a project-based learning environment including students' behavioral intention toward the use of this technology in such learning environment.

One of important factors when integrating digital technology in the classroom is the extent to which the technologies are accepted by students (Yeou, 2016). Hence, it is critical to understand factors that can explain and predict the success of the use of Augmented Reality among the students. For this reason, in order to be able to fully

integrate Geogebra AR in a project-based geometry learning environment, it is necessary to first explore students' acceptance to the technology. Moreover, different relationship between the TAM factors that depends on the technology is being evaluated (Ibili, Resnyansky, & Billinghamurst, 2019).

However, there has been little research on applying the TAM model to understand students' acceptance of the use of AR in Mathematics learning. Further, to the best of our knowledge, there were no studies that reported the use of TAM to explore students' behavioral intention in using GeoGebra AR for learning geometry. As a result, in this paper, we report our study employing TAM model to examine student's behavioral intention in the use of GeoGebra Augmented Reality in a project-based geometry learning environment. The study also investigated students' TAM constructs according to genders and schools. Therefore, this study adds valuable insight into educational technology and mathematics education literature in the context of Technology Acceptance Model (TAM) and the implementation of Augmented reality technology in a project-based geometry learning environment.

#### RELATED LITERATURE AND HYPOTHESES

Technology Acceptance Model (TAM) is a theoretical framework used to investigate how and when users will adopt and use a new technology (Davis, 1989). This model suggests that Perceived Ease of Use (PEU) and Perceived Usefulness (PU) are two significant factors that determine individual's attitude in using technology (Venkatesh & Davis, 2000). TAM is well-known model and has proven to be a theoretical model to explain and predict user's behavior in the use of technology.

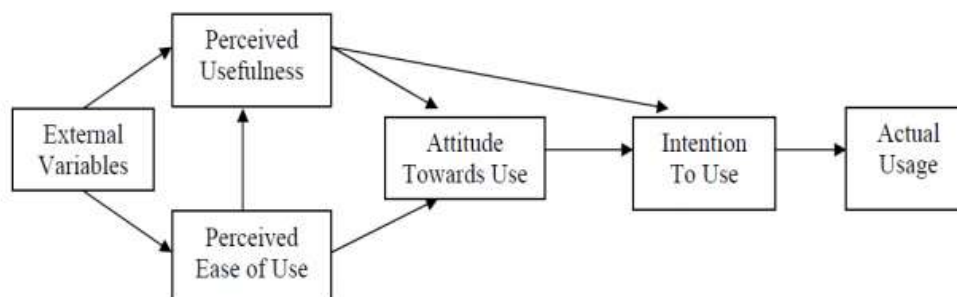


Figure 1

First modified version of the Technology Acceptance Model (TAM) (Davis, 1989)

TAM has been employed in many studies (Alharbi & Drew, 2014; Huang, 2017; Nagy, 2018), and the model has demonstrated a unique way of predicting students' behavioral intention (BI) in using technology. It has emerged as a scientific model for understanding students' acceptance of the use of technology (Abdullah & Ward, 2016; Lin, Persada, & Nadlifatin, 2014; Ramírez Anormaliza, Sabaté i Garriga, & Guevara Viejo, 2015).

There are a number of studies that examine relationship between the TAM factors with difference technologies. For instance, regarding the use of TAM to assess students perceived use of mobile technology in the classroom, Briz-Ponce, Pereira, Carvalho, Juanes-Méndez, and García-Peñalvo (2017) found that Perceived Usefulness (PU) and Perceived Ease of Use (PEU) show direct effect on Attitude (AT). Similarly, Islam (2011) investigated educator behavioral intention toward the use of e-learning and found that PEU has positive direct effect on PU, but it does not indicate direct effect on BI. However, there is a lack of studies in term of the use of TAM model to examine students' acceptance and behavioral intention to integrate Augmented Reality in geometry learning. This might be due to AR is relatively new technology in the classroom.

A number of studies have extended the TAM model by adding external variables in order to strengthen the model. However, in this study we did not extend the original framework by adding external factors. Yet, we extended the framework by assessing direct effect of PEU on BI. Therefore, the variables included (Figure 2) in this study were the standard TAM constructs namely Perceived Ease of Use (PEU), Perceived Usefulness (PU), Attitude toward Use (AT), Behavioral Intention (BI), and Actual Usage (AU)

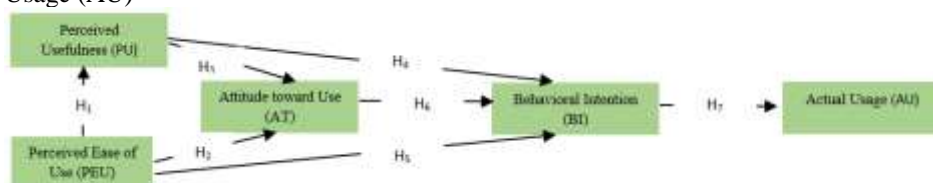


Figure 2  
Structural model of hypothesis

#### Perceived Ease of Use (PEU)

In this study, Perceived Ease of Use (PEU) is defined as the degree to which the students believe that using Augmented Reality will be easy. Previous studies revealed that PEU increases students' acceptance to technology (Huang, 2017), Attitude toward Use (Cheung & Vogel, 2013), Perceived Usefulness (Wu & C. Zhang, 2014), and Behavioral Intention (BI) (Chen & Tseng, 2012; Wu & C. Zhang, 2014). This study examined to what extent secondary school students' PEU influences PU and AT. Furthermore, to extent the original TAM model, the study also analyzed direct influence of PEU on BI. We expected that PEU would influence PU, AT and BI. To examine these, hypothesis 1, hypothesis 2, and hypothesis 5 were proposed.

H<sub>1</sub>: There is positive and direct effect of Perceived Ease of Use (PEU) toward students' Perceived Usefulness (PU) of Augmented Reality in a project-based geometry learning environment

H<sub>2</sub>: There is positive and direct effect of Perceived Ease of Use (PEU) toward students' Attitude toward Use (AT) of Augmented Reality in a project-based geometry learning environment

H<sub>5</sub>: There is positive and direct effect of Perceived Ease of Use (PEU) toward students' Intention to Use (BI) Augmented Reality in a project-based geometry learning environment

#### **Perceived Usefulness (PU)**

According to Davis (1989), Perceived of Usefulness (PU) is the degree to which users believe that technology will enhance their performance. In this study, we defined PU as the degree to which students believe that using Augmented Reality will increase their performance in a project-based geometry learning environment. TAM suggests that when users use technology, PU is factor that influence their BI before they actual use. Thus, it is widely believed that students' positive attitude toward technology is influenced by their assumption that technology is useful for learning (Lai, Wang, & Lei, 2012). Furthermore, users' PU can influence their BI to adopt technology (Zain et al., 2019). This study is intended to examine to what extent PU influences students' Attitude toward Use and Students' Behavioral Intention to Use Augmented Reality. Therefore, we proposed hypothesis 3 and hypothesis 4.

H<sub>3</sub>: There is positive and direct effect of Perceived Usefulness (PU) toward students' Attitude toward Use (AT) of Augmented Reality in a project-based geometry learning environment

H<sub>4</sub>: There is positive and direct effect of Perceived Usefulness (PU) toward students' Intention to Use (BI) Augmented Reality in a project-based geometry learning environment

#### **Attitude toward Use (AT)**

Attitude toward Use (AT) is defined as acceptance of rejection when users use technology (Zain et al., 2019). Previous studies have assessed AT on technology acceptance and found that it can increase the use of Behavioral Intention (BI) (Calisir, Altin Gumussoy, Bayraktaroglu, & Karaali, 2014; Shyu & Huang, 2011). These two factors that affect AT are PEU (Calisir et al., 2014; B. Wu & C. Zhang, 2014) and PU (Calisir et al., 2014; B. Wu & C. Zhang, 2014). In this study, we expected that AT influences students' BI in using Augmented Reality for geometry learning. Therefore, we proposed hypothesis 6.

H<sub>6</sub>: There is a positive and direct effect of Attitude toward Use (AT) toward students' Intention to Use (BI) Augmented Reality in a project-based geometry learning environment

#### **Behavioral Intention (BI)**

Behavioral Intention is defined as behavioral tendency to continue using the technology in the future. This construct is very crucial in determining whether users will continue using technology in the future. Previous studies have investigated the impact of BI on users' acceptance of technology and revealed that BI has positive relationship with Actual Usage (AU). Previous studies also showed that BI is influenced by PU (Tarhini, Elyas, Akour, & Al-Salti, 2016; B. Wu & C. Zhang, 2014) and PEU (Tarhini et al.,

2016; B. Wu & C. Zhang, 2014). In this study, we expect that BI influences students' actual use of augmented reality. Therefore, the following hypothesis was proposed.

H<sub>7</sub>: There is positive and direct effect of Intention to Use (BI) toward students' Actual Usage of Augmented Reality in a project-based geometry learning environment

## METHOD

### Design of the Study

The study adopted a quantitative approach as it is considered to provide more reliability, validity, objectivity, and generalizability to the findings. As it has been argued, if the researchers collect data based on a representative sample of the population, by employing a quantitative approach, they are more able to generalise statements made about the topic being examined (Fraenkel & Wallen, 2009).

### Research Instrument

According to Lew, Lau, and Leow (2019), questionnaire is one of the most widely used methods in the studies of technology acceptance. Therefore, we developed a questionnaire based on TAM Model (Davis, 1989). The questionnaire consisted of 18 items groups under five TAM constructs namely Perceived Usefulness (PU), Perceived Ease of Use (PEU), Attitude toward Using (AT), Intention to Use (BI), and Actual System Use (AU). Each item of the instrument used a five-point Likert Scale (1 = strongly disagree, 2 = disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree).

To establish content validity of the questionnaire, the questionnaire was validated by three experts. Then, it was revised based on their comments. A pilot test was conducted with 5 selected students to make sure the questionnaire is understandable for them. Further, we calculated Cronbach's alpha to assess reliability and found that it was .933, which indicates that all items exhibit high reliability and measure the same concept. Table 1 presents Cronbach's alpha coefficients of multi constructs that indicate adequate reliability.

Table 1  
Cronbach's Alpha Coefficient of the questionnaire constructs

Construct	Cronbach's Alpha Coefficient
Perceived Usefulness (PU)	.849
Perceived Ease of Use (PEU)	.754
Attitude toward using (AT)	.740
Intention to Use (BI)	.787
Actual System Use (AU)	.739
Total	.933

### Research Participant

This study was carried out at two lower secondary schools in Indonesia. The first school was considered high performing school, while the second one was regarded middle performing school. From each school, we randomly selected one class of year 9. From first school, we had 32 students consisting of 17 females and 15 males, whereas from the

second school we had 20 students consisting of 9 females and 11 males. As a result, in total, we had 52 students from both classes.

### Data Collection and Setting

As mentioned earlier, the data collection of this research project took place in two classes of year 9. We implemented six geometry project-based lessons for the classes. During the lessons, students used mobile phones installed with GeoGebra Augmented Reality. They worked in groups comprising of four to five students and used this technology to investigate their mathematical tasks. The main task of the project was to assign the students to design handcraft that consists of 3 dimensional mathematical objects. In the sixth lesson, the students were required to present their project designs. Figure 3 shows samples of students' activities using GeoGebra during the lessons. After completing all the lessons, we administered a TAM survey instrument. It took about 10 minutes for the students to complete the questionnaires.



Figure 3  
Some students' activities using GeoGebra Augmented Reality

### Data analysis

All students' responses were coded in a 5-point scale. Statistical Package for Social Science (SPSS) was employed to conduct descriptive and inferential statistical analysis (Byrne, 2007). Regarding descriptive statistic, means and standard deviations of all items were calculated and presented in a table. In terms of inferential statistics, correlation analysis and multiple regression were employed to examine the hypotheses. Also, we conducted independent t-test to assess each TAM construct according to genders and schools

## FINDINGS

In this section, we present results of descriptive analysis, correlation matrix, multiple regression, and the overall analysis of TAM constructs. In addition, we report results of t-test that examine TAM constructs according to participants' genders and schools.

### Result of Descriptive Analysis

The results of descriptive analysis of the measurement items were presented in Table 2. It shows that all the items exhibit positive perceived toward the use GeoGebra Augmented Reality, with all mean values over 50% of the total score. Furthermore, standard deviations provide an indication of how far the students' responses vary from the mean. Overall, the results show that standard deviation is ranging from .575 to .871. This indicates that students' responses on average were a little over 0.57 and .87 point from the means of the items.

Table 2  
Results of descriptive analysis

Item	Mean	S.D
PEU1 I can use GeoGebra Augmented Reality easily	3.87	.741
PEU2 Learning how to use GeoGebra Augmented Reality is easy for me	3.81	.647
PEU3 It is easy to have skills on how to use GeoGebra Augmented Reality	3.87	.850
PEU4 If I learn more, I will be skillful in using GeoGebra Augmented Reality	3.98	.794
PU1 GeoGebra Augmented Reality is useful to learn mathematics in everyday life.	4.33	.634
PU2 I easily understand geometry as it is supported by a GeoGebra Augmented Reality	3.83	.825
PU3 The GeoGebra Augmented Reality helps to broaden my knowledge and enhance my learning achievement	4.00	.760
PU4 When I use GeoGebra Augmented Reality, learning geometry and completing the project take less time	4.00	.834
PU5 I think GeoGebra Augmented Reality is an important tool for project-based learning	3.74	.871
AT1 The use of GeoGebra Augmented Reality-based project is a good idea	4.13	.575
AT2 Learning with GeoGebra Augmented Reality is an insightful idea.	4.11	.667
AT3 In all aspects, GeoGebra Augmented Reality is good	3.91	.694
BI1 I will use GeoGebra Augmented Reality in mathematics learning, not only for geometry	3.62	.795
BI2 I will recommend GeoGebra Augmented Reality to my friends	3.57	.801
BI3 I will watch tutorial videos of GeoGebra Augmented Reality-based learning more often	3.51	.804
AU1 It is true that GeoGebra Augmented Reality is relevant to learning geometry	3.87	.741
AU2 It is true that GeoGebra Augmented Reality is easy to use	3.81	.647
AU3 GeoGebra Augmented Reality is effectively used as media for learning of geometry in a project-based environment	3.87	.850

### Results of Correlation Analysis

Table 3 reveals the correlation matrix between the scales investigated. The results showed that the correlation between all constructs is significant ( $p < 0.05$ ) and positive. The results also revealed that most of the correlation coefficients are higher than 0.5, which means the relationships are very strong.



Table 3  
The correlation matrix between the TAM constructs

Constructs	PEU	PU	AT	BI	AU
PEU	1.000				
PU	.732**	1.000			
AT	.673**	.707**	1.000		
BI	.606**	.644**	.456**	1.000	
AU	.789**	.672**	.656**	.319*	1.000

\*\* Correlation is significant at the 0.01 level (2 tailed)

Among the constructs, it is found that relationship between Actual Usage (AU) with Perceive Ease of Use (PEU) is the strongest one with r value of 0.789. On the other hand, the relationship between AU and BI is the weakest one with r value of 0.319.

### Results of Multiple Regression

Table 4 presents the hypothesis testing of the structure model. It shows that PEU significantly affected PU ( $\beta = .778$ ,  $p < 0.05$ ), which shows 53.6% variance in PU. Regarding AT, PU and PEU constructs had significant effects on AT with value of ( $\beta = .338$ ,  $p < 0.05$ ) and ( $\beta = .327$ ,  $p < 0.05$ ) respectively. The results show that both constructs accounted for 56.9% of the variance in AT. Furthermore, PU ( $\beta = .615$ ,  $p < 0.05$ ) and PEU ( $\beta = .434$ ,  $p < 0.05$ ) showed significant positive affect on BI. On the other hand, AT ( $\beta = .113$ ,  $p > 0.05$ ) did not has significant affect in BI. These constructs contributed 41.8% variance in PU. Finally, BI had significant positive affect on AU ( $\beta = .270$ ,  $p < 0.05$ ) with contribute .102 variance in BI.

Table 4  
Multiple regression analysis of TAM attributes

D.Var	R <sup>2</sup>	I.Var	Beta ( $\beta$ )	Standard Error of $\beta$	t-statistic	Significance
PU	.536	PEU	.778	.110	7.054	.030
AT	.569	PU	.338	.120	2.816	.014
		PEU	.327	.127	2.570	.007
BI	.470	PU	.615	.178	3.465	.001
		AT	.113	.223	.0506	.615
		PEU	.434	.204	2.230	.031
AU	.102	BI	.270	.119	2.257	.029

Table 5  
Results of hypothesis

Hypothesis	Effects	Direction	Path Coefficient	Result (Support to Hypotheses)
H <sub>1</sub>	PEU → PU	Positive	0.778	Supported
H <sub>2</sub>	PEU → AT	Positive	0.327	Supported
H <sub>3</sub>	PU → AT	Positive	0.338	Supported
H <sub>4</sub>	PU → BI	Positive	0.615	Supported
H <sub>5</sub>	PEU → BI	Positive	0.434	Supported
H <sub>6</sub>	AT → BI	Positive	0.113	Not Supported
H <sub>7</sub>	BI → AU	Positive	0.270	Supported

Table 5 presents summary of the result which shows that hypothesis 5 is not supported meaning that attitude toward using does not have significant affect in students' intention to use of Augmented Reality in a project-based geometry learning environment.

To show significance of the impact, we present Figure 2 showing path coefficients and their significance of each construct across the TAM constructs.

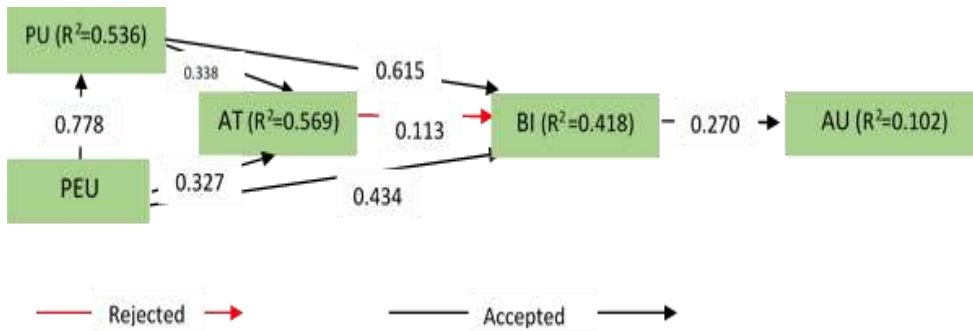


Figure 2  
Testing the hypothesis of the structural model

**Results of Independent T-Test**

As mentioned earlier, this study also examined TAM constructs according to genders and schools. Descriptive statistics and the independent sample t-test were employed to assess whether gender plays an important role in the TAM constructs of the students. Results of each construct according to gender are presented in Table 6.

Table 6  
The mean of each TAM constructs according to gender

TAM Construct	Mean (x)		t	p
	Female (N =27)	Male (N=25)		
Perceived Usefulness (PU)	3.90	4.08	2.340	.327
Perceived Ease of Use (PEU)	3.70	4.08	.993	.024
Attitude toward Use (AT)	3.99	4.12	.888	.379
Intention to Use (BI)	3.44	3.69	1.284	.207
Actual Usage (AU)	3.79	4.17	2.415	.020

The results showed that there was statistically significant difference in mean scores of students Perceived Ease of Use (PEU) for female (Mean = 3.70) and male (Mean = 4.08),  $p < .05$ , and mean scores of students Actual Usage (AU) for female (Mean = 3.79) and male (Mean = 4.17),  $p < .05$ . It shows that male students had higher scores for both constructs. On the other hand, there was no statistically significant difference in mean score of the students' Perceived Usefulness (PU) for female (Mean = 3.90) and male (Mean = 4.08), Attitude (AT) for female (Mean =3.99) and male (Mean =4.12), and Behavioural Intention (BI) for female (Mean = 3.44) and male (Mean =3.69), ( $p>0.05$ ).

We also examined TAM constructs according to schools. As mentioned earlier, participants of this study were students from two secondary schools. School A represented high achievement schools while school B represented low achievement schools. Table 7 shows that there was no statistically significant differences in mean scores of all TAM constructs according to the school.

Table 7

The mean of each TAM construct according to the school

TAM Construct	Mean (x)		t	p
	School A (N=30)	School B (N=22)		
Perceived Usefulness (PU)	3.98	3.98	-.007	.995
Perceived Ease of Use (PEU)	3.81	4.00	-1.244	.220
Attitude toward Use (AT)	4.01	4.11	-.740	.463
Intention to Use (BI)	3.53	3.63	-.475	.638
Actual Usage (AU)	3.94	4.04	-.650	.520

## DISCUSSION

The main aim of the study is to examine factors that affect secondary students' behavioural (BI) intentions in the use of Augmented Reality in a project-based geometry learning environment. Behaviour Intention to Use (BI) is one of the important factors in determining the Actual Use (AU) of Augmented Reality. The success of the use of technology is evaluated through students' Behavioural Intention. Therefore, it is critical to assess the students' acceptance and behavioural intention to ensure that students will continue utilizing this technology in their future learning. In this context, the hypotheses related to directional links between TAM factors were tested. The effect of students' genders and schools on their TAM constructs were also examined.

Overall, the findings of this study suggested that perceived of Usefulness (PU) is the strongest factor of students' Behavioural Intention (BI) in the use GeoGebra Augmented Reality. However, contrary to prior studies, the finding showed that Attitude toward Using (AT) does not directly affect students' behaviour intention (BI) in the use of Augmented Reality in geometry learning. In addition, this study revealed that there are significant differences in mean scores of perceived Ease of Use (PEU) and Actual Usage (AU) according to gender. Results of this study demonstrated several important points of discussion.

It was revealed that Perceived Ease of Use (PEU) directly affect students' Perceived Usefulness (PU) which is in line with the results of previous studies (Ibili, Resnyansky, & Billinghamurst, 2019; Revythi & Tselios, 2019; Verma & Sinha, 2018; Zain et al., 2019). The finding also confirmed that hypothesis H<sub>1</sub> is accepted implying that secondary school students' perceived usefulness of GeoGebra Augmented Reality will increase when they perceive that the technology is easy to use. Therefore, for teaching purpose, it is critical to design augmented reality-based teaching resources that are easily accessed and used by students.

PEU was also found to have a direct positive effect on attitude (AT) which is consistent with the findings of previous research (Briz-Ponce, Pereira, Carvalho, Juanes-Méndez,

& García-Peñalvo, 2017; Lee, 2010; Revyathi & Tselios, 2019; Verma & Sinha, 2018). The finding verifies that hypothesis H<sub>2</sub> was accepted, indicating perceived ease of use will play critical role in their attitudes toward the use of Augmented Reality in a project-based geometry learning environment. However, this results is incompatible with studies conducted by Drennan, Kennedy, and Pisarski (2005) and Ibili et al. (2019).

Regarding Perceived of Usefulness (PU), this factor was found to have a direct positive effect on Attitude (AT) which supports the results of previous studies (Briz-Ponce et al., 2017; Ibili et al., 2019; Lee, 2010). Based on this finding, it confirms that hypothesis H<sub>3</sub> was accepted which indicates that secondary school students' attitude toward the use of Augmented Reality in a project-based geometry learning environment will increase positively when they have better perception toward the usefulness of the technology. Therefore, it is important for mathematics teachers who adopt this technology to show their students that this technology can facilitate them to better understand mathematics.

It is interesting that the study reveals Perceived of Usefulness (PU) has direct effect on Behavioural Intention (BI) which is in line with the findings of other studies (Budi, Efendi, & Dahesihsari, 2013; Weng, Yang, Ho, & Su, 2018). They indicate that in order to increase students' behavioural intention to use Augmented Reality, during the process of Integration of this technology in the classroom, particularly when teachers integrate Augmented Reality technology in the classroom, it is necessary to convince students that this technology is useful to enhance their understanding of mathematical concept, with particular emphasis on geometry .

Perceived Ease of Use (PEU) also has positive direct effect on Behavioural Intention (BI). This finding is consistent with finding of other studies (Chao, 2019; Said, Izharuddin, Idris, & Othman, 2018; Suki & Suki, 2011). It confirms that hypothesis H<sub>5</sub> was accepted which indicates that AR technology needs to be user friendly in order to increase students' behavioural intention in using it in the future. This finding is crucial to extent TAM original model which does not look at the relationship between PEU and BI.

Another interesting result is that Attitude toward Using (AT) indicated a weak direct effect on Behavioural Intention (BI). This finding is aligned with Sun (2003), Taylor and Todd (1995) and (Zain et al., 2019) revealing that AT is not important factor to BI. Similar finding was also revealed by Venkatesh and Davis (2000) that AT was a weak predictor for BI and AU. For this reason, hypothesis H<sub>6</sub> was rejected. Therefore, it can be argued that students' attitude is not critical in determining their behavioural intention in the use of Augmented Reality.

The result of this study does not support Hypothesis 6 because of the following reasons First, students did not have previous experience with the integration of Augmented Reality in learning mathematics as argued by Zain et al. (2019) that experience will increase students' confidence in the use of technology which will automatically improve students' attitude toward technology.. Based on this point of view, we assume that the result might be different when students have enough knowledge and experiences in using Augmented Reality. Therefore, further study is necessary to include experienced

users as the participants. Second, this study shows that attitude was significantly affected by perceived ease of use and perceived of usefulness. As this was the first experience for the student, the perceived of ease of use might increase when they get used to the technology which will consequently improve their attitudes toward the integration of AR in their learning.

Finally, the results of this study showed that Behavioural Intention (BI) has positive direct influence on students' Actual Use of Augmented Reality. This finding is in line with the findings of previous studies (Shyu & Huang, 2011; Tarhini, Elyas, Akour, & Al-Salti, 2016). For this reason, hypothesis H<sub>7</sub> was accepted. It is clear that in order to improve the actual use of Augmented Reality in a project-based geometry learning environment it is needed to increase students' behavioural intention to the technology.

This study confirms that perceived of usefulness was the strongest factor that play a significant role in influencing students' behavioural intention to use Augmented Reality in a geometry project-based learning environment. Furthermore, perceived ease of use had very strong positive effect on students' perceived of usefulness. Hence, the findings indicated several important points for teachers and developer of educational augmented reality: First, it is necessary for developer of educational AR to ensure that AR based educational resources should be user friendly and easily used by secondary school students in order to increase their perceived usefulness of the technology for their learning purpose, and Second, this study urges teachers to be able to show and convince students that this technology is useful for them in learning mathematics.

As mentioned earlier, we also examined whether genders and schools play a significant role in the TAM constructs. The results showed that gender plays significant role only in Perceived Ease of Use (PEU) and Actual Usage (AU). As Perceived Ease of Use plays significant effect on students' actual usage; thus, the finding indicate several important points: First, the finding makes it clearer that PEU has strong effect on AU since the finding showed that when gender has played significant role on PEU it also plays similar significant role on AU; Second, this finding supports Teo, Fan, and Du (2015) study which revealed that technology integration is more challenging for females than males; Finally, it is crucial to take gender into account when AR technology is integrated in the classroom.

Regarding school, the results showed that there is no statistically significant difference in mean scores of all TAM constructs according to schools. As mentioned earlier, we collected data from two schools that have different level of students' achievement where the first School was considered to have a better quality than the second School. Hence, the finding indicates that school level does play significant role in students' behavioural intention in using Augmented Reality. This might happen because we provided the same devices and resource when we integrated the technology in the study.

#### **CONCLUSION, LIMITATIONS AND FUTURE WORK**

The aim of this study is to examine factors that affect students' behavioral intention in the use of Augmented Reality in project-based learning environment. In addition, this study examined TAM constructs according to genders and schools. For this purpose,

hypotheses regarding links between factors of the TAM model were examined. As the results, PEU and PU were found to be strong predictors of BI. Observed together, PEU and PU were found to have direct influence on AT. However, AT was not seen to be a significant predictor of BI. Furthermore, it showed that gender plays significance role in students' Perceived Ease of Use (PEU) and Actual Usage (AU), while school levels do not play significant effect on students' TAM constructs.

This study is significant because it is the first attempt that TAM model has been used to examine students' behavioral intention in the use of Augmented Reality in a project-based geometry learning environment. The implication of this study that designer and developer of educational AR should develop a more user-friendly application of AR. Moreover, in term of the implementation in the classroom, teachers need to take gender into account when they use this technology for teaching and learning geometry.

However, this study has some limitations. First, data were collected from only two secondary schools. For this reason, in subsequent studies it is recommended to compare finding from a bigger sample size in different locations. In addition, the study did not include external variables to assess students' behavioral intention. Therefore, we suggest for future research to add external variables in order to gain a better understanding on students' behavioral intention in using GeoGebra Augmented Reality. Furthermore, it is necessary to examine the issue of integration Augmented Reality in a wider context. For instance, it would be beneficial to conduct further study on challenges of the integration of Augmented reality and how this technology effect students' learning and achievement in a project-based learning for geometry learning.

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