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The effect of augmented reality mobile learning in microeconomic course

Dayana Farzeeha Ali[1], Nusaila Johari[2], Aimi Ruzaini Ahmad[1]
[1]Faculty of Social Sciences and Humanities, School of Education, Universiti Teknologi Malaysia, Johor, Malaysia
[2]Industrial Logistics Section, Universiti Kuala Lumpur - Malaysian Institute of Industrial Technology (UniKL-MITEC), Johor, Malaysia

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ABSTRACT

Recently, there has been a surge of interest for students to use technology while engaging in their learning. Augmented reality is one of the technologies found suitable for use in the educational field, such as in science, mathematics, and engineering. However, it is not yet being explored in the Microeconomics course. Therefore, this study investigated the effectiveness of using augmented reality, namely Augmented Reality Mobile Learning in Microeconomic courses (ARMLAAPPS). This study used a quasi-experimental design, and two groups were involved: the control and experimental groups. They are undergoing teaching and learning sessions using ARMLAAPPS and conventional teaching methods. This study indicates that students in the experimental group showed a significantly higher visualization skills level than those in the control group after teaching and learning. Besides, this study also found that ARMLAAPPS can assist in highlighting student-centered learning, stimulating student interest and curiosity, increasing student cognitive, affective, and psychomotor processes, and increasing student involvement in the information-seeking process. Educators are suggested to use augmented reality in their teaching and learning since it has effectively enhanced students' visualization skills and promoted a better understanding of knowledge.

Corresponding Author:

Dayana Farzeeha Ali
Faculty of Social Sciences and Humanities, School of Education, Universiti Teknologi Malaysia
Sultan Ibrahim Chancellery Building, Jalan Iman, 81310 Skudai, Johor, Malaysia
Email: dayanafarzeeha@utm.my

1. INTRODUCTION

In Malaysia, one of the programs offered at the university level is economics which includes programs such as business and accounting. Microeconomics course is a compulsory course offered by most specializations in the faculty of economics, business management, accounting, hospitality, and human resources to enable them to get a certificate, diploma, or degree [1]. This course acquires the students to master a few skills such as understanding or memorizing concepts, mathematical skills, statistical skills, graph drawing, application of theory, and problem-solving skills.

However, most students claim that the microeconomics course is difficult to master [2]–[4]. It requires students to have good analytical and problem-solving skills. This is quite challenging, especially for students who have low visualization skill levels [5], [6]. Students with low visualization skills will have difficulty visualizing, sketching, and interpreting the graphs, affecting their understanding of microeconomics concepts and academic performance. Therefore, a preliminary study was conducted to identify student achievement in a microeconomics course at a public university in Malaysia. Table 1 shows the examination for microeconomic courses based on a percentage at a public university in Malaysia from 2016 to 2019.

Table 1 shows that most students had moderate and low achievement in microeconomic courses. Students are less skilled in translating problem statements that require the application to read and draw the graph from the problem given. Students also face difficulties imagining the shape of the graph through the mathematical statement sentences given when answering the exercise questions [7]. According to previous researches, students cannot learn this microeconomics course because of a lack of visualization abilities [8], [9]. Students must acquire visualization abilities to visualize data in the form of figures and graphs.

Table 1. Examination for microeconomic courses based at a public university in Malaysia from 2016 to 2019

Grade	Year			
	2016	2017	2018	2019
A	14.19	18.6	25.54	28.36
B	58.16	55.5	29.82	21.25
C	22.17	14.8	22.45	26.17
Failed	5.48	11.1	22.19	24.22

In pedagogy, microeconomics requires students to learn and apply ideas and draw and describe curves [3], [8]. This course requires students to utilize visualization skills to solve problems. Visualization abilities are a person's ability to visualize pictures, inventiveness in mental vision, and the ability to draw, color, and sketch [10]. Students facing basic statistical and mathematical skills problems struggle with drawing and interpreting graphs and data [11]. Data interpreting skills require the students to use their visualization skills to make it easier to sketch and draw graphs, interpret data and graphs, and convert graphs into data language more efficiently [5]. In the microeconomics course, visualization abilities may assist students develop their creativity, creating graphs, and visualizing strategies to transform graphs into data and vice versa [1]. Therefore, visualizing skills are a crucial ability that can help pupils improve their cognitive [12] and numeric literacy [5].

One of the most significant factors in guaranteeing learning efficacy is to assist students in improving their visualizing abilities [13], [14]. Visualization as an effort to more systematically and concentratedly detail the information received through objects or graphics [15]. Recently, there has been a changing teaching trend from conventional methods to the rapid use of technology in education [16], [17]. Traditional teaching methods are gaining less interest in being implemented in the classroom [18]. It is maybe due to the difficulty for educators to deliver the information, especially for complex abstracts and concepts [19]. Furthermore, students in the current trend prefer to use technology in their daily lives.

Augmented reality (AR) technology is one of the technologies that can enhance student visualization skills [20]. AR allows users to access virtual objects in the real world in real time. The use of AR in the educational field is explored chiefly in science, technology, engineering, and mathematics subjects [21]. Most researchers are interested in exploring AR because this technology can enhance student visualization skills. The unique elements of AR are replacing existing objects, simplifying the information process, simulating aids, attracting consumers, replacing experiments, and boosting students' motivation toward learning [22]. Many studies found that using AR technology in teaching and learning is an effective way of increasing students' attention as well as increasing the students' level of understanding [23].

Additionally, AR used with mobile devices, or AR mobile learning can offer an interactive environment to the student so that they can conduct a learning process in a flexible learning environment and at their own pace. With the AR mobile learning application, users can access the space shared by virtual objects while the rest are in the real world. Virtue in the AR environment and mobile devices has made learning based on mobile devices easier [24].

However, no studies were done to investigate the impact of AR mobile learning on students' visualization skills for the Microeconomic courses. Microeconomics courses have similar elements to mathematics in terms of using graphs, data, and interpretations which require good visualization skills [1], [3]. Therefore, researchers have developed an augmented reality mobile learning application (ARMLAPPS) and studied its effectiveness compared to conventional teaching methods.

2. RESEARCH METHOD

This study used a quantitative method that involved a quasi-experimental research design. The quantitative technique utilized in this work is a quasi-experimental design with control and treatment groups employing pre-test and post-test [25]. The quasi-experimental design is appropriate for usage when a random study into a control group or a random experimental group is challenging to accomplish since the groups are chosen before the study is undertaken [26]. Due to time restrictions, this research will concentrate on

non-random sampling approaches that emphasize purposeful sampling. Purposive sampling is easy to execute since it is simple, quick, convenient, and inexpensive [27].

The respondents in this study involved a group of diploma students in the Faculty of Business Management from a public university in Johor, Malaysia. The respondents were divided into two groups, namely the control and experimental groups. There were 38 respondents from the control group chosen to use the conventional method and 36 from the experimental group used ARMLAAPPS. Both groups learned Monopolistic Competition and Oligopoly topics which are the most difficult topics in learning microeconomics. While using ARMLAAPPS, the students are to imagine a graph, draw a graph, interpret data into a graph, and vice versa. This topic helps the students learn how to draw a graph and interpret the data, which involves visualization skills.

The independent variables in this study involved the effectiveness of ARMLAAPPS and conventional learning, whereas the dependent variable was visualization skills. The data on students' visualization skills were obtained through pre-test and post-test using descriptive and inferential analysis in each phase. Pre-tests were given to respondents in the first week of the study to determine their baseline level of visualizing skills. The researchers provided post-tests to the responders three weeks after the intervention. The data was analyzed with the statistical package for the social sciences (SPSS) software. The quantitative data from this study were examined using descriptive and inferential statistics.

The descriptive analysis was used to analyze maximum scores, mean value and respondents' standard deviation scores. In contrast, the inferential analysis of paired sample t-test was employed to determine if there was a significant difference in the mean value of the post-test between the control and experimental groups in terms of improving students' visualization skills. The independent sample t-test was implemented to determine the effect of ARMLAAPPS on students' visualization skills compared to the conventional method. The researcher developed two instruments to carry out this study. The first instrument used in this study was the microeconomics Visualization Skills instrument to measure student visualization skills levels. Secondly, this study used the Likert-Scale instrument to examine the students' perception of ARMLAAPPS. The first instrument was distributed to the conventional and experimental groups, while the second instrument was distributed to the experimental group of respondents.

3. RESULTS AND DISCUSSION

The study aims to compare the effects on students' visualization skills after undergoing the teaching method using ARMLAAPPS and conventional methods in microeconomics. Table 2 shows the differences between the control group's pre-test and post-test mean scores. It has been analyzed using inference analysis, namely Paired Sample Test. It is used to test the existence of a mean difference for the same group (students) twice (pre and post) for the control group.

Table 2 shows that the mean score increased from 26.18 before the intervention to 39.47 following it, indicating a difference between the pre-test and post-test. This shows that the post-test results are better than the pre-test. The standard deviation also showed a slight increase of 8.42 for the pre-test and 8.76 for the post-test. Due to the mean value and standard deviation of these post-tests, it can be concluded that the level of the students' visualization skills was still low but improving.

The purpose of the paired sample test is to determine the effect of learning based on conventional approaches on students' visualization skills. Table 3 shows the values of t=9.841, df=37, p=0.0001 ($p<0.05$). This indicates that there is a significant difference between the pre and post-test. In conclusion, conventional learning methods significantly enhance students' visualization skills for microeconomics courses. It means the conventional learning approach positively affects students' visualization skills. Table 4 shows the differences between mean scores of pre-tests and post-test for the experimental group.

Table 2. The differences between the mean scores of pre-test and post-test for the control group

	Mean	N	Std. Deviation	Std. Error Mean
Pre	39.47	38	8.76	1.42
Post	26.18	38	8.42	1.37

Table 3. Paired sample t-test for the control group

	Paired differences					t	Df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% confidence interval of the difference Lower	Upper			
Post- Pre	13.2897	8.32420	1.3506	10.5538	16.02557	9.841	37	.000

Table 4 shows that the students' mean score for their level of visualizing grew from 31.67 before the intervention to 49.31 after it. The standard deviation also showed an increase of 8.11 for the pre-test and 8.38 for the post-test. From this value, it can be concluded that there is an increase in the level of visualization of the students after learning interventions using ARMLAAPPS. Based on Table 4, it can be concluded that the level of students' visualization skills was low before the intervention and was increased to a moderate level after the intervention.

The purpose of implementing the paired sample t-test is to determine the effect of ARMLAAPPS on students' visualization skills. Based on Table 5, it shows the value of t=12.587, df=35, p=0.0001 ($p<0.05$). In conclusion, these findings indicate that ARMLAAPPS significantly enhances students' visualization skills for microeconomics courses. This proves learning by using ARMLAAPPS has a positive effect on visualization skills.

Table 4. Differences between mean scores of pre-tests and post-test for the experimental group

	Mean	N	Std. Deviation	Std. Error mean
Pre	31.67	36	8.11	1.35
Post	49.31	36	8.38	1.40

Table 5. Paired sample t-test for the experimental group

	Paired differences					t	Df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error mean	95% Confidence interval of the difference Lower	Upper			
Post-Pre	17.63889	8.40800	1.40133	14.79403	20.48375	12.587	35	.000

An independent sample test was conducted to compare the students' visualization skills in experimental and control groups. This was done after both groups had completed learning using ARMLAAPPS and conventional learning methods. Table 6 shows the findings of the independent sample t-test. This test was used to compare two groups in one variable.

Table 6 shows the different standard deviation values for the control group, which are 8.76 and 8.38 for the experimental group. On the other hand, the mean score value increases when compared to the post-test for the control group and experimental group for students' visualization skill level, which is 39.47 for the conventional approach (control group) and 49.31 using ARMLAAPPS (experimental group). Table 7 shows the independent sample T-Test. The purpose of the independent sample t-test is to determine the effect of the ARMLAAPPS on students' visualization skills if compared to conventional approaches. T-test for equality of means shows the value of t=-4.928, df=72, sig. (2 tailed)=0.00; indicated that there is existence difference between these two groups. From this value, it can be concluded that there is an increase in the level of visualization skills of the students by using the ARMLAAPPS compared to the conventional method. Thus, it can be concluded that using ARMLAAPPS in teaching and learning would improve and positively affect students' visualization skills more than applying the conventional method.

Table 6. Different standard deviation values

	Mean	N	Std. Deviation	Std. Error mean
Control group	39.47	38	8.76	1.42
Experimental group	49.31	36	8.38	1.40

Table 7. Independent sample t-test

	Levene's test for equality of variances		t-test for equality of means						
	F	Sig.	t	f	Sig. (2-tailed)	Mean difference	Std. Error difference	95% Confidence interval of the difference Lower	Upper
Equal variances assumed	.53	.819	4.928	2	.000	-9.8317	1.99492	-13.80868	-5.85506
Equal variances not assumed			4.934	1.992	.000	-9.83187	1.9925	-13.80385	-5.85989

On the other hand, Table 8 shows the percentage of student's perceptions of ARMLAAPPS. The table makes it abundantly evident that implementing ARMLAAPPS in teaching and learning supports each of the constructs, such as stimulating students' interests and curiosity, which scored the highest (95.14%). They were followed by elements of using visualization skills with 94.05%. On the other hand, 93.52% of students agreed that ARMLAAPPS involved cognitive, affective, and psychomotor processes, and 90.97% of students agreed that ARMLAAPPS promoted student-centered learning. Lastly, 84.26% of students agreed that there is an opportunity for them to ask questions and make a conclusion in the information-seeking process in the teaching and learning session using ARMLAAPPS.

Table 8. Student's perception of ARMLAAPPS

Construct	No (%)	Yes (%)
Promote active learning style		
Thinking during activities in the classroom (C1)	11.1	88.9
Identifying, finding and testing knowledge (C2)	11.1	88.9
Thinking about issues or in solving problems (C3)	0.0	100
Actively engage during the learning process (C4)	13.9	86.1
Total	9.03	90.97
Stimulating student's interest and curiosity		
Interested in wanting to know (C5)	2.8	97.2
Interested in exploring and seeking information (C6)	5.6	94.4
Interest in resolving a given issue (C7)	8.3	91.7
Increase student's motivation to study this course (C8)	2.8	97.2
Total	4.86	95.14
Involves cognitive, affective and psychomotor processes		
Learning based on techniques, procedures and ways of seeing problems and solving them (C9)	5.6	94.4
Be able to think better when conducting activities in making observations and assumptions (C10)	5.6	94.4
The learning helps students think to make conclusions based on the information obtained (C11)	8.3	91.7
Total	6.48	93.52
To ask questions and make conclusion on the process of information seeking		
Interest in asking questions if there are any learning concerns (C12)	11.1	88.9
Lecturer give challenging questions (C13)	22.2	77.8
Lecturer ask students to make conclusions based on learning findings (C14)	13.9	86.1
Total	15.74	84.26
Involve visualization skill		
This learning provides a clear picture of this courses (C15)	11.1	88.9
This learning helps you in terms of sketching and drawing graphs (C16)	2.8	97.2
This learning helps you to interpret graphs (C17)	5.6	94.4
This learning can improve student's memorization level (C18)	5.6	94.4
Process of viewing, imagining and sketching can raise student's understanding level (C19)	8.3	91.7
This learning help students in interpreting data (C20)	8.3	91.7
This learning help students to visualize graph more clearly (C21)	0.0	100.0
Total	5.95	94.05

The construct of AR stimulates interest and curiosity, showing the highest percentage of all items. The construct of visualization skills also shows a high percentage, and all students agree that this learning has helped them to describe a graph more clearly (C21). In addition, almost 95% of students agreed that using ARMLAAPPS managed to help them in sketching and drawing (C16) and helped them to interpret graphs more easily (C17), and improved their memorization level (C18).

Almost all students agreed that ARMLAAPPS is learning based on techniques, procedures, and ways of seeing problems and solving them more easily than the conventional way (C9). Besides, it can help the students to think better when doing activities in making observations and conclusions (C11). For student-centered learning constructs, all students agreed they get the opportunity to think about issues and solve them (C3). In contrast, 86.1% of students agreed they were actively involved during the learning process (C4).

Lastly, in the construct of asking the questions and making a conclusion in finding information, only 77.8% agreed the instructors prepared questions that challenged their minds (C13). In comparison, more than 85% of students agreed that they had the opportunity to ask questions (C12) and were allowed to make conclusions by learning from the findings (C14). This construct means that students like to ask questions, and then the lecturer asks students to develop conclusions based on their learning results.

ARMLAAPPS in teaching and learning sessions has thus been shown to increase students' interest and curiosity, improve visualization skills, involve cognitive, affective, and psychomotor processes, encourage student-centered learning, and give students opportunities to pose questions and draw conclusions from the learning activities. AR technology inspires students to pursue in-depth learning of new concepts and abilities [28]. Educators must empower students' cognitive powers to make learning more meaningful through student-centered strategies and facilitation by educators who use students' cognitive skills [29].

Overall, from the research, the conventional method and ARMLAAPPS positively impact the students' visualization skills. However, this study concluded that the students' visualization skills exposed to ARMLAAPPS are higher than those exposed to conventional teaching methods in microeconomics. It proved that using ARMLAAPPS in learning microeconomics subjects will positively and better enhance students' visualization skills than traditional teaching methods.

All of these advantages came from the uniqueness of ARMLAAPPS, which was developed and equipped with interactive video, 2D, and 3D AR video images to provide a platform to help the students understand how to draw and illustrate graphs and concepts more clearly. It is also equipped with other multimedia elements, such as a combination of images, text, animation, video, and audio. This way, it can help improve the students' visualization skills. The integration of AR in ARMLAAPPS enables the students to improve their visualization skills during the teaching and learning process and allows them to view 2D and 3D graph views more accurately.

ARMLAAPPS helps to reduce cognitive load, especially in complex learning. This is because ARMLAAPPS allows the students to implement their imagination more easily. Furthermore, to explain abstract concepts in the subject, they lack learning materials to help the students understand learning. In this study, ARMLAAPPS allows presentation in the form of 2D and 3D images and animations and has helped students learn the concept of drawing graphs, understanding graphs, and interpreting graphs and data that requires good visualization skills. This is because AR can deliver content that requires visualization capabilities directly to the user, which in turn helps them to understand and learn a concept [15].

The advantages of learning using ARMLAAPS compared to conventional teaching methods in teaching and learning are largely due to AR technology's ability to convey abstract information in a simpler approach [30]. It is very helpful in microeconomics courses because there are many complex abstract concepts, especially for the topics Monopolistic Competition and Oligopoly. In addition, AR technology allows students to explore learning content from new perspectives [31]. AR also provides an interactive learning environment that can increase the students' motivation and interest [32].

A study by Song, Kalet, and Plass [33] found that multimedia learning helps in increasing student motivation during learning. Animation and video are useful in attracting students and increasing their motivation [34], [35]. Besides, AR technology's influence, multimedia increases students' motivation to learn. Multimedia in teaching and learning can produce positive learning effects [36]. Various studies have reported that the use of multimedia, such as animation and interactive video, can have a positive impact on learning. AR was developed by combining AR technology with multimedia elements. It can be concluded that AR is more effective in improving the students' visualization level than the conventional method.

4. CONCLUSION

Microeconomics is a difficult subject, but it is a compulsory course for students in the School of Business and Administration. Microeconomics requires the students to have good visualization skills because this course needs the students to have mastery of drawing and illustrating graphs, interpreting data, and understanding complex concepts. Many studies have shown that the current teaching methods need to be transformed from conventional practice to technology-based learning.

AR is a new technology with great potential to be applied in education. Therefore, this study discussed the implications of conventional teaching methods and AR-based learning methods in enhancing students' visualization skills in microeconomics courses. This study shows a significant difference in students' visualization skills after the treatment session, using the conventional method and AR. It indicated improved students' visualization skills using conventional methods and AR. However, using AR in teaching and learning is more effective and has a better impact than the traditional method. Since students' visualization skills who have been exposed to ARMLAAPPS are higher than those who have been exposed to traditional teaching methods in the microeconomics subject. It might be due to augmented reality technology's unique characteristics and the interactivity of multimedia elements used in ARMLAAPPS. To conclude, ARMLAAPPS improves the students' visualization skills more effectively than the conventional method and positively impacts the students' visualization skills.

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BIOGRAPHIES OF AUTHORS

Dayana Farzeeha Ali received her bachelor's degree and Doctor of Philosophy in Technical and Vocational Education from Universiti Teknologi Malaysia (UTM). She is currently an Associate Professor with Faculty of Social Sciences and Humanities, School of Education, UTM. She also holds the post as the Director of Corporate Affairs Section, Office of Strategy and Corporate Affairs, UTM. Her research interest includes technical and engineering education, visualization skills, innovation, and creativity in education, and any related to technology in education. She can be contacted at email: dayanafarzeeha@utm.my.

Nusaila Johari received the Ph.D. degree in Technical and Vocational Educational and Training from Universiti Teknologi Malaysia. She is currently a Senior Lecturer at Industrial Logistics Section, UniKL-MITEC. Her current research interests include business management, students' learning and development and areas of education. Her publication topics include microeconomics education, business management education, visualization skills and Augmented Reality technology. She can be contacted at email: nusaila@unikl.edu.my.

Aimi Ruzaini Ahmad is a postgraduate student in Technical and Vocational Education (TVET) at Universiti Teknologi Malaysia (UTM), Johor Bahru, Johor. She received her Bachelor Degree in Engineering (Computer) and Master in Educational Technology from UTM. Her main research interests include the TVET field including digital education, educational technology, web-based learning and e-learning. Currently, she works as Vocational Training Officer and she has 11 years experience as an Assistant Director in Information Technology Department at ILP Perai, Penang (2 years), Human Resources Department Headquarters, Putrajaya (8 years) and ILP Pasir Gudang, Johor (1 years), before pursuing her PhD studies. She can be contacted at email: aimi0806@gmail.com.