

The Acceptance and Interest of Students in Using Virtual Reality (VR) for Learning Mathematics

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Abstract Nowadays, Virtual Reality (VR) is one of the new technologies that have been used in learning session that have a positive impact on the students. This article is intended to study the students' acceptance and interest in the use of VR in learning Mathematics. This study involves 37 students, of whom are 15 male students and 22 female students with age range of 15 and 16 years from Sekolah Menengah Maahad Tahfiz Ilmuan (SMITIN) located in Bangi, Selangor. The module that contains 13 questions and 1 set of questionnaires is used to collect the research data. The findings reveal that majority of the students show good results in the use of VR as learning tools in the lesson, whereby 89% of them got grade A in the task whilst the rest of them got grade A-. These technologies have a positive impact on the students in understanding Mathematics. Furthermore, the findings show that the usage of VR in the group can not only help improve students' social skills in doing tutorial in the class but also increase their interests in learning Mathematics. The implementation of VR application has a positive impact on the students in learning Mathematics with the help of their teachers and parents. Nevertheless, parents need to control the usage of the gadgets.

Keywords Virtual Reality (VR), Active Learning Method, Passive Learning Method, Problem Based Learning Method

1. Introduction

Knowledge and information can be found through different media. There are two types of learning that have been implemented in the education which are passive learning method and active learning method. Passive learning method is a method that students are not visibly doing anything, except watching, listening, or reading, which is a teacher-centered learning method [1]. This process creates convergent thinking, where a given question typically has only one right answer. Furthermore, according to Kikuchi [2], passive learning method depends only on the teachers to solve and explain the problems and students are only required to listen and write all the answer. It only required one-way learning method between students and teachers. This method used face-to-face delivery resources through the use of teaching space and seminar rooms. It entails the physical presence of learners in the rooms to learn the subject [3]. Besides passing the information to the students, that method encouraged people to interact and learn from other students [4].

However, passive learning method may seem good, but it is difficult to be done because of the limited space and time. There are many benefits of passive learning method but teaching a lot of students requires bigger spaces and rooms and travel [5]. Furthermore, this method is known to be costly, considering that the students are required to attend special class with additional cost on the books and teaching material [6]. That's why nowadays this method is

not necessarily effective for students [7], [8]. Previous research and studies have shown that [9], students may struggle to solve a given task and incompetent of recalling given ideas if they rely only on lecturers.

Many institutions are still using these ineffective and non-interactive styles which result in a lack of interest among learners. Thus, in order to help students improve their learning journey, educators are encouraged to search for better approaches and learning styles [8]. Most likely students are in the passive recipients of knowledge rather than being involvedly active in the classroom [10] because the students only listen and respond to teacher's lectures, and repeat the information provided earlier by the teacher [11].

Based on the study performed, active learning method are preferred compared to passive learning method in the education system. Active learning method is a method that require student's participation in the class. According to [12], the two core elements in the active learning method are introducing exciting student's activity and promote student engagement in the class. Students enjoy their lesson in the class if they involve all the activities in the classroom. They understand what they learn, discuss and present and also improve their social skills in terms of interacting with other people. From this method, there will be multi-answer from one question and there is no right or wrong for the answer depends on how they explain the answer [13]. Besides that, active learning requires students' participation in applying knowledge rather than memorizing the facts and they know how to collaborate and discuss with other peers [14]. There are 3 approaches in active learning method which are cooperative learning method, problem based learning and collaborative learning method.

Cooperative learning (CL) method has been introduced to develop communication skills, self-developments and all good skills between students in the classroom. This method ensures students meaningfully and enthusiastically involved in their learning, reaching up to their potential [15]. It is the approaches that students possessing different levels of capability work together to make their effort in small groups to achieve a purpose, and maximize their personal potential and learning. Besides that, CL is a good learning approach to implement because of its positivity relationship between learners, as it can reduce peer competition and make a good teamwork [16], [17]. According to the previous research, significantly improvements in students' behavior can be seen. They matured in decision making and improved their interpersonal relationships when using CL as learning method compared to competitive and individualistic learning process [18].

In addition, Problem Based learning (PBL) method is also the approach that can improve academic skills, problem solving and communications skills among students. Similar to CL, PBL required a small group of

students to solve the problems in academic curriculum without the tutor [19], [20]. Both methods need the initiative from students to progress through the project as well as for their own learning [21]. The main goal of PBL is to help the students gain knowledge from attending the problem and focus on the process to handle the problem. It has few steps to think which are digging the information about the problem, discovery of topics to be explored and also emerging of the strategies to solve problems [22]. Problem-based learning is a special learning because the focus of learning is on the problem and learning experience in real life. Hence, it also improve the critical thinking skills of the students and teamwork skills [22],[23].

Collaborative learning method has also been introduced to improve the passive learning method in student's education. More senses involve sound, touch, emotions and sight, as it can be recognized as an important part of an education system [24]. There are more than two learners work and learn together to solve the assignments in CL [25]. Students who are involved in CL are responsible for both their own learning and their colleagues' learning. Thus, the success of one student helps other students to be successful, too [26], [27]. Collaborating learning approaches make active involvements, interactions, evaluations, swapping ideas and experiences between students and increased their interests while promoting critical thinking [27]. The ultimate purpose of the approaches is to make students more appreciate and enjoy the subjects as well as improves their social skills and capable to solve assignments in a group. As we can see, lecturer will become a facilitator, a consultant when conflict occurs, and an observer in a group discussion [28], [29].

The improvement of modern information technology can expand CL approach become i) among students themselves and ii) students and teachers [30]. This new approach is known as a Computer-Supported Collaborative Learning (CSCL) [8]. According to this approach, with the help of the technology and gadget, students can improve their knowledge and learning [8]. In order to enhance the smooth of learning journey of students, educators are looking forward to implement new technologies in their classrooms because it can easily attract students to improve their academic performances [31]. The emergence of the AR and VR have a great impact on the coaching and learning process also create new ways to teach students and make the learning process livelier and more interesting [32].

Interactive technology for educational system is emerging at an amazingly fast rate, and advances in virtual reality (VR) that have led to many possible new applications [32]. VR can be described as "The use of computer modeling and simulation that makes a person to interact with an artificial three dimensional (3D) visual or other sensory environment" [33]. Furthermore, VR can allow students to see and interact with virtual surroundings

and objects [32]. It can be delivered through a headset, which lets the students to feel objects and receive the 3D environment. Thus, students are totally engrossed in the virtual environment, as it replaces the physical environment around them [34]. As we can see, VR is a real-time immersive simulations through digital graphics and transport users to a fully world environment [35].

VR is classified into two major types of level of interaction which are immersive VR environment and non-immersive VR environment [36]. Immersive VR environment are presented on bigger size screen or through head mounted display unit include special computer hardware which are suits, gloves, paddles and high-end computer classifications [36]. In contrast, non-immersive VR computer simulation is characterized based on a conventional personal computer, including touch screen, ergonomic keyboard, joystick and mouse [36].

2. Methodology

2.1. Design

The VR Mathematics Workshop is part of the Faculty of Engineering and Built Environment (FKAB) Universiti Kebangsaan Malaysia, UKM - led workshop to encourage the students' interest in Mathematics. This quantitative research was held to improve the understanding of students in Mathematics with the help of teaching tool which is Virtual Reality (VR).

The students participate in this well-planned hands-on activity based on the module. Facilitators have developed the module that contains 'VR Math' application guide. "VR Math" application is one of the VR application systems that can be used to learn Mathematics, as shown in Figure 1.



Figure 1. VR Math application

2.2. Participants

37 students from Sekolah Menengah Integrasi Tahfiz Ilmuan (SMITIN), Bangi Malaysia were invited to participate in the program. 9 small groups of 4 students were given the task and a questionnaire. The demographic profile in Table 1 shows 15 male students and 22 female students who were 15 and 16 years old were involved in the program.

Table 1. Demographic profile

Gender	Frequency	%
Male	15	40.54
Female	22	59.46
Total	37	100

2.3. Instrumentation

Table 2. Details of the questionnaire's Likert Scale

Number of Scale	Details
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

Quantitative data for this research was collected through survey questionnaire. A set of questionnaires in the form of Likert Scale was given to the students regarding their opinions towards the use of VR in Mathematics subject.

The five Likert Scales used such as “1” - “Strongly Disagree”, “2”- “Disagree”, “3” - “Neutral”, “4” - “Agree”, and “5” - “Strongly Agree”. The details of the Likert scale from 1 to 5 are tabulated in Table 2. The descriptive data analysis was analyzed by using Rasch Measurement Model software (Winstep software). The reliability of the instrument was high with Cronbach’s Alpha value of 0.85.

2.4. Procedure

The workshop session was conducted on 7 November 2019 that focused on the usage of Virtual Reality (VR) in Mathematics. A total of 9 groups of students were formed and actively involved during the workshop session. The group members were required to works cooperatively with their team to complete the module.


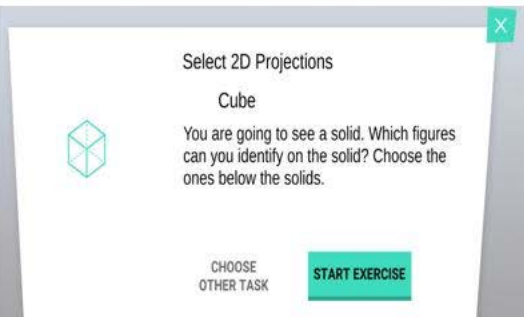
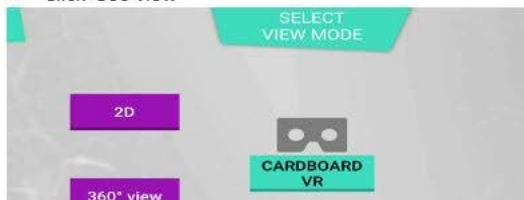
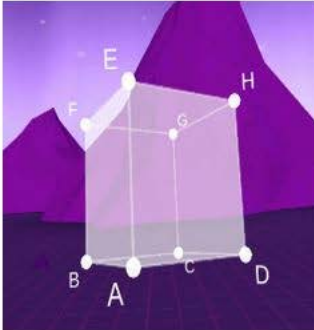
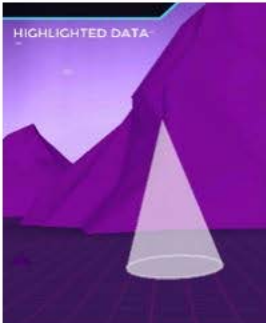
MODULE	TASK
<p>IDENTIFY 2D SHAPES</p> <ul style="list-style-type: none"> Click 'Identify 2D Shapes'  <ul style="list-style-type: none"> Click 'Start Exercise'  <ul style="list-style-type: none"> Click '360 view' 	<p>TASK 1</p>  <p>You are going to see a solid. Which figures can you identify on the solid? Choose the ones below the solids.</p> <p>(A) square (B) rectangle (C) triangle</p> <p>Check Answer</p> <p>Answer :</p> <p>TASK 2</p>  <p>HIGHLIGHTED DATA</p> <p>You are going to see a solid. Which figures can you identify on the solid? Choose the ones below the solids.</p> <p>(A) square (B) triangle (C) circle</p> <p>Check Answer</p> <p>Answer :</p>

Figure 2. Example of questions in the module

A short briefing was conducted by the Head of the workshop to provide the fundamental knowledge on how to use the VR Math application in the smartphone and VR glasses. Each student needed to install the VR Math application in their smartphone in order to answer the 13 questions provided in the module. Figure 2 shows the example of questions in the module. 9 units of VR glasses were given to each of the group to let them try and answer the questions in the module. At the end of the workshop, the students need to complete the questionnaire given by the facilitator. The details of the questionnaire are shown in Table 3.

Table 3. Details of the questionnaire

Number of Question	Details of the Question
Question 1	Do VR applications help students understand the Mathematics subject?
Question 2	Do you want VR applications to be one of the topics in your school's Mathematics curriculum?
Question 3	As a student, do you want your parents to help with the use of VR application especially in Mathematics subject?
Question 4	Do you believe that applications such as VR can stimulate students' interest in current technological developments?
Question 5	Are you more motivated to learn Mathematics subject with the use of VR applications?



Figure 3. Application of VR glasses in the workshop

Figure 3 shows the application of VR glasses in the workshop as one of the learning tools. The students had answered all the questions using the “VR Math”

application, as shown in Figure 4. At the end of the workshop, the students needed to submit the module together with the answer and the questionnaire.



Figure 4. “VR Math” application

3. Results and Discussions

Figure 5 shows the total marks that each of the students achieved in the module given. Total marks in percentage (%) for 37 students are shown in Figure 6 as below. As observed, most of the students got above 30 out of 39, which is above 77% marks. The highest mark is 39 out of 39, which is 100% marks and there are 14 students achieving full marks. The overall percentage marks for 37 students is shown in Figure 7. According to Figure 7, there are 17 students who scored 97.5%, 9 students scored 92.5%, 7 students scored 87.5%, followed by 4 students achieved 77.5% in the task given. Moreover, all the marks that achieved are categorized into grades which are 33 out of 37 (89%) students scored A and only 4 students scored A- as shown in Figure 8. It shows that all the students understood clearly about the task given and they enjoyed the subject that used virtual reality (VR) as a learning tool. These technologies have an impact on students’ attitude towards that Mathematics subject.

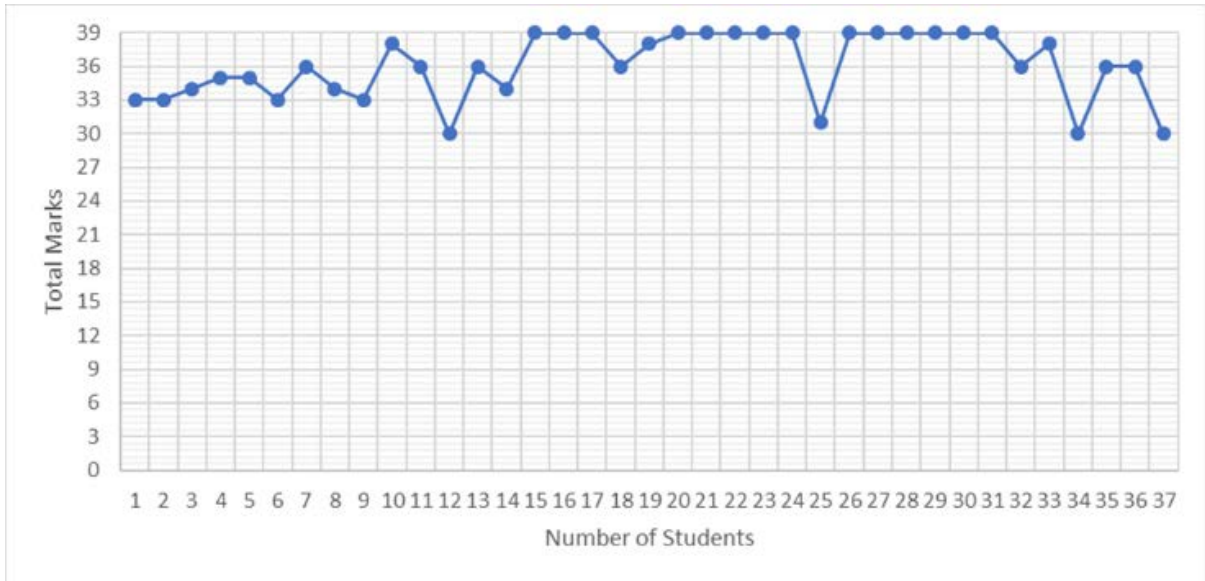


Figure 5. Total Marks for 37 students

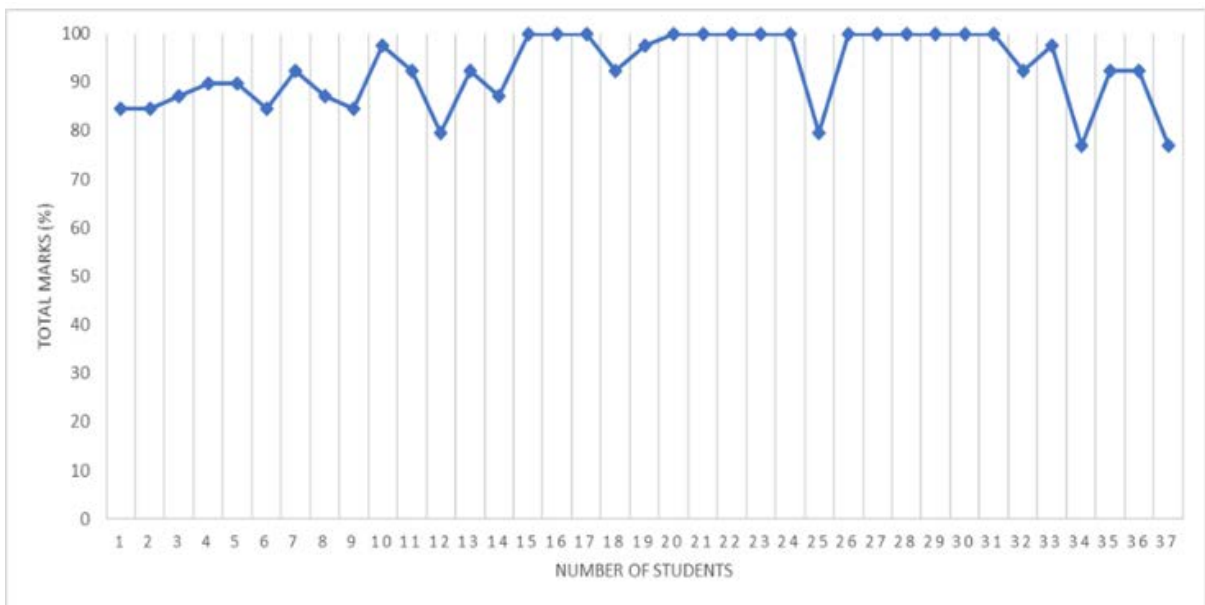


Figure 6. Total Marks (%) for 37 students

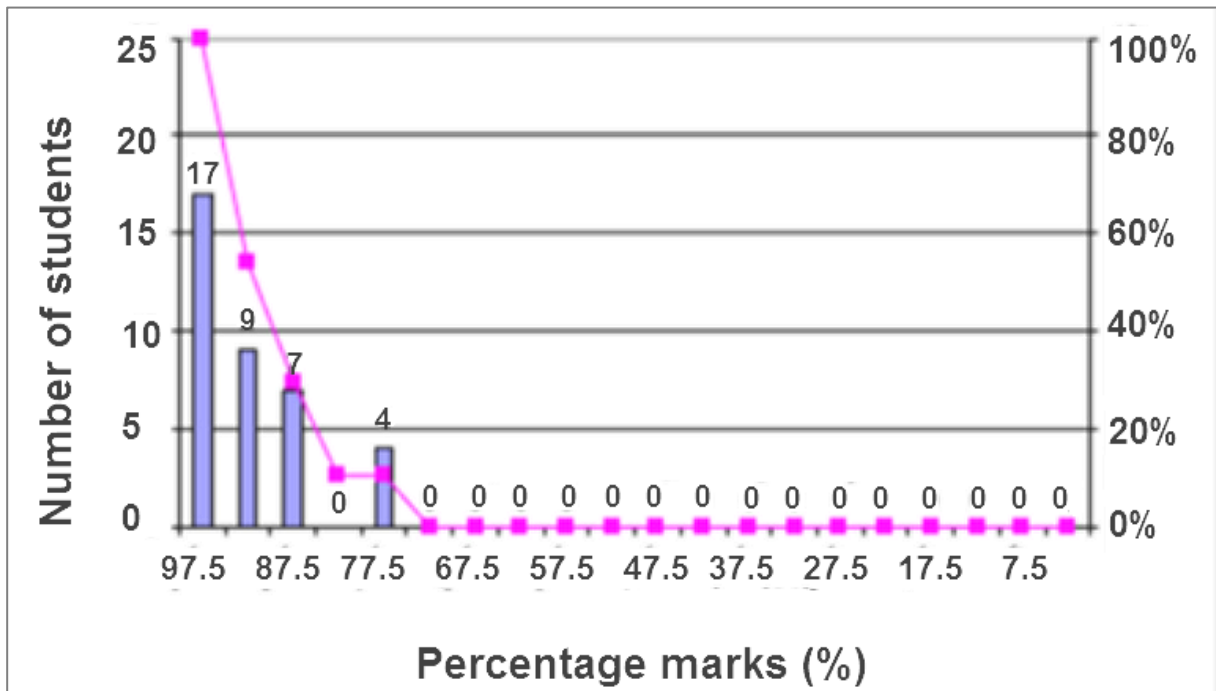


Figure 7. Overall percentage marks for 37 students

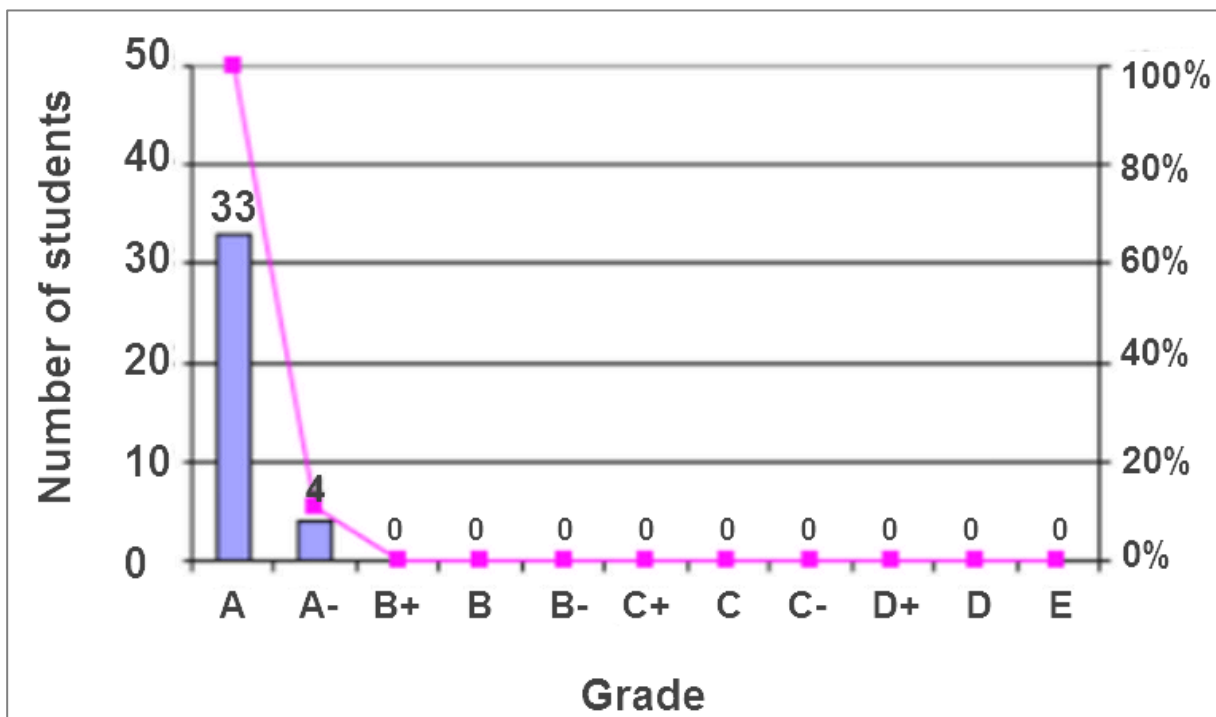


Figure 8. Overall grades for 37 students

PERSON	37 INPUT		37 MEASURED		INFIT		OUTFIT	
	TOTAL	COUNT	MEASURE	REALSE	IMNSQ	ZSTD	OMNSQ	ZSTD
MEAN	28.4	5.0	2.22	.84	.98	.0	.96	.0
S.D.	2.6	.0	1.42	.24	.57	.9	.56	.9
REAL RMSE	.88	TRUE SD	1.12	SEPARATION	1.28	PERSON RELIABILITY		.62

ITEM	5 INPUT		5 MEASURED		INFIT		OUTFIT	
	TOTAL	COUNT	MEASURE	REALSE	IMNSQ	ZSTD	OMNSQ	ZSTD
MEAN	151.0	37.0	.00	.29	1.03	.1	.96	-.2
S.D.	9.7	.0	.78	.05	.27	1.1	.17	.8
REAL RMSE	.30	TRUE SD	.72	SEPARATION	2.43	ITEM RELIABILITY		.85

Figure 9. Statistics Summary for Item and Person

Table 4. Overall data collected from the questionnaire survey

Number of Question	Item Description	Response				
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Question 1	Do VR applications help students understand the Mathematics subject?	0 (0%)	0 (0%)	13 (35.1%)	15 (40.5%)	9 (24.3%)
Question 2	Do you want VR applications to be one of the topics in your school's Mathematic curriculum?	0 (0%)	1 (2.7%)	5 (13.5%)	19 (51.4%)	12 (32.4%)
Question 3	As a student, do you want your parents to help with the use of VR application especially in Mathematics subject?	0 (0%)	3 (8.1%)	8 (21.6%)	18 (48.6%)	8 (21.6%)
Question 4	Do you believe that applications such as VR can stimulate students' interest in current technological developments?	0 (0%)	0 (0%)	4 (10.8%)	8 (21.6%)	25 (67.6%)
Question 5	Are you more motivated to learn Mathematics subject with the use of VR applications?	1 (2.7%)	1 (2.7%)	8 (21.6%)	15 (40.5%)	12 (32.4%)

The overall data collected from the survey are tabulated in Table 4. This workshop has received good responses from most of the students. They prefer to choose “Agree” and “Strongly Agree”. Meanwhile, for Likert scale point “Disagree” and “Strongly Disagree”, none responded to that answer.

Cronbach Alpha is generally used to measure the internal consistency reliability of the items. When Cronbach Alpha values exceed 0.7, it shows that the items have high internal consistency and reliability. As shown in Figure 9, the value of item reliability is 0.85, exceeding the acceptable values (0.7). It shows that the items are adequate to measure the students’ perception toward VR.

Figure 10 below shows the number of students’ vote for each questionnaire scale in Question 1. From Figure 8, it shows that there are no students who strongly disagree and disagree for Question 1. Furthermore, 15 out of 37 (40.5%) students agree and 9 out of 37 (24.3%) students strongly agree that VR applications help them to understand mathematics because VR applications can attract students’ attention to learn more about that subject.

In Question 2, the number of students’ vote for each questionnaire scale are shown in Figure 11. There are 0 students who strongly disagree and only 1 student who

disagree with that question. 19 out of 37 (51.4%) students agree that VR applications are one of the topics in the school’s Mathematic curriculum. From the results, it shows that virtual reality really can improve the student’s knowledge and they enjoy learning the subject.

In addition, Figure 12 shows the number of students’ vote for each questionnaire scale in Question 3. According to Figure 12, the result shows that 8 out of 37 (21.6%) students vote for neutral and strongly Likert scale point. Nevertheless, half of the students which is 18 out of 37 (48.6%) students agree that they want their parents to take part in the VR learning process. From this survey, it shows that the students need their parents’ involvement throughout the learning process. Therefore, it is important for parents to spend their time together with the students throughout the learning process.

Moreover, the number of students’ vote for each questionnaire scale in Question 4 is shown in Figure 13. Overall, 67.6% , namely 25 out of 37 students strongly agree and 8 out of 37 (21.6%) students agree that additional learning tools such as virtual reality can help stimulate students’ interest in learning the subject. These VR technologies allow students to see and interact with the virtual environments and objects. In this new era, students

prefer to explore new technology (VR) and if they combine it with the subject that they learn, it has an impact; for example, it prolongs the students' focus in learning process. They can see real things through the glasses and easily relate with the subject.

Lastly, Figure 14 shows the number of students' vote for each questionnaire scale in Question 5. Percentage of the students that agree and strongly agree are higher than the students that disagree and strongly disagree which is 73%.

15 students agree and 12 students strongly agree that they are more motivated and enjoy learning Mathematics subject with the use of VR applications. It shows that VR have benefited the students in learning Mathematics. In addition, students can discuss with their friends how to use VR applications in the subject as well as improve their social skills and not only doing tutorial in the class. They can use their critical thinking and explore new things to solve the problems in the subject.

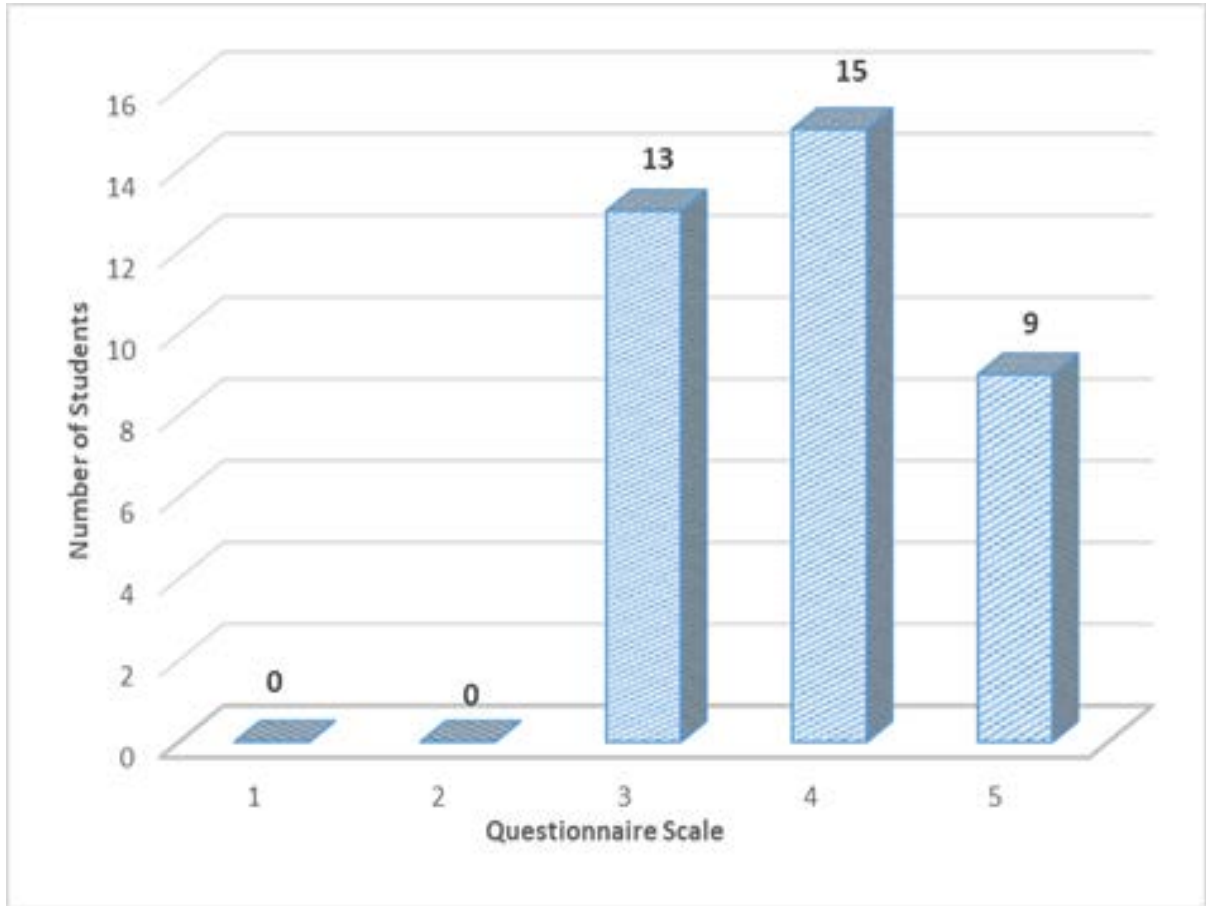


Figure 10. Number of students' vote for each questionnaire scale in Question 1

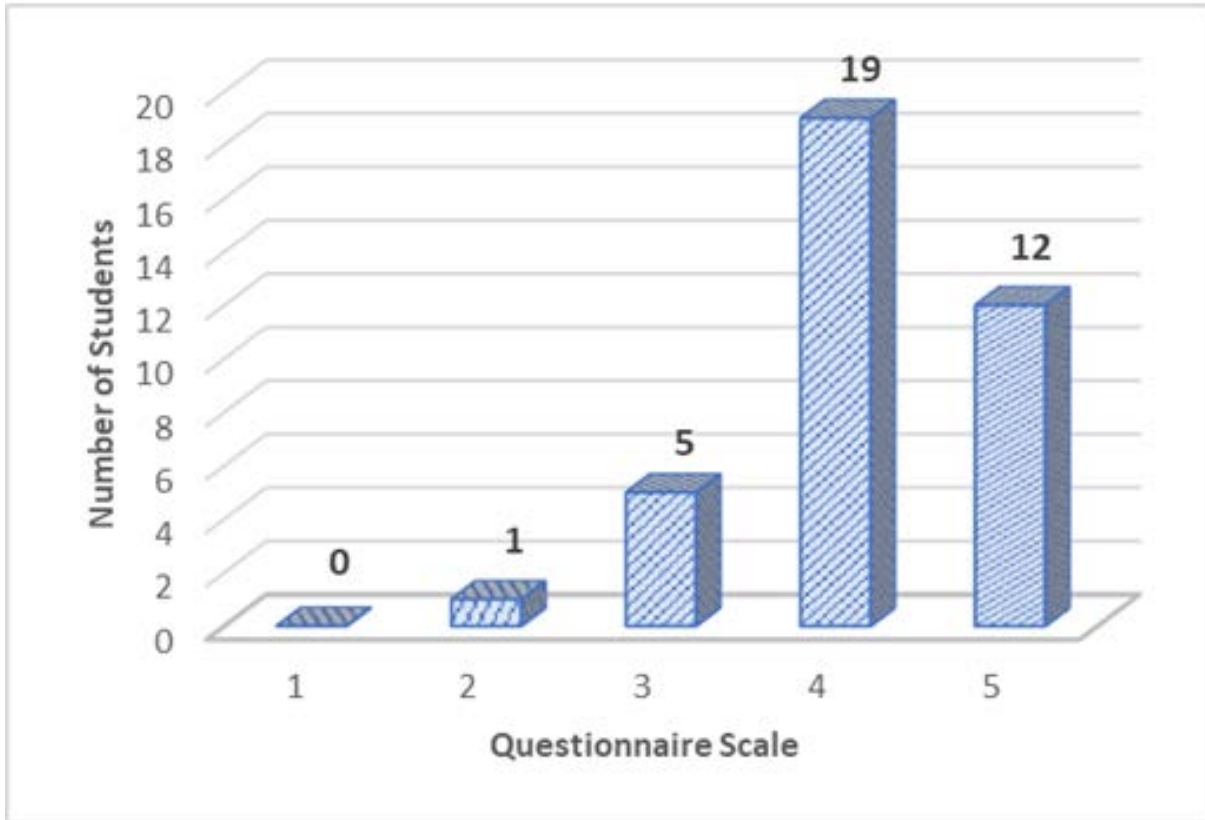


Figure 11. Number of students' vote for each questionnaire scale in Question 2

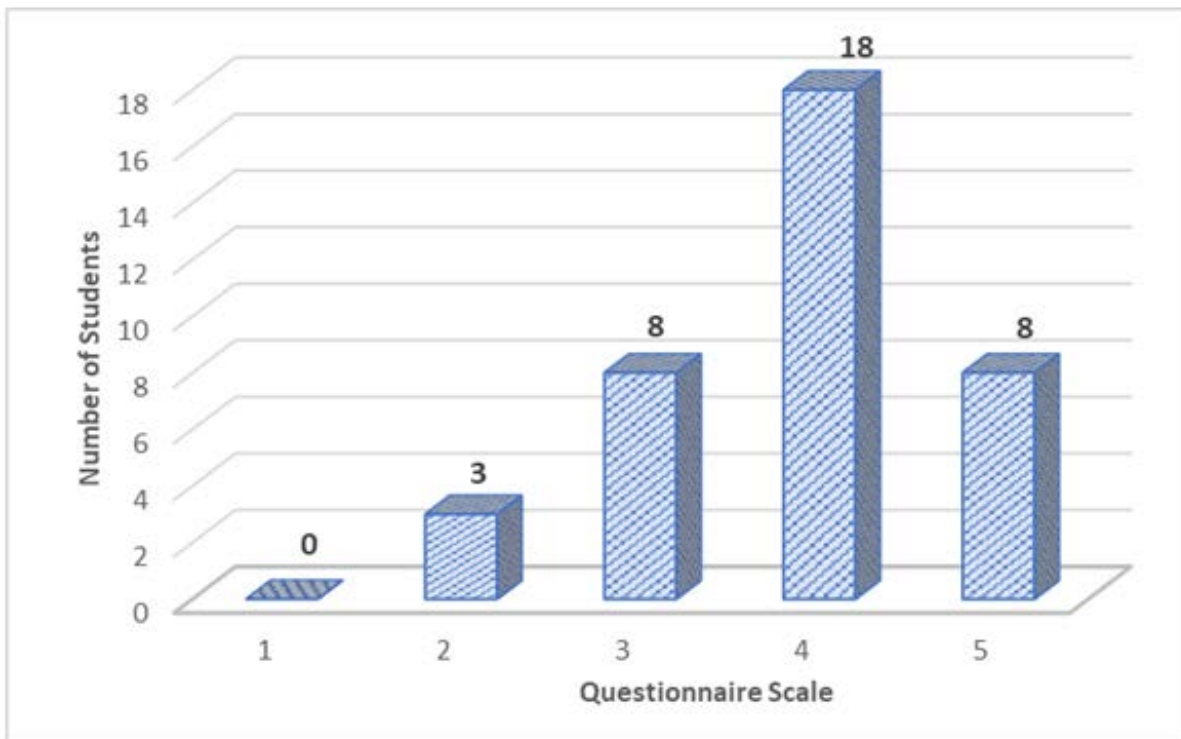


Figure 12. Number of students' vote for each questionnaire scale in Question 3

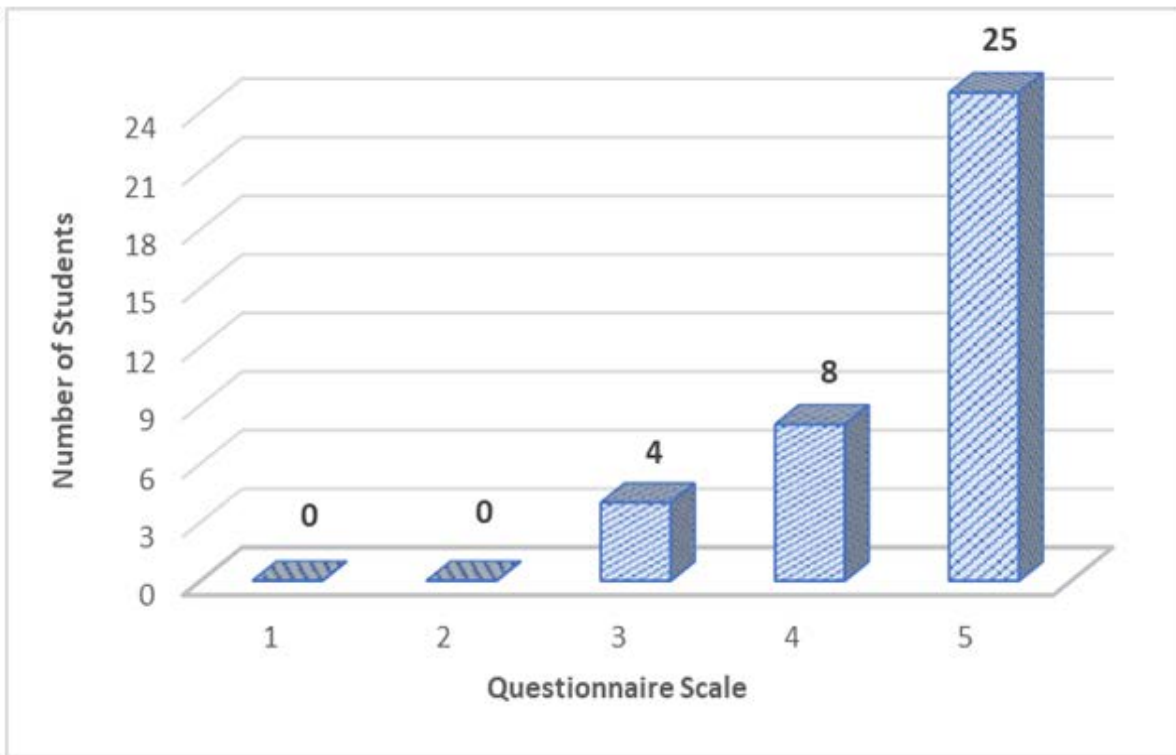


Figure 13. Number of students' vote for each questionnaire scale in Question 4

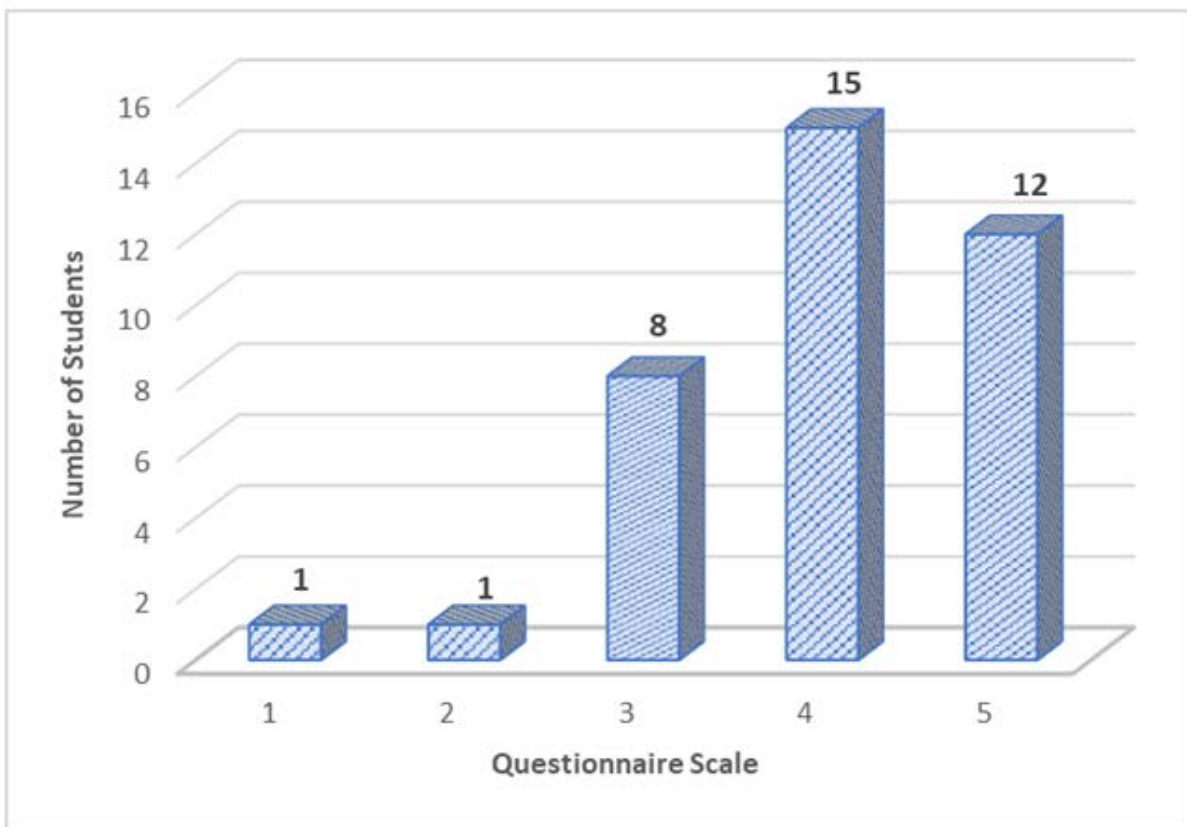


Figure 14. Number of students' vote for each questionnaire scale in Question 5

4. Conclusions

VR Mathematics Workshop is one of the initiatives taken by FKAB, UKM as a learning support activity to improve the students' understanding and interests in Mathematics using virtual reality. Analysis done in this paper shows that the use of VR has benefited the students in terms of understanding the subject. Majority of the students got good results in the task given.

This paper reveals that throughout the workshop, most of the students agree that the usage of virtual reality has increased the students' interest in learning Mathematics. Students are more motivated to learn Mathematics and enjoy learning it with the involvement of their parents and teachers. The result of this study is in line with the results of the previous studies on students' interests and understanding in Mathematics. It is revealed that students' understanding and interests in learning mathematics were increasing [37, 38]. Therefore, the applications can increase the student's interests in learning Mathematics subject and they can discuss with their friends on how to use VR applications in the subject as well as improving their social skills in the class. They can use their critical thinking and explore new things to solve the problems in the subject when using VR applications.

To help more students to get good grades in the subject, the author believes that the implementation of VR application has a positive impact on the students with the help of their teachers and parents. Nevertheless, parents need to control the usage of the gadgets so that the students only use the gadgets in the classroom. They need to have time balance when using the gadgets and also do some outdoor activities to reduce the stress in the classroom. Overall, VR Mathematics workshop is considered as one of the Mathematics learning supports for students. With the help of facilitators and carefully constructed tasks and exercises, this workshop can improve the students' Mathematics performance. Students are more appreciative and willing to conduct more exercises during Mathematics workshop with the use of VR compared to the traditional learning activities. Objectively, this Mathematics workshop will create a better appreciation and awareness among students towards Mathematics education. However, this study was limited to the respected respondents and questions; therefore, a broader sample and questions are recommended for achieving better results.

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