Augmented Reality Assisted Flipped Classroom Model Against Students' Mathematical Problem-Solving Ability

Raras Cahyaningrum[1], Windia Hadi[2*]

[1,2]Pendidikan Matematika, Universitas Muhammadiyah Prof Dr. Hamka, Indonesia
*windia.hadi@uhamka.ac.id

Abstrak

Penggunaan media *Augmented Reality* masih jarang digunakan di sekolah dikarenakan pendidik kurang berinovasi dalam pembelajaran di dalam kelas. *Augmented Reality* adalah teknologi yang memadukan objek nyata tiga dimensi secara langsung sehingga dapat memengaruhi kemampuan pemecahan masalah matematis. Tujuan dari penelitian ini adalah untuk mengetahui pengaruh model *Flipped Classroom* berbantuan *Augmented Reality* terhadap kemampuan pemecahan masalah matematis peserta didik. Penelitian ini merupakan penelitian kuasi eksperimen dengan desain *posttest-only control group*. Populasi penelitian ini terdiri dari seluruh peserta didik kelas VIII. Pengambilan sampel dengan menggunakan teknik *Cluster Random Sampling*. Sampel terdiri dari kelas eksperimen dan kontrol masing-masing 35 peserta didik. Tes uraian yang diberikan pada akhir penelitian digunakan sebagai metode pengumpulan data. Menurut hasil *posttest*, rata-rata skor pemecahan masalah menggunakan model *Flipped Classroom* dengan *Augmented Reality* adalah 69,03, sedangkan skor rata-rata menggunakan model *Flipped Classroom* tanpa *Augmented Reality* adalah 58,97. Hal ini memperlihatkan peserta didik yang menggunakan model *Flipped Classroom* dengan *Augmented Reality* memiliki kemampuan pemecahan masalah matematis yang lebih baik dibandingkan dengan model *Flipped Classroom* tanpa *Augmented Reality*. Dengan demikian, ada pengaruh penggunaan media *Augmented Reality* terhadap kemampuan pemecahan masalah matematis.

Kata kunci: *Augmented Reality*, *Flipped Classroom*, Pemecahan Masalah Matematis

Abstract

The use of Augmented Reality media is still rarely used in schools due to the lack of teachers' innovation in classroom learning. Augmented Reality is a technology that combines three-dimensional real objects directly so that they can influence mathematical problem-solving abilities. The objective of this study is to determine the effect of the Augmented Reality-assisted Flipped Classroom model on students' mathematical problem-solving abilities. This research is a quasi-experimental study with a posttest-only control group design. The population of this study consists of all students of class VIII. Samples are taken using the Cluster Random Sampling technique. The samples consist of experimental and control classes, each of which consists of 35 students. The description test given at the end of the study is used as a data collection method. According to the posttest results, the average problem-solving score using the Flipped Classroom model with Augmented Reality is 69.03, while the average score using the Flipped Classroom model without Augmented Reality is 58.97. This shows that students who use the Flipped Classroom model with Augmented Reality have better mathematical problem-solving abilities compared to the Flipped Classroom model without Augmented Reality. Therefore, there is an effect of using Augmented Reality media on mathematical problem-solving abilities.

Keywords: Augmented Reality, Flipped Classroom, Mathematical Problem Solving

INTRODUCTION

Problem-solving is a skill that must be instilled in students to prepare a superior generation that is ready to face the challenges of the 21st century. Problem-solving is a very influential part of the mathematics curriculum because it allows students to apply the skills and knowledge needed to solve non-routine problems to gain proficiency while learning (Aryaningsih et al., 2016). Problem-solving ability is the ability to answer questions that are difficult to solve or cannot be answered using existing knowledge (Septian & Ramadhanty, 2020). Problem-solving ability is an important concept that students must understand when learning mathematics (Amalia & Hadi, 2021). The most important goal in learning mathematics is the ability to solve problems (Asriyani et al., 2020).

Based on the results of the study, the ability to solve problems is still low. The study results show that the average test score is 34,60; 49,26; and the average pre-test problem-solving ability score of 35,00 (Arnata et al., 2020; Khofifah et al., 2021; Utami, 2017). Survey (TIMSS) 2018 Indonesia obtained an average score of 397 out of an average international score of 500 (Masfufah & Afriansyah, 2021). The factors that cause weak problem-solving abilities in students are students who are not used to solving open-ended questions (Hadi & Faradillah, 2022), teaching is still centered on educators (Harahap & Surya, 2017), and the teacher's lack of interest in class in applying learning methods (Bakar & Panjaitan, 2019). Therefore, problem- solving skills are needed by using appropriate learning models during mathematics lessons.

The Flipped Classroom model can improve problem-solving skills that keep up with technological developments (Utami, 2017). Flipped Classroom is a learning model that involves students effectively in the learning process (Damayanti & Sutama, 2016). Flipped Classroom learning requires educators to access online materials uploaded by educators before class sessions and use class time to participate in and discuss learning activities and problem- solving guided by educators (Bhagat et al., 2016). In addition, the Flipped Classroom model makes learning effective because students can take advantage of available technology to study anywhere and anytime and make students independent during the learning process (Arnata et al., 2020; Nurhadiat & Syakdiyah, 2019).

Good use of technology can streamline learning, such as using Augmented Reality (AR) media in the Flipped Classroom learning model (Herpika & Mawardi, 2021). Augmented Reality is a technology that combines a three-dimensional real environment derived from two- and three-dimensional virtual objects and then estimates these virtual objects in real-time (Mustaqim & Kurniawan, 2017). Augmented Reality media prioritizes reality because

Augmented Reality media is closer to the real environment. The development of Augmented Reality is very fast, causing its development to be used in various fields including education, especially learning mathematics (Sujadi et al., 2015). By using Augmented Reality media and mathematical objects, one can imagine concretely from three-dimensional modeling that matches the original object directly through geometric flat planes on paper (Suharso, 2015). AR media can be combined with the Flipped Classroom model and math skills (Nurwijaya, 2021).

Many studies discuss mathematical problem-solving abilities (Cahyani & Setyawati, 2016; Khofifah et al., 2021; Marita et al., 2022; Rohmatulloh & Nindiasari, 2021), the use of the Flipped Classroom model (Anis & Irhadtanto, 2020; Azizah et al., 2022; Handayani et al., 2021; Marita et al., 2022), and Augmented Reality media (Jannah & Oktaviani, 2022; Nurwijaya, 2021; Septiana & Faradillah, 2022) but no research discusses the Flipped Classroom model, Augmented Reality media, and problem-solving abilities. The application of Flipped Classroom can increase the ability to solve problems with technology-based media, one of which is Augmented Reality (Marita et al., 2022; Suharso, 2015). Therefore, in-depth research must be conducted on the effect of using Flipped Classroom assisted by Augmented Reality media on mathematical problem-solving abilities. The researchers aimed to see the effect of teaching mathematics by the Flipped Classroom model assisted by Augmented Reality on students' mathematical problem-solving abilities.

METHODS

The method used in this research is the quasi-experimental method. In quasi-experimental research, the researcher does not randomize the subjects and form a new class, but the subjects in that class. Posttest-only control design as a research design. This study uses an experimental class with the Flipped Classroom model treatment assisted by Augmented Reality media, while the Flipped Classroom model treatment without Augmented Reality media is for the control class. The ability to solve problems is the dependent variable while the use of Augmented Reality media in Flipped Classroom is the independent variable. All class VIII students of SMPN 234 Jakarta for the 2022/2023 school year are the population in this study. Cluster Random Sampling is used as a sampling technique. The Cluster Random Sampling technique is a random sampling technique based on groups or clusters. Class VIII-7 (35 students) is as the experimental class and class VIII-6 (35 students) is as the control class.

His study uses a description test as an instrument. The test instrument consists of five description questions to assess problem-solving abilities. The test instrument has been

validated. Validity and reliability tests are used to validate the instrument. The validation test uses the product moment formula with a significance level of 0.05 and the validation criteria are $r_{count} > r_{table}$ so H_0 can be accepted, so the instrument is valid. The reliability test uses the Alpha Cronbach formula with a significance level of 0,05. The stages of data analysis were divided into three categories (1) describing the data using descriptive statistics, (2) testing the normality and homogeneity of the data, and (3) drawing conclusions based on hypothesis testing. The normality test was carried out to find out whether the research data were normally distributed or not. The normality test uses the Kolmogorov-Smirnov test with a significance level of 0.05. After the data is normal, it is continued with a homogeneity test, to see whether the group variance is uniform or different. The homogeneity test uses the Levene test with a significance level of 0.05. Then test the hypothesis using the Independent Sample T Test using SPSS 26.0 software for Windows. The H_0 hypothesis is accepted if there is an influence of the Augmented Reality-assisted Flipped Classroom model on problem-solving abilities compared to a significance value of 0,05 with a one-tailed value. The purpose of testing the hypothesis is to find out whether there is an effect on problem-solving abilities after applying the Augmented Reality-assisted Flipped Classroom model. After seeing the influence, it is continued with the Cohen's d effect size test.

RESEARCH RESULT

The results of testing the research instrument through the validation test and reliability test show that the research results are obtained from the calculated correlation coefficient for each item. Then to find out if the question is valid or not, the correlation coefficient value is compared to the value of r_{table} with n=35 at a significance level of 0,05 which is 0,344. With the provision that the items are valid if calculated $r_{count} > r_{table}$. Of the 5 essay questions that have been tested, it turns out that all are valid or feasible to use for research. Furthermore, the results of calculating the reliability of problem-solving ability descriptions obtained $r_{11} = 0,838$ and the reliability calculation value of $r_{table} = 0,344$ then $r_{11} > r_{table}$. Therefore, it can be concluded that the description questions on mathematical problem-solving abilities are reliable and appropriate to be used as research instruments.

After going through validation tests on the validity and reliability of the questions, the results were feasible to use in research instruments conducted in different schools at SMPN 234 Jakarta. In the experimental class with problem-solving ability data using the Flipped Classroom model assisted by Augmented Reality and the control class using the Flipped Classroom model without Augmented Reality. The following is a calculation assisted by

SPSS 26.0 for Windows software on data analysis. Table 1 displays the test results in the experimental class and the control class.

Table 1. Posttest Results Experiment and Control Class

Information	Experiment Class	Control Class
Number of students	35	35
Highest Score	80	72
Lowest Score	60	48
Means	69,03	58,97
Median	68	60
Mode	68	56
Standard Deviation	5,51	5,25

Based on Table 1. The average score in Flipped Classroom learning with the help of Augmented Reality is 69,03, while the average score for Flipped Classroom learning without Augmented Reality is 58,97. The results of the average score show that the ability to solve problems is higher in teaching Flipped Classroom with the help of Augmented Reality compared to learning Flipped Classroom without Augmented Reality.

Table 2. Comparison of Students' Mathematical Problem-Solving Ability

No	Indicator	Ideal Score	Experiment		Control	
			Total Score	Mean	Total Score	Mean
1	Understanding the Problem	4	672	19,2	646	18,4
2	Making plans	4	611	17,4	579	16,5
3	Implementing Plans	4	554	15,8	526	15,1
4	Rechecking	4	534	15,2	471	13,4

Table 2 shows the difference in the size of the ability to solve mathematical problems for the experimental and control groups, with the achievement indicators for the experimental group being higher than those for the control class. The largest acquisition of the second class indicator is the indicator of understanding the problem and the lowest indicator is re-examining. The next step is to test the prerequisites for conducting data investigations, namely the normality test and homogeneity test. Kolmogorov Smirnov as a normality test. Table 3. displays the normality test

Table 3. Normality Test Results

	Experiment Class	Control Class
α	0,05	0,05
Kolmogorov Smirnov test value	0,09	0,11
Conclusion	Normal	Normal

Table 3 shows the test results for both classes are higher than the value of α = 0,05, so it can be concluded that the two classes are normally distributed. The next test is the homogeneity test with the Levene test. The test criteria are determined, namely the significance value is greater than the value α = 0,05 both variances are homogeneous. Table 4. displays the homogeneity test findings.

Table 4. Homogeneity Test Results

	Experiment Class	**Control Class**
α	0,05	0,05
Levene's the value	0,87	
Conclusion	Homogeneous	

The homogeneity test obtains a significance value of 0.87 which is greater than the value of α = 0,05. It can be concluded that H_0 is rejected so that both classes have the same (homogeneous) variance. The next test is hypothesis testing using the t-test if the prerequisites for data analysis, namely normality and homogeneity have been met. shows the findings of the hypothesis test

Table 5. Hypothesis test results

	Experiment Class	**Control Class**
One-tailed t-test result	0,00	
Conclusion	H_0 is rejected	

The results of the t-test are shown in Table 5, namely 0.00 less than a significance value of 0,05 meaningH_0 is rejected. Therefore, it can be concluded that the mathematical problem-solving ability of the Flipped Classroom model class with Augmented Reality is better than the mathematical problem-solving ability of the Flipped Classroom model class without Augmented Reality. Thus there is a significant influence on students' problem-solving abilities using the Flipped Classroom model assisted by Augmented Reality.

Table 6. Cohen's d effect size of the experimental class and the control class

	Experiment Class	**Control Class**
Means	69,03	58,97
Standard Deviation	5,51	5,25
Effect Size test results	1,86	
Conclusion	very big effect	

Table 6 shows the Cohen d effect size of the posttest scores of the experimental and control classes. The effect size obtained was 1.86, which was categorized as having a very large influence, meaning that the Flipped Classroom model class with the help of Augmented Reality had a very large influence in solving mathematical problems than the Flipped

Classroom model class without Augmented Reality. As a result, the use of Augmented Reality is a medium that has a very large influence on students' mathematical problem-solving abilities.

DISCUSSION

The results of the research hypothesis test show that the ability to solve mathematical problems of students who apply Flipped Classroom with Augmented Reality assistance is better than teaching Flipped Classroom without Augmented Reality assistance. This is because Augmented Reality media can be visualized concretely, directly on geometric patterns on paper that are similar to real objects using three-dimensional virtual forms. According to findings by (Ahsan, 2020) revealed Augmented Reality is an application that allows users to connect real phenomena that can be observed with graphics, animation, and textual or images that become real. According to (Suharso, 2015) it has been proven that the use of the learning environment using Augmented Reality can facilitate the work of educators in presenting teaching materials, shorten time and create interactive situations in learning.

The use of the Flipped Classroom model is a combination of varied learning, because students are provided with time to work both individually and in groups. As a result, students are actively involved in learning activities in class, influencing their understanding of concepts, and increasing their problem-solving which causes the road to good achievement encouraging students to understand concepts or teaching materials well (Zulkarnain & Budiman, 2019).

Flipped Classroom learning is divided into two pre-class and in-class activities. Student activities during pre-class are watching video discussions, teaching modules, writing sample questions and preparing questions if they are not understood. Student in-class activities, namely discussions related to the material being studied by conducting questions and answers on the material and solving problems individually. This activity requires student independence and the development of one's knowledge so that the material is better understood when studying in class. When students enter class, they already have the provision of material concepts that make understanding ideas smooth. This statement is in line with (Ansori & Herdiman, 2019) that students can learn material concepts through independent learning and apply them to problem-solving abilities.

The experimental class learning process applies Flipped Classroom learning assisted by Augmented Reality media. Augmented Reality is an application that is already available on

the Play Store and its application is using a mobile phone. Augmented Reality media is applied when learning in class. Students apply directly the use of Augmented Reality which is carried out in groups using mobile phones. With Augmented Reality media students can visualize the shape of three-dimensional objects in the real shape of the spatial structure being studied so that they can increase their understanding of students' mathematical problem-solving abilities. With Augmented Reality media students understand more about building flat-sided spaces (Ahsan, 2020).

According to (Anis, 2020) the purpose of using Augmented Reality is to increase understanding and knowledge of the real environment, in which the Augmented Reality structure combines several technologies and adds them from data contextually so that understanding is visible. At the end of learning in class students are given practice questions related to the material that has been studied and worked on individually.

The control class learning process does not use Augmented Reality media. In learning, students only understand from the spatial images they make themselves and they can only imagine them visually. In-class learning uses Student Worksheets to better understand the concepts of the material that has been given. Student Worksheets are done in groups. Students discuss with their group mates to solve the given problem. The results of the discussion were presented in front of the class by group representatives. Educators and students together conclude the learning material that day. At the end of learning in class students are given practice questions related to the material that has been studied and worked on individually.

From the presentation of the research results, the Flipped Classroom model with the help of Augmented Reality can affect problem-solving skills better than Flipped Classroom without Augmented Reality. If seen from the acquisition of the average score of solving mathematical problems taught using the Flipped Classroom model assisted by Augmented Reality is 69,03; while the class without Augmented Reality assistance is 58,97. Likewise, the average results of each indicator, Flipped Classroom learning model assisted by Augmented Reality on the indicators of understanding the problem 19,2; making plans 17,4; implementing plans 15,8; and checking again 15,2. While learning the Flipped Classroom model without Augmented Reality on the indicators of understanding the problem 18,4; making plans 16,5; implementing plans 15,1; and re-examining 13,4. It was explained that the Augmented Reality-assisted Flipped Classroom model had a significant effect on mathematical problem-solving abilities. Research findings also show the suitability of current findings compared to Flipped Classroom without Augmented Reality. Flipped Classroom can significantly influence mathematics learning and is very useful for learning in diverging

disciplines and educational levels (Strelan et al., 2020; Wei et al., 2020). Good use of technology can streamline learning, such as using Augmented Reality (AR) media in the Flipped Classroom learning model (Herpika & Mawardi, 2021).

CONCLUSION

Based on the results of the study, there was an effect of Augmented Reality-assisted Flipped Classroom on the ability to solve mathematical problems in class VIII students of SMPN 234 Jakarta on the material of flat-sided spaces. The Flipped Classroom model with the help of Augmented Reality is better than the teaching of the Flipped Classroom model without the help of Augmented Reality in the ability to solve students' mathematical problems. This is because teaching in the Flipped Classroom with the help of Augmented Reality encourages students to be independent, builds the concept of the material provided and is assisted by Augmented Reality media to visualize three-dimensional objects in real terms so that it makes it easier to understand the material being taught. Students actively collaborate and apply their understanding to solve problems assigned by teachers to increase students' mathematical problem-solving abilities.

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