AKSIOMA: Jurnal Program Studi Pendidikan Matematika
Volume 12, No. 2, 2023, 1896-1902

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v12i2.6826

STUDENT'S REFLECTIVE ABSTRACTION ON THE APPLICATION OF AUGMENTED REALITY-ASSISTED MATHEMATICS LEARNING MEDIA

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Received 21 December 2022; Received in revised form 13 May 2023; Accepted 08 June 2023

Abstrak

Hasil observasi pada salah satu sekolah di SMA Pangkalpinang adalah banyak siswa yang mengalami kesulitan parah dalam pembelajaran matematika. Pembelajaran matematika lebih bermakna dan mudah diingat oleh siswa jika konsep yang belum mereka ketahui dapat mereka temukan sendiri. Oleh sebab itu abstraksi reflektif siswa dirasa sangat penting untuk dikembangkan. Penelitian ini bertujuan untuk meningkatkan abstraksi reflektif siswa dengan menggunakan media pembelajaran matematika berbantuan *augmented reality*. Penelitian dilakukan melibatkan siswa kelas X sebanyak 44 orang yang terbagi pada dua kelas. dua kelas yang dilibatkan terdiri dari satu kelas eksperimen dan satu kelas lagi sebagai kelas kontrol masing-masing berjumlah 22 siswa. Pengumpulan data menggunakan teknik tes yang diberikan saat pretest dan postest. Soal pretest dan postest sudah disesuaikan dengan indikator abtraksi reflektif sehingga dapat dipastikan kredibel dalam pengukuran abstraksi reflektif siswa. Analisis data menggunakan uji prasyarat kolmogorov smirnov dan levene yang sebelumnya dilakukan uji N-Gain terlebih dahulu, lalu dilanjutkan dengan uji hipotesis menggunakan uji U-Mann Whitney. Hasil yang didapatkan adalah, dengan menggunakan media pembelajaran matematika berbantuan *augmented reality* dapat meningkatkan kemampuan abstraksi reflektif siswa.

Kata kunci: abstraksi reflektif *augmented reality*; media pembelajaran matematika

Abstract

The result of observations at one of the high schools in Pangkalpinang shows that many students experienced severe difficulties in learning mathematics. Mathematics learning is more meaningful and easy for students to memorize if they are able to find the unknown concepts on their own. Therefore, students' reflective abstraction is considered very important to develop. This study aims to improve students' reflective abstraction by using augmented reality assisted mathematics learning media. The research was conducted involving 44 grade 10 students who were divided into two classes. The two classes involved consist of one experimental class and one control class; each class consists of 22 students. The data collection used is the test technique given during the pretest and posttest. The pretest and posttest questions have been adapted to indicators of reflective abstraction so that it can be ascertained that the questions are credible in measuring student's reflective abstraction. The data analysis used is the Kolmogorov Smirnov and Levenen prerequisite tests which were previously carried out by the N-Gain test first, then continued with hypothesis testing using the U-Mann Whitney test. The results obtained show that the application of augmented reality mathematics learning media can improve students' reflective abstraction abilities

***Keywords**: augmented reality; mathematics learning media; reflective abstract*

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

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INTRODUCTION

Preliminary observations have been made at a high school in Pangkalpinang to see the process of learning mathematics and interviews with students have been conducted. The process of learning mathematics is dominated by the role of the teacher, there were no students who actively asked questions and submitted opinions when they were asked by the teacher. During interview students explained that they found it difficult to learn mathematics, they were not motivated in learning mathematics, and they did not understand the mathematical concepts they were learning.

Many students experience severe and ongoing difficulties in the process of learning mathematics (Huijsmans, Kleemans, & Kroesbergen, 2022). The results of the latest research on the process of learning mathematics is that the limitations of mathematics teaching methods greatly affect the learning outcomes; students do not understand the concepts can cause students to be reluctant to learn mathematics (Haser, Doğan, & Kurt Erhan, 2022). Mathematics is complex and broad, making it unsuitable for learning by memorizing and using this method can cause students to feel bored and unmotivated in learning mathematics (Francisco, Maher, Wilkinson, Alston, & Krupnik, 2021). Therefore, in learning mathematics, teachers are expected to be able to develop various teaching methods, such as using a learning media in teaching. A learning media makes students amused and more motivated in learning mathematics and it is adaptive to the current era.

An adaptive learning media to the characteristics of students and the times is the one related to technology. Augmented Reality (AR) is a technology that can facilitate students in learning mathematics. Many studies have been conducted between 2015 and 2020 and it is known that AR is more commonly used in developing countries compared to developed countries (Buentello-Montoya, Lomelí-Plascencia, & Medina-Herrera, 2021). The use of information technology must be applied to the mathematics learning process, so that mathematics learning can follow the world trends and students become more motivated and do not feel weary during study (Stojanović et al., 2021).

In addition to teachers being able to use appropriate learning methods through the use of media, students are also expected to master mathematical concepts. Because students' abilities in the form of Ways of Understanding and the learning media applied by the teacher in the form of Ways of Thinking cannot be separated from one another (Harel, 2008). Mathematical concepts are connected to each other, therefore when students do not master the concepts they are currently learning, it will be more difficult for students to continue to the next concept (Wafiqoh & Kusumah, 2019). Mathematical concepts that are not mastered by students in one of the Pangkalpinang High Schools are closely related to their reflective abstraction abilities. Reflective abstraction is a student's ability to build concepts based on the previous concepts (Kara, Simon, & Placa, 2018). According to Piaget, reflective abstraction is part of abstraction (Djasuli, Sa, Parta, & Daniel, 2017). Reflective abstraction makes students effectively divert low operations to higher levels of operations than before (Vacca, 2019), so that this creates concepts building using student's reflective abstraction to be

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

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different from the concepts obtained in the usual way (Simon, 2020). The reflective abstraction is the highest form of thinking and is an important aspect associated with the concepts they just mastered (Allen & Bickhard, 2016; Cetin & Dubinsky, 2017). Reflective abstraction is the ability to reconstruct or build the new concepts based on the previous concepts (Nutchey, Grant, & Cooper, 2016). Another opinion says that reflective abstraction is a cognitive development process that has the goal of building concepts that students have not yet understood (Yilmaz & Argun, 2018). Reflective abstraction is divided into two parts according to Piaget; they are the reorganization or reconstruction of existing concepts to build new concepts and the projection of existing knowledge into higher forms of thinking (Cetin & Dubinsky, 2017). Therefore, students who do not understand mathematical concepts can be confirmed that they have low reflective abstraction.

Based on the problems presented above, and the importance of media in the form of AR and the importance of student's reflective abstraction, a study was conducted entitled "Student's Reflective Abstraction in the Application of Augmented Reality-Assisted Mathematics Learning Media". This study takes a theme related to "character education and competitiveness" in accordance with the focus of educational research listed in the 2017-2045 National Research Master Plan. The purpose of this research is to find out the increase of student's reflective abstraction that is given Augmented Reality-assisted mathematics learning media.

RESEARCH METHODOLOGY

The research was conducted at one of the high schools in Pangkalpinang; it involved 44 students as research subjects. High school students who were used as research subjects were divided into two classes; they are X MIPA 1 and X MIPA 2. Students in X MIPA 1 was studied as a control class, they were given learning by using media in the form of blackboards and conventional learning, while students in X MIPA 2 was studied as an experimental class, they were given augmented reality-assisted mathematics learning media. The data collection used is the test technique given during the pretest and posttest. The pretest and posttest questions have been adapted to indicators of reflective abstraction so that it can be ascertained that the questions are credible in measuring student's reflective abstraction. The data analysis technique used is a quantitative analysis technique involving statistics to answer the research hypothesis. The data generated from the pretest and posttest of students in X MIPA 1 and MIPA 2 are used to calculate the N-Gain value of each student's score. The results of the N-Gain value were then going through normality prerequisite test using the Kolmogorov Smirnof and Levene through the help of SPSS IBM 26. Hypothesis testing was carried out using the Mann Whitney U-Test because the N-gain values of the two classes were not normally distributed. Hypothesis testing also uses the help of IBM SPSS 26.

RESULTS AND DISCUSSION

The pretest was carried out both in the control class and in the experimental class. After the pretest was carried out, a learning was carried out

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

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using AR-assisted mathematics learning media for students in X MIPA 2 (experimental class) while ordinary blackboard was used as a media for the conventional learning model in X MIPA 1 (control class). After the learning has been carried out, posttests were given in order to find out the increase in students' reflective abstraction.

The results obtained for both the pretest and posttest of the two classes can be seen in Table 1 and Table 2.

Tabel 1. *Pretest* and *posttest* results of students in XI MIPA 1

Num.	Initials Name	Pretest Value	Posttest Value	N-Gain value
1	A N	8	15	7,61
2	A A M	10	0	-11,11
3	A A	3	7	4,12
4	A N	10	15	5,56
5	A N S	22	20	-2,56
6	D P S	10	0	-11,11
7	D	3	0	-3,09
8	D N S	3	3	0,00
9	I D	20	15	-6,25
10	L D L	12	13	1,14
11	M A S	20	0	-25,00
12	M B	0	9	9,00
13	M Z	11	11	0,00
14	N F A P	13	0	-14,94
15	N	5	3	-2,11
16	0	13	0	-14,94
17	P A F	15	15	0,00
18	R N K	20	0	-25,00
19	R A	15	0	-17,65
20	R	25	13	-16,00
21	S B	3	3	0,00
22	T A	5	0	-5,26

Tabel 2. *Pretest* and *posttest* results of students in XI MIPA 2

Num.	Initials Name	Pretest Value	Posttest Value	N-Gain value
1	A	0	5	5,00
2	A E	5	0	-5,26
3	A R P	30	15	-21,43
4	A R U	20	0	-25,00
5	Ae	15	30	17,65
6	A B	20	20	0,00
7	A A P	25	0	-33,33
8	B S S	15	17	2,35
9	E	0	5	5,00
10	F T A	0	5	5,00
11	K B A	5	5	0,00
12	K J	0	10	10,00
13	K N S	25	25	0,00
14	L	0	10	10,00
15	M D F	10	10	0,00
16	M S Q	12	20	9,09
17	P Y	0	10	10,00
18	S C B	17	24	8,43
19	S	12	17	5,68
20	S N F	30	34	5,71
21	S O	20	7	-16,25
22	V V	30	32	2,86

Based on Table 1 and Table 2, the results of the pretest and posttest tests of X MIPA 1 and MIPA 2 can be viewed. The N-Gain values obtained from the two classes were continued to normality and homogeneity tests to find out the statistical test used in order to find out the increase of students' reflective abstractions after given learning using AR-assisted mathematics learning media. The normality test uses the Kolmogorov Smirnov test and the homogeneity test uses the Levene test. Both normality tests and homogeneity tests were calculated using SPSS IBM 26. The results of calculations using SPSS IBM 26 on the normality and homogeneity tests are as follow in Tabel 3.

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

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Tabel 3. Normality Test

	Kategori	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Hasil	Kelas_MIPA2	.251	22	.001	.888	22	.017
	Kelas_MIPA1	.507	22	.000	.255	22	.000
a. Lilliefors Significance Correction							

On Table 3 it can be seen that the significance value of the normality test is 0.001 for X MIPA 2 and 0.000 for X MIPA1. The conclusion criterion for the data normality test using SPSS 26 is if sig < 0.05 it is concluded that the distribution of data is not normal, whereas if sig > 0.05 then the distribution of data is normally distributed.

Based on the test data that can be seen on Table 3, it can be concluded that X MIPA 1 data is not normally distributed because the value of sig (0.000) < 0.05 and X MIPA 2 data is also not normally distributed because sig (0.001) < 0. 05. The test is continued with a homogeneity test which can be seen in Table 4.

Tabel 4. Homogenity Test

		Levene Statistic	df1	df2	Sig.
Hasil	Based on Mean	3.539	1	42	.067
	Based on Median	.941	1	42	.338
	Based on Median and with adjusted df	.941	1	21.089	.343
	Based on trimmed mean	.945	1	42	.336

Determining the homogeneity of the Levene test using SPSS IBM 26 can be done by comparing the sig value derived from the test results with a value of 0.05. If the homogeneity test sig > 0.05 then the data comes from a homogeneous population, but if the homogeneity test sig < 0.05 then the data comes from a non-homogeneous population. On Table 10, it shows the sig value of the homogeneity test of 0.067. Because the sig value of the data is > 0.05 or 0.067 > 0.05, it can be concluded that the data comes from a homogeneous population.

N-Gain value data for X MIPA 1 and MIPA 2 are not normally distributed, so the hypothesis testing is continued with non-parametric statistical tests. In this study, the U-Mann Whitney test was used as the non-parametric test. The U-Mann Whitney test was carried out using the SPSS IBM 26 application, the results can be seen in Table 5.

Tabel 5. Result of U-Mann Whitney test

Test Statistics[a]	
	Result
Mann-Whitney U	136.500
Wilcoxon W	389.500
Z	-2.485
Asymp. Sig. (2-tailed)	.013
a. Grouping Variable: Kategori	

The hypotheses in this study are:

Ho : There is no increase in students' reflective abstraction after given learning using augmented reality-assisted mathematics learning media

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

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Ha : There is an increase in students' reflective abstraction after given learning using augmented reality-assisted mathematics learning media

Hypothesis testing can be concluded by comparing the sig value obtained with a value of 0.05. If the U-Mann Whitney sig test value is <0.05 then Ho is rejected and Ha is accepted, but if the U-Mann Whitney sig test is > 0.05 then Ho is accepted and Ha is rejected. On Table 11 it can be seen that the sig value is 0.013. Because the sig value is <0.05 or 0.013 <0.05 then Ho is rejected and Ha is accepted. It can be concluded that there is an increase in students' reflective abstraction after re after given learning using augmented reality-assisted mathematics learning media.

CONCLUSION AND RECOMMENDATIONS

Mathematics learning media uses augmented reality-assisted can increase students' reflective abstractions. This increase was proven by the existence of trials for two classes which resulted in a U-Mann Whitney hypothesis test value using SPSS IBM 26 of 0.013 which could conclude that the alternative hypothesis was accepted from this study.

The learning given was done in only three meetings so that even though it had increased based on the statistical test results, it could be seen that the students' reflective abstraction on the posttest results was still below 50. Therefore it is suggested to the next researcher to apply AR-assisted mathematics learning media by adding the intensity of the meeting (more than 3 meetings) so that the student's reflective abstraction can be above 50

ACKNOWLEDGEMENTS

The author would like to express their gratitude to the University Muhammadiyah Bangka Belitung through the Institute for Research and Community Service (LPPM) for funding this research process to completion. Author also would like to express their gratitude to those who have helped to develop learning media to be used in this study. Finally, author would like to thank the editorial team and reviewer team who have facilitated and assisted in the process of publishing this research.

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ISSN 2089-8703 (Print)
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