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Analysis of Student's Mathematical Communication Skills through Problem Based Learning Models Assisted by Augmented Reality

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Abstract

This study aims to determine whether the increase in mathematical communication skills of students who received the Problem Based Learning Learning Model based on Augmented Reality was higher than the increase in mathematical communication skills of students who did not receive a problem-based learning model. Students' mathematical communication skills measured in this study include students' abilities in terms of modeling, namely:Presenting real objects, pictures, or diagrams into mathematical ideas, Drawing is Expressing mathematical ideas orally or in writing in the form of images or visuals and Reporting, namely Using language, notation and mathematical structures to present and communicate ideas to draw conclusions. This research is a quasi-experimental study with a population of all students of SMP Muhammadiyah 04 Medan Indonesia. Two classes are selected at random from the available classes. The experimental class was treated with a culture-based Problem Based Learning learning model with Augmented Reality assistance, while the control class was not given any treatment. Data analysis was carried out using parametric statistics, namely the t-test. The results showed that the increase in students' mathematical communication skills who were taught through the culture-based Problem Based Learning learning model assisted by Augmented Reality was higher than the increase in the mathematical communication skills of students who were not given the Augmented Reality-assisted culture-based Problem Based Learning learning.

Keywords
Communication skills; problem based learning; culture; augmented reality

I. Introduction

One of the lessons learned at school and has an important role in everyday life is mathematics. Various branches of mathematics ranging from algebra, statistics to calculus have applications in all modern science today. Mathematics with its various roles makes it a very important science, and one of the roles of mathematics is as a thinking tool to lead students to understand the mathematical concepts they are studying. To understand this concept, it is necessary to have mathematical communication skills (Material et al., nd).

The importance of this communication is explained that mathematical communication is a way of conveying and giving ideas about something to other people both verbally and in writing(Fadillah et al., 2019), (Purnamasari & Afriansyah, 2021). Furthermore, other experts

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explain that mathematical ability is the ability to organize thoughts, communicate mathematical ideas or ideas logically and clearly to others.(Ulya et al., 2019).The same thing was also said by other experts explaining that mathematical ability is a way or way for students to convey and conclude the thoughts they have so that they can be understood by others. (Muslimahayati, 2019).

From some of the expert opinions above, it can be concluded that communication skills are one of the most important abilities for students to remember a number of concepts being studied. So that students are able to express again in another form that is easy to understand so that students are able to solve the problems they face.However, the implementation of mathematical communication skills for students is often ignored by an educator so that students' communication skills are very low which ultimately results in learning mathematics itself not being achieved.(Saragih, 2007),(Saragih S; Rahmiyana, 2013), (Surya et al., 2018),(Permatasari et al., 2018), (Ayu Herdini et al., 2019).

The learning is aimed at reconstructing students who are looking for information and finding out knowledge that is able to solve problems, cooperate, and tolerate diversity. If the desire is successful in a satisfying way, it will increase students' self-confidence as well as a high sense of responsibility and civilized humans who can identify themselves with stable, independent personalities and have emotional stability with intellectual knowledge. (Pradana, D. et al. 2020)

The objectives of learning mathematics according to the Ministry of National Education and Mathematics Competency Standards are:

1. Understand mathematical concepts, explain the relationship between concepts and apply concepts or algorithms flexibly, accurately, efficiently, and precisely, in problem solving.
2. Uses reasoning on patterns and traits, performs mathematical manipulations in making generalizations, constructing proofs, or explaining mathematical ideas and statements.
3. Solving problems which include the ability to understand problems, design mathematical models, complete models and interpret the solutions obtained.
4. Communicate ideas with symbols, tables, diagrams, or other media to clarify the situation or problem.
5. Have an attitude of appreciating the usefulness of mathematics in life, namely having curiosity, attention, and interest in learning mathematics, as well as a tenacious and confident attitude in problem solving. (Ministry of National Education, 2006)

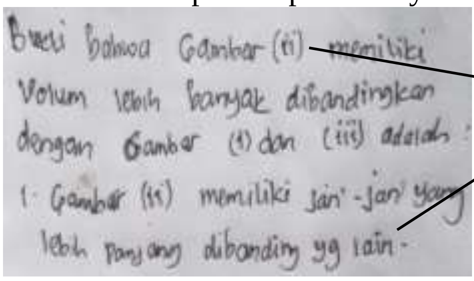
The objectives of learning mathematics above along with these competency standards should really be achievable by a student as the beginning of preparation for obtaining higher education and achieving educational goals at school. At the school level, the emergence of problems in teaching mathematics can be caused by internal students who do not like mathematics or those caused by the mathematics teacher himself.

Several literature studies that the researchers conducted found that students' mathematical communication skills were very low, which was caused by various factors (Saragih & Habeahan, 2014), (Phungsuk et al., 2017). One of them is the inaccuracy and lack of variety in the use of learning models and learning media used by teachers in the classroom (Santika et al., 2020)

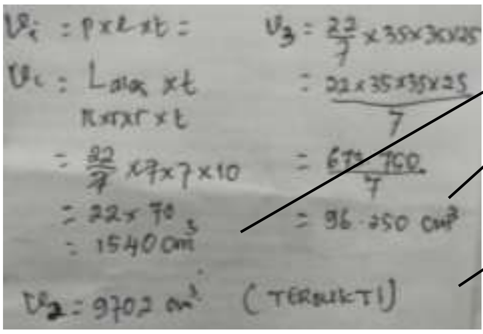
In addition, learning mathematics in class is not meaningful, structured and does not emphasize students' understanding and communication, so that students' understanding of mathematical concepts and communication skills is very weak. (Kaya & Aydin, 2016). Especially if it is related to the cultural context (Kartini Parmono, 2016) this can be seen from the process of student answers to the questions below:

The picture on the side is a picture of Cultural Integration in the Problem of Building Space. If the height of the first, second and third Gordang Sambilan in the picture below is 10 cm, t cm, and 25 cm. While the diameters of the first and second Gordang Sambilan are 14 cm and 21 cm, the radius of Gordang the third is 35 cm and the second Gordang Volume is 9702 cm3. Prove that the third Gordang has more volume than the first and second Gordang!

The completion process by students is shown in the image below:



Students have not been able to write down the components contained in the questions and have not been able to express mathematical ideas in writing, both in the form of symbols and verbally



Students are able to carry out the answer completion process but not in a structured manner. And have not been able to write conclusions using language, notation and structure as part of communication in the process of concluding

From the picture above, it can be seen that the student is still not able to solve the problem of cultural-based mathematical communication skills, this is one of the impacts of conventional methods taught by teachers. The fact shows that so far most teachers use conventional learning models(UNDIKSHA, 2017) and many are dominated by teachers (UNESA, 2016), such as the results of interviews that have been carried out on pre-observation, teachers only transfer knowledge with discussion and lecture methods. The use of learning models is also very rarely done considering students are less active and only one-way communication exists and the lack of use of technology in learning

The application of the Problem Based Learning (PBL) model is one of the solutions to the many problems that arise above. One of the characteristics of this learning model is that it is preceded by student orientation to problems that cause students to be active and begin to respond to the problems presented(Barracks, 2020), (Hamburg & Vladut, 2016).

This PBL model is very good when combined with technology media, especially in the use of technology such as Geogebra 3D Augmented Reality which has not been implemented. (Alkhattabi, 2017), (Ossy et al., 2016),(Ambarwulan & Muliyati, 2016) because this can help develop creativity and improve students' thinking skills through the investigations they carry out so that students' understanding, especially on communication skills in learning mathematics, can increase. In addition, Augmented Reality can present images or animations that are more interesting and memorable, so that learning can be felt by students to be more fun and not boring and accelerate the learning process.(Riyanto & SR, 2015), (Maulana Arifin et al., 2020), (Purwandari et al., 2021).

Based on the above problems as well as some of the solutions previously mentioned, the researcher tried to combine the Problem Based Learning Model with the Geogebra 3D Augmented Reality computer technology media, to improve students' Mathematical Communication Ability. By applying a problem-based learning model that is in accordance with the needs and existing resources, as well as having a view on technological developments and the demands of the globalization era, the application of the PBL model using Geogebra 3D Augmented Reality is expected to be able to improve students' Mathematical Communication Ability(Purwandari et al., 2021), (Ambarwulan & Muliyati, 2016)

II. Review of Literature

2.1. Mathematical Communication

Mathematical communication is a way of sharing and clarifying an understanding through mathematical ideas conveyed in the form of symbols, notations, graphs and terms. (Maisyarah & Surya, 2017). Mathematical communication is also a tool that can be used to solve mathematical problems. According to the Big Indonesian Dictionary, communication is the sending and receiving of messages between two or more people so that the intended message can be understood. However, there are several experts who express their opinions about communication, including: a. Mathematical communication skills are the ability to convey mathematical ideas and the ability to understand and accept other people's mathematical ideas carefully, analytically, critically and evaluatively to sharpen understanding(Syukri et al., 2020). b. Communication is the process of delivering information, ideas, emotions, expertise and others through symbols such as words, pictures, numbers, and others. (Rahmy et al., 2019)c. Communication is the act of carrying out contact between sender and receiver, with the help of messages; The sender and receiver have some shared experiences that give meaning to messages and symbols sent by the sender, and are received and interpreted by the receiver(Nuraida & Amam, 2019).

It was further explained that without communication, humans are difficult to relate to each other (Lagur et al., 2018). The importance of this mathematical communication skill makes it one of the focuses in learning mathematics (Nuraeni & Luritawaty, 2018), (Purnamasari & Afriansyah, 2021). In each lesson, more emphasis is placed on mastery of mathematical concepts and communication so that students have good basic skills to achieve other basic abilities such as reasoning, connection and problem solving. This is in line with the principle of learning, where students must learn mathematics, especially in mathematical communication. (Sritresna, 2017).

Other experts explain that mathematical communication skills are the ability to organize mathematical thoughts, communicate mathematical ideas logically and clearly to others, analyze and evaluate mathematical thoughts and strategies used by others, and use mathematical language to express ideas appropriately.(Hasibuan & Hasibuan, 2020)It was further explained that mathematical communication skills can be interpreted as a student's ability to convey an idea or ideas that he knows mathematically through writing that occurs in the classroom environment. The definition of communication skills from other experts is a way to convey messages from the messenger to the recipient of the message to inform, opinion or behavior either directly orally or indirectly through the media.(Rifa'i, 2015).

Based on the description above, mathematical communication in this study is the ability that a person has to convey the message he has obtained which is measured from the following aspects: 1) Presenting real objects, pictures, or diagrams into mathematical ideas, 2) Expressing mathematical ideas orally or in writing in the form of images, 3) Using language, notation and mathematical structures to present and communicate ideas to draw conclusions.

2.2. Problem Based Learning Model

The term Problem Based Learning (PBM) was adopted from the English term Problem Based Instruction (PBI). This problem-based learning model has been known since the time of John Dewey ((Problem, 2018), (Madio, 2016). The PBM model or Problem Based Instruction (PBI) is also known by other names such as Project Based Teaching (Project Learning), Experience Based Instruction (Learning Based on Experience), Authentic Learning (Authentic Learning), and Anchored Instruction (meaningful learning or rooted in life).(Santika et al., 2020), (Phungsuk et al., 2017).

Problem-Based Learning Model (PBM) is a learning innovation that uses constructivism(UNDIKSHA, 2017), (Puadi, 2017). Likewise with other opinions that the Problem-based Learning Model is a learning model that invites students to actively learn and PBM begins with giving problems which are daily experiences.(UNESA, 2016), (Jumaisyaroh et al., 2015). Furthermore, in another definition, it is explained that problem-based learning strategies are learning strategies by confronting students with practical problems as a foothold in learning or in other words students learn through problems given by an educator.(Yuyu Yuliati, 2016), (Dhiman, 1981). Problem-based learning is student-centered learning where students learn through open-ended problem solving experiences found through studies that have been studied(Barracks, 2020), (Hamburg & Vladut, 2016)

From the opinions of the experts above, the problem-based learning model in this study is a learning approach that uses problems as the starting point of learning by referring to the 5 phases of learning.

2.2. Steps of Problem Based Learning Model

The learning model is a conceptual framework that describes a systematic procedure in organizing learning experiences to achieve certain learning objectives and is a guide for learning designers and educators in planning and implementing teaching and learning activities.(Susilawati et al., 2017). Learning models can use a number of methodological and procedural skills, such as formulating problems, asking questions, discussing and debating meetings(Giriyanti, 2017). The problem-based learning model is a conceptual framework that describes a systematic procedure for organizing learning experiences that refers to the following five syntaxes:

Table 1. Problem Based Learning Model Syntax

Phase	STEP	LEARNING ACTIVITIES
1	Phase 1: Student orientation on problems	Explain the learning objectives and provide problems related to the introduction of cylinder elements and cylinder volume through a power point slide
2.	Phase 2: Organizing students to learn	Form heterogeneous groups and provide LKPD Students in groups fill in the blanks on the LKPD that has been provided
3.	Phase 3: Guiding individual and group investigations	The teacher goes around checking activities and providing assistance to groups that need assistance Students describe the shape of the tube and open the blanket and calculate the volume of the tube
4.	Phase 4: Develop and present the work	Students draw a tube and project it using Geogebra 3D Augmented Reality and calculate its volume
5.	Phase 5: Analyze and evaluate the problem solving process	Checking the results that have been obtained and communicating them

2.3. Augmented Reality

Augmented Reality is a technology that can combine virtual objects in the form of two or three dimensions into a real environment by projecting these virtual objects into the real world.(Alkhattabi, 2017), (Ossy et al., 2016), (Riyanto & SR, 2015). This technology is commonly used in the world of television and cinema. Cinema with 3D design, for example, is able to amplify the emotions of the audience with the presence of the film's stars as if they were real in front of us. In other words, this technology turns the abstract into concrete(Purwandari et al., 2021), (Maulana Arifin et al., 2020), (Ambarwulan & Muliyati, 2016) as shown below:

This technology has also begun to be developed in the world of education (Argo et al., 2016). Especially during the COVID-19 pandemic, this technology has become a technology that is quite developed because the objects taught are as if they are real in plain sight(Liu et al., 2016), (Wafa & Hashim, 2016). This Augmented Reality technology can be downloaded via the Play Store application from the android platform and then developed and integrated according to the desired field. However, in this study, researchers will not download from Playstore but make it themselves by coding process through an algorithm.

2.4. Culture

Culture is the values, traditions or truths that exist in society(Setiawan & Sulistiani, 2019). This value is the basis of human life in social life(Fitrianingsih et al., 2019). Cultural values make the concept and meaning of communication in a society run in harmony and rhythm(Lubis et al., 2018), (Hasibuan & Hasibuan, 2020). Thus the position of cultural values must be maintained in harmony in implementing cultural education and national character(Agustin et al., 2019), (Fadillah et al., 2019).

Many things can be done to preserve a culture. Language, customs, traditional clothing, regional dances, traditional ceremonies, musical instruments, folk songs, traditional games, traditional instruments and so on are all parts of the culture that we must preserve. In the world of education, for example, arts and culture subjects, regional languages, local content, and so on are subjects that we are familiar with as a means to maintain and remind us of the culture of our respective regions.(Misfeldt et al., 2019). Ethnomathematics, for example, specifically studies the relationship between mathematics and cultures in Indonesia, both in traditional clothing, traditional dances, language and so on.(Rifa'i, 2015).

Ethnomathematics is learning mathematics by incorporating cultural elements in it. It was further explained that ethnomathematics is a learning strategy by linking cultural elements into mathematics(Samantha & Almalik, 2019). Meanwhile, according to Nursyahidah, ethnomathematics is a mathematical idea that arises from the daily activities of humans in their environment and understands how mathematics and culture are interrelated with the aim of being able to express the relationship between the two.(Nursyahidah et al., 2018).

From the several definitions of ethnomathematics above, the writer concludes that culture is the habits that exist in a tribe, or society, such as language, customs, traditional clothing, regional dances, traditional ceremonies, musical instruments, folk songs, traditional games, traditional tools or ethnomathematics and other sciences that specifically explain the traditions of a region. While ethnomathematics is a culture that is studied or associated with learning mathematics. In this study, the culture that emerged was the historical icons in the city of Medan as a form of application of the spatial structure that was raised through augmented reality.

III. Research Method

This research is a quasi-experimental research with the aim of improving student learning outcomes in students' mathematical communication skills(Fadillah et al., 2019), (Ayu Kartika Ningsih, Rahayu Kariadinata, 2021)at the same time to find out the pattern of student answers in the culture-based Augmented Reality Assisted Problem Based Learning Model. The design of this research are:

Table 2. Research Design

A1	O1	X	O2
A2	O1		O2

Description:
A 1 : Experiment Class
A 2 : Control Class
X : Treatment in the form of PBL culture-based and Augmented Reality
O1 : Preliminary Test of Communication Skills Mathematics
O2 : *Posttest* Mathematical Communication skills

The population in this study were all students of class IX SMP Muhammadiyah 04 Medan. Then 2 classes were randomly selected from the available classes IX 2 is designated as the experimental class and class IX 3 as the control class. The instrument used to collect data in this study consisted of a test of students' mathematical communication skills consisting of a pretest and post test.

Quantitative data that will be analyzed in this study is the results of the students' pretest and posttest. The data obtained from the scores of students' mathematical communication skills were grouped according to learning groups (PBM assisted by Geogebra 3D Augmented Reality and without learning). Data processing begins with testing the statistical requirements needed as a basis for hypothesis testing, including the normality test of the data and the homogeneity of variance test. Next, a t-test was performed.

IV. Result and Discussion

Before looking at the improvement of students' mathematical communication, the pretest and posttest tables for each sample class will be presented first.

Table 3. Recapitulation of Pretest Results

Class	Maximum Score	X_{max}	X_{min}	$X_{rata-rata}$	SD	Percentage $X_{rata-rata}$
Experiment	25	15	6	11.70	2.23	46,80 %
Control	25	15	5	9, 93	2.57	39.72 %

Note: Percentage is a percentage of compared to its Maximum Score

Table 4. Recapitulation of Posttest Results

Class	Maximum Score	X_{max}	X_{min}	$X_{rata-rata}$	SD	Percentage $X_{rata-rata}$
Experiment	25	25	15	21.33	2, 28	85.32%
Control	25	18	10	19.17	2.93	76.68%

Note: Percentage is a percentage of compared to ScoreMaximum

From the table above, it can be seen that the percentage of the average score between the two classes, both at the pretest and posttest, is not much different. In the experimental class the percentage increase was 38.52%, while in the control class the increase was 36.96%. Furthermore, it will be discussed how much improvement occurred between the experimental class and the classcontrol. The increase in mathematical communication skills between the experimental class (which is taught with a culture-based Augmented Reality-assisted problem-based learning model) and the control class (which does not receive a problem-based learning model) is calculated using the normalized gain formula or N-gain. In the N-gain data processing, the ability to understand concepts also obtained the highest score (χ_{maks}), lowest score ($\chi_{\min}$), average score ($\chi_{rata-rata}$) and standard deviation (SD) for each sample class, can be seen in the following table.

Table 5. Results of N-gain Mathematics Communication Ability in the Two Sample Classes

Class	$X_{\max}$	$X_{\min}$	$X_{rata-rata}$	SD
Experiment	1.00	0.44	0.79	0.14
Control	1.00	0.45	0.66	0.15

In the table above, it can be seen that the highest N-gain value in the two classes is 1. Meanwhile, the average N-gain value for the experimental class is 0.79 and the control class is 0.66. So the average N-gain in the experimental class is slightly higher than the average N-gain in the control class. From this acquisition, the difference in the average N-gain between the two classes is 0.13. The table also shows that the standard deviation values for the experimental and control classes are very thin, namely 0.14 for the experiment and 0.15 for the control class.

Before analyzing the data on mathematical communication skills in the experimental class and classcontrolFirst, the prerequisite test is carried out, namely the normality test and the homogeneity test of the N-gain. The normality test in this study used the Kolmogorov-Smirnov technique while the homogeneity test used the Levene test.

4.1 Normality Test on N-gain Mathematical communication ability

The hypotheses tested to determine the normality of the N-gain data group of mathematical communication skills are:

H0 : f(x) = normal

Ha : f(x) is normal≠

Table 6. N-gain Normality Test Results of Mathematical Communication
(Tests of Normality)

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistics	df	Sig.	Statistics	df	Sig.
EX	.109	30	.200*	.947	30	.138
CONTROL	.159	30	.051	.949	30	.161

a. Lilliefors Significance Correction

*. This is a lower bound of the true significance.

From the results of the Kolmogorov-Smirnov test, it is known that the significance value of the experimental class is 0.200 while the control class is 0.051. Because the significance value of the experimental class is 0.200 > , (0.2000 > 0.05) so that the N-gain data for the experimental class is normally distributed, and for the control class the value of sig > (0.051 > 0.05), it means that the N-gain data for the class controls are also normally distributed. So the N-gain data for the experimental class and the control class come from normally distributed data. Thus the N-gain data on students' overall mathematical communication skills can be concluded to be normally distributed.

4.3 Homogeneity Test on N-gain Mathematical Communication Ability

After going through the normality test stage, the N-gain data must also go through the homogeneity test stage. In this study, the homogeneity test used the F test. The hypotheses tested to determine the homogeneity of the N-gain data group of mathematical communication skills were:

H0 : $\sigma_1^2 = \sigma_2^2$

Ha : $\sigma_1^2 \neq \sigma_2^2$

Description:

- σ_1^2 is the group score variance of Augmented Reality-assisted culture-based problem-based learning model
- σ_2^2 is the variance of the scores of groups that do not get a problem-based learning model (Control)

Table 7. Experimental Class N-gain Homogeneity Test Results and Class Control

Test of Homogeneity of Variances

Mathematical communication

Levene Statistics	df1	df2	Sig.
.056	1	58	.814

Note: the table above uses Levene's test

From Levene's results using the SPSS 16 program, it is known that for homogeneity testing with Levene's test the value of sig > (0.814 > 0.05) and F count so that the null hypothesis is accepted, which means all populations have the same/homogeneous variance. Thus the N-gain data on the ability to understand the concept as a whole can be concluded to have the same or homogeneous variance. Based on the normality and homogeneity tests above, it is concluded that the N-gain data of students' mathematical communication skills are normally distributed and have the same variance.

From the results of the analysis prerequisite test, namely the normality and homogeneity test, it shows that the N-gain data of students' mathematical communication skills are normally distributed and the variance of each data group is the same, so to analyze it using parametric statistical tests, namely using t-test with statistical hypotheses that must be tested for communication skills. mathematics is formulated as follows:

H0 : $\mu_x = \mu_y$

Ha : $\mu_x \neq \mu_y$

Description:

μ_x :Improvement of students' mathematical communication skills taught by learning Augmented Reality-assisted culture-based PBM model

μ_y : Improving students' mathematical communication skills taught without learning Augmented Reality-assisted culture-based PBM model

The following shows the results of the N-gain t-test of the two sample classes using SPSS

Table 8. t-test results of students' mathematical communication skills

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Mathematical communication	Equal variances assumed	.056	.814	3.554	58	.001	.13100	.03686	.05721	.20479
	Equal variances not assumed			3.554	57.708	.001	.13100	.03686	.05720	.20480

Based on the results of the calculations in the table above using the t-test at a significance level of 05, it is obtained that tcount is 3.554 with a significance value of 0.001 while ttable is 2.00. Because tcount (3.554) > t table (2.00) and the significance value (0.001) < , so H0 is rejected. So it can be concluded that the increase in students' mathematical communication skills who are taught through learning culture-based Problem Based Learning assisted by Augmented Reality is higher than the group of students who are not taught Problem Based Learning based on culture assisted by Augmented Reality.$\alpha = 0, \alpha\ (0{,}05)$

V. Conclusion

As for some of the conclusions found in this study, the percentage of the average score between the two classes, both at the pretest and posttest, was not that much different. In the experimental class the percentage increase was 38.52%, while in the control class the increase was 36.96%.Based on normality and homogeneity testing, it can be concluded that the N-gain data on students' mathematical communication skills are normally distributed and have the same variance.

While the results of data analysis conducted on increasing students' mathematical communication skills through culture-based Problem Based Learning assisted by Augmented Reality, it was found that The increase in mathematical communication skills of students who are taught through culture-based problem-based learning assisted by Augmented Reality is higher than the group of students who are not taught Problem Based Learning based on culture-assisted Augmented Reality.

References

Agustin, RD, Ambarawati, M., & Era Dewi Kartika, ED (2019). Ethnomathematics: Culture in Mathematics Learning. Laplace: Journal of Mathematics Education, 2(1), 11–18. https://doi.org/10.31537/laplace.v2i1.190

Alkhattabi, M. (2017). Augmented reality as e-learning tool in primary schools' education: Barriers to teachers' adoption. International Journal of Emerging Technologies in Learning, 12(2), 91–100. https://doi.org/10.3991/ijet. v12i02.6158

Ambarwulan, D., & Muliyati, D. (2016). The Design of Augmented Reality Application as Learning Media Marker-Based for Android Smartphone. Journal of Physics Education Research & Development P-ISSN: 2461-0933 e-ISSN: 2461-1433, 2(1), 73–80.

Argo, TA, Prabonno, S., & Singgi, P. (2016). Youth Participation in Urban Environmental Planning through Augmented Reality Learning: The Case of Bandung City, Indonesia. Procedia - Social and Behavioral Sciences, 227, 808–814. https://doi.org/10.1016/j.sbspro.2016.06.149

Ayu Herdini, R., Suyitno, H., Marwoto, P., Raya, KK, Kulon, T., & Tengah, J. (2019). Mathematical Communication Skills Reviewed from Self-Efficacy by Using Problem Based Learning (PBL) Model Assisted with Manipulative Teaching Aids Article Info. Journal of Primary Education, 8(1), 75–83. https://doi.org/10.15294/JPE.V8I1.25311

Ayu Kartika Ningsih, Rahayu Kariadinata, IN (2021). IMPROVING STUDENT'S MATHEMATIC COMMUNICATION ABILITY WITH ETHNOMATHEMATIC BASED LEARNING. 16(1), 20–35.

Materials, P., Based, A., Mathematical, P., Improving, U., & Communication, K. (nd). The effect of mathematical reasoning-based teaching materials to improve mathematical communication skills 1,2). c, 11–18.

Barak, M. (2020). Problem-, Project- and Design-Based Learning: Their Relationship to Teaching Science, Technology and Engineering in School. Journal of Problem-Based Learning, 7(2), 94–97. https://doi.org/10.24313/jpbl.20200.00227

Dhiman, SC (1981). Tentorium in Leptocorisa varicornis Fabr. (Heteroptera -- Coreidae). Folia Morphologica, 29(4), 336–338.

Fadillah, L., Subroto, T., & Praja, ES (2019). Mathematical Communication Skills and Student Responses in Ethnomathematical-Based Problem Based Learning Models. Journal of Mathematics Education and Science (JES-MAT), 5(1), 71. https://doi.org/10.25134/jes-mat.v5i1.1722

Fitrianingsih, Y., Suhendri, H., & Astriani, MM (2019). Development of Mathematics Comics Learning Media for Culture-Based Class VII Junior High School / MTS Students. Quotation, 5(2), 36–42.

Giriyanti, P. (2017). The Influence of Problem-Based Learning Models on Students' Scientific Literacy Skills on Ecosystem Materials for Class X SMA. Biology Education Thesis, 05(1), 1–8.

Hamburg, I., & Vladut, G. (2016). PBL - Problem Based Learning for Companies and Clusters. Transportation Research Procedia, 18, 419–425. https://doi.org/10.1016/j.trpro.2016.12.055

Hasibuan, SA, & Hasibuan, SS (2020). The Effectiveness of Mandailing Culture-Based Mathematics Teaching Materials in Improving Students' Mathematical Communication Ability. … Scientific Mathematics Education, 7(2), 141–152. https://ejournal.stkipbbm.ac.id/index.php/mtk/article/view/513

Jumaisyaroh, T., Napitupulu, EE, & Hasratuddin, H. (2015). Improving Mathematical Critical Thinking Ability and Learning Independence of Junior High School Students

Through Problem-Based Learning. Kreano, Journal of Creative-Innovative Mathematics, 5(2), 157. https://doi.org/10.15294/kreano.v5i2.3325
Kartini Parmono. (2016). VALUE OF LOCAL WISDOM IN TRADITIONAL BATIK KAWUNG Kartini Parmono. Faculty of Philosophy, Gadjah Mada University, Yogyakarta, 1(1).
Kaya, D., & Aydin, H. (2016). Elementary mathematics teachers' perceptions and lived experiences on mathematical communication. Eurasia Journal of Mathematics, Science and Technology Education, 12(6), 1619–1629. https://doi.org/10.12973/eurasia.2014.1203a
Lagur, DS, Makur, AP, & Ramda, AH (2018). The Influence of Numbered Head Together (NHT) Cooperative Learning Model on Mathematical Communication Ability. Mosharafa: Journal of Mathematics Education, 7(3), 357–368. https://doi.org/10.31980/mosharafa.v7i3.160
Liu, Y., Holden, D., & Zheng, D. (2016). Analyzing students' Language Learning Experience in an Augmented Reality Mobile Game: An Exploration of an Emergent Learning Environment. Procedia - Social and Behavioral Sciences, 228(June), 369–374. https://doi.org/10.1016/j.sbspro.2016.07.055
Lubis, SI, Mujib, A., & Siregar, H. (2018). Ethnomathematics Exploration on Gordang Sambilan Musical Instruments. Edumatics: Journal of Mathematics Education Research, 1(2), 1. https://doi.org/10.32939/ejrpm.v1i2.246
Madio, SS (2016). The Effect of Problem-Based Learning on Mathematical Reasoning and Communication Skills of Junior High School Students in Mathematics. Journal of Mathematics Education, 10(2). https://doi.org/10.22342/jpm.10.2.3637.93-108
Maisyarah, & Surya. (2017). Students' Connecting Mathematics Ability in Connecting Mathematics Ability Students in Solving Mathematical Problems. Journal of Mathematics Education, 2(1), 0–8. https://www.researchgate.net/publication/321803645_Kecepatan_Connection_Mathematics_Connecting_Mathematics_Ability_Students_dalam_Melesaikan_Masalah_Mathematika
Problems, PB (2018). APPLICATION OF A PROBLEM-BASED LEARNING MODEL TO IMPROVE OUTCOMES INTRODUCTION Education is a major factor in the formation of the human person and is important for developing and advancing the life of an education. 2(1), 86–95.
Maulana Arifin, A., Pujiastuti, H., & Sudiana. (2020). Development of STEM learning media with augmented reality to improve students' mathematical spatial abilities. Journal of Mathematics Education Research, 7(1), 59–73. http://journal.uny.ac.id/index.php/jrpmhttps://doi.org/10.21831/jrpm.v7i1.32135
Misfeldt, M., Tamborg, AL, Dreyøe, J., & Allsopp, BB (2019). Tools, rules and teachers: The relationship between curriculum standards and resource systems when teaching mathematics. International Journal of Educational Research, 94(November 2018), 122–133. https://doi.org/10.1016/j.ijer.2018.12.001
Muslimahayati, M. (2019). Students' Mathematical Communication Ability with Ethnomathematical Realistic Learning Approach with Ethnomathematics (PMRE). RAFA Journal of Mathematics Education, 5(1), 22–40. https://doi.org/10.19109/jpmrafa.v5i1.3773
Nuraeni, R., & Luritawaty, IP (2018). Developing Students' Mathematical Communication Ability through Think Talk Write Strategy. Mosharafa: Journal of Mathematics Education, 5(2), 101–112. https://doi.org/10.31980/mosharafa.v5i2.265

Nuraida, I., & Amam, A. (2019). Hypothetical Learning Trajectory in Realistic Mathematics Education To Improve the Mathematical Communication of Junior High School Students. Infinity Journal, 8(2), 247. https://doi.org/10.22460/infinity.v8i2.p247-258

Nursyahidah, F., Saputro, BA, & Rubowo, MR (2018). A Secondary Student's Problem Solving Ability in Learning Based on Realistic Mathematics with Ethnomathematics. JRAMathEdu (Journal of Research and Advances in Mathematics Education), 3(1), 13. https://doi.org/10.23917/jramathedu.v3i1.5607

Ossy, WDE, Zaini, T., & Bahri, B. (2016). Application of Augmented Reality Technology in System Learning Media. Journal of Computer Engineering AMIK BSI, 2(8), 122–131.

Permatasari, D., Sutiarso, S., & Coesamin, M. (2018). Ethnomathematics-Based Transferring in Mathematical Communication Skills. 6, 30–41.

Phungsuk, R., Viriyavejakul, C., & Ratanaolarn, T. (2017). Development of a problem-based learning model via a virtual learning environment. Kasetsart Journal of Social Sciences, 38(3), 297–306. https://doi.org/10.1016/j.kjss.2017.01.001

Pradana, D. et al. (2020). Nasionalism: Character Education Orientation in Learning Development. Budapest International Research and Critics Institute-Journal (BIRCI-Journal). P. 4026-4034.

Puadi, EFW (2017). Analysis of Increasing Mathematical Connection Ability of Ptik Students Through Problem-Based Learning. Journal of Mathematics Education STKIP Garut, 5. http://jurnal.upmk.ac.id/index.php/sumku/article/view/139

Purnamasari, A., & Afriansyah, EA (2021). Mathematical Communication Skills of Junior High School Students on the Topic of Data Presentation at Islamic Boarding Schools. 1, 207–222.

Purwandari, P., Yusro, AC, & Purwito, A. (2021). Augmented Reality-Based Physics Module as an Alternative Student Learning Resource. Scientific Journal of Physics Education, 5(1), 38. https://doi.org/10.20527/jipf.v5i1.2874

Rahmy, SN, Usodo, B., & Slamet, I. (2019). Mathematics communication skill of student in junior high school based on students thinking style. Journal of Physics: Conference Series, 1188(1). https://doi.org/10.1088/1742-6596/1188/1/012107

Rifa'i, R. (2015). The Use of Cooperative Script Model on Students' Mathematical Understanding and Communication Ability. Journal of Educational Studies and Teaching, 1(1), 30.

Riyanto, & SR, S. (2015). Utilization of Augmented Reality in Interactive Learning Media of Planet Revolution Utilization of Augmented Reality in Interactive Learning Media of Planet Revolution. Juita, III(November), 187–192.

Samantha, R., & Almalik, D. (2019). Ethnomathematics in Dengklaq Game as Mathematics Learning Media. AKSIOMA: Journal of Mathematics Education Study Program, 3(2), 58–66. https://doi.org/https://doi.org/10.24127/ajpm.v8i3.2303

Santika, IWD, Parwati, NN, & ... (2020). The Influence of Problem-Based Learning Models in Online Learning Settings on Mathematics Learning Achievement and Problem Solving Ability…. … Learning …, X, 105–117. https://ejournal-pasca.undiksha.ac.id/index.php/jurnal_tp/article/view/3397

Saragih S; Rahmiyana. (2013). IMPROVING MATHEMATIC COMMUNICATION ABILITY OF SMA/MA STUDENTS IN SIMPANG ULIM DISTRICT THROUGH STAD TYPE COOPERATIVE LEARNING MODEL. Journal of Education and Culture, 19(June 2013), 174–188.

Saragih, S. (2007). DEVELOPING LOGICAL THINKING ABILITY AND MATHEMATIC COMMUNICATION OF FIRST HIGH SCHOOL STUDENTS THROUGH REALISTIC MATHEMATICS APPROACH. Indonesian education university.

Saragih, S., & Habeahan, WL (2014). The Improving of Problem Solving Ability and Students' Creativity Mathematical by Using Problem Based Learning in SMP Negeri 2 Siantar. 5(35).

Setiawan, A., & Sulistiani, IR (2019). Value, Culture and Character Education in Basic Mathematics Learning at Elementary/Middle Schools. Elementary: Scientific Journal of Islamic Basic Education, 1(1), 41. https://doi.org/10.33474/elementeris.v1i1.2767

Sritresna, T. (2017). Utilization of Microbial K Onsortium To Improving Active Mud S System Performance. Journal "Mosharafa," 6(3), 17–22.

Surya, E., Syahpurta, E., & Juniati, N. (2018). Effect of problem based learning toward mathematical communication ability and self-regulated learning. Journal of Education and Practice, 9(6), 14–23. https://ojs.unimal.ac.id/index.php/mjml/article/view/741/0

Susilawati, S., Jamaluddin, J., & Bachtiar, I. (2017). The Effect of Problem-Based Learning Model (Pbm) with Multimedia Assistance on Critical Thinking Ability of Class VII Students of SMP Negeri 2 Mataram in terms of academic ability. Mipa Incandescent Journal, 12(2), 64–70. https://doi.org/10.29303/jpm.v12i2.343

Syukri, A., Marzal, J., & Muhaimin, M. (2020). Constructivism-Based Mathematics Learning Multimedia to Improve Students' Mathematical Communication Skills. Indonesian Journal of Science and Mathematics Education, 3(2), 117–132. https://doi.org/10.24042/ijsme.v3i2.6201

Ulya, H., Rahayu, R., Kartono, K., & Isnarto, I. (2019). Students' Mathematical Ability in Application of Collaborative Assessment. Reflections on Education: Scientific Journal of Education, 10(1), 113–120. https://doi.org/10.24176/re.v10i1.4125

UNDIKSHA. (2017). NATIONAL CONFERENCE. In M. . Dr. Luh Putu Artini, MS Dr. LP. Ballet, MP Dr. Made Kerta Adhi, MP Ni Ketut Ariwati, S.Pd, MP Drs. I Made Sidhiyasa, MH Dr. I Wayan Suardiana, & M. . Dr. Ni Made Dhanawati (Eds.), NATIONAL CONFERENCE OF TEACHERS AND EDUCATION INNOVATION (KONASGI) (November Issue).

UNESA, L. (2016). National Seminar. In IW Susila, Suroto, & Tukiran (Eds.), Innovation and Downstreaming of Research Results for Community Welfare (Vol. 9, Issue November, p. 10). LPPM UNESA Surabaya. https://www.infodesign.org.br/infodesign/article/view/355%0Ahttp://www.abergo.org.br/revista/index.php/ae/article/view/731%0Ahttp://www.abergo.org.br/revista/index.php/ae/article/view/269%0Ahttp://www.abergo.org.br/revista/index.php/ae/article/view/106

Wafa, SN, & Hashim, E. (2016). Adoption of Mobile Augmented Reality Advertisements by Brands in Malaysia. Procedia - Social and Behavioral Sciences, 219, 762–768. https://doi.org/10.1016/j.sbspro.2016.05.077

Yuyu Yuliati. (2016). Improving Science Process Skills of Elementary School Students Through Problem-Based Learning Models. Journal of Pendas Cakrawala, 2(2), 71–83.