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Problem-Solving Skills Viewed from Students' Learning Style in Problem-Based Learning Assisted by Assemblr Based Javanese Culture Augmented Reality

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Abstract

Problem-solving skills are one of the core skills in mathematics learning; this skill helps the student be an effective problem solver. Conditions in the field show that the problem-solving skills of Indonesian students are currently low. This study aims to know the improvement of problem-solving skills and the description of that skill in terms of learning styles in problem-based learning assisted by Assemblr based on Javanese culture augmented reality. The research method used was a mixed method with a sequential explanatory strategy. Data collection techniques included tests, questionnaires, and interviews. Quantitative data were analyzed through statistical tests and groupings of student learning styles. Qualitative data analysis was carried out through data collection, reduction, presentation, conclusions, and triangulation techniques. This study used a one-group pretest-posttest design with a random sampling technique, and research subjects was selected by purposive sampling based on learning styles. Results show that there are no students with an auditory learning style. Students' problem-solving skills increased with the n-gain score, which is 0.5 in the moderate category. In terms of learning styles based on Polya's stages, show that students' problem-solving skills with visual, kinesthetic, and visual-kinesthetic styles are quite good. Students can understand problems, formulate problem-solving plans, and carry out formulations, but students with visual and kinesthetic learning styles are still not careful in calculations and re-checking answers, while students with visual-kinesthetic learning styles do not re-check their answers. Further research is expected to examine all learning styles, including auditory learning styles.

Keywords: Augmented reality, Javanese culture, problem-based learning, problem-solving skills

INTRODUCTION

Mathematics is one of the materials studied by students ranging from primary, secondary to higher education. Mathematics is important to learn because mathematics is one of the keys to the development of science and technology as a means of logical, critical, and systematic thinking in solving various existing problems. Mathematics is inseparable from problem-solving (Ulya, Kartono, & Retroningsih, 2014). Problem-solving is an important part of learning mathematics because, in the process of solving problems, students use their knowledge and skills to solve a problem (Misu, 2014). Therefore, since mathematics is not only studied conceptually but is also used in solving problems in students' daily lives (OECD, 2012), one of the objectives of learning mathematics is to shape students into effective problem solvers (Torio, 2015).

Problem-solving skills in mathematics learning are an approach that aims to find methods to solve a problem by starting by observing problems, compiling hypotheses, and reviewing the results obtained so that they can conclude solutions (Nurojab & Sari, 2019). The problem-solving process can be done through four steps or phases: understanding the problem, formulating a problem-solving plan, carrying out the formulations, and re-checking the results of problem-solving (Polya, 1973). Problem-solving in mathematics learning is not only limited to conceptual problems but also problems in the context of daily life, so it is

hoped that students can solve existing problems using mathematical concepts learned at school. Conditions in the field show that the problem-solving skills of Indonesian students are currently low. Based on the results of a survey on the Programme of International Student Assessment (PISA), which examines the mathematical ability of students aged 15 years, it shows that the average score of Indonesian students is only 379, far from the average of 489, thus placing Indonesia in the last 10 rankings (OECD, 2019). In the PISA test, mathematics problems are inseparable from problem-solving, so from these results, it can be said that the problem-solving skills of Indonesian students are still low. In addition, based on initial observation, students in grade VIII of SMP N 22 Semarang still have difficulty with the problem-solving process, which makes them have low problem-solving skills, so this skill is important to develop.

Low problem-solving skills are also shown by several previous studies, which state that students are not used to using and developing their problem-solving skills (Agustina, Musdi, & Fauzan, 2014). Furthermore, Windari, Dwina, and Suherman (2014) mentioned that in the problem-solving process, students can only reach the formulating problem-solving steps. Many factors affect the ability to solve problems, one of which is the student's learning style. A difference in learning style results in differences in students' ability to solve a problem (Ricardo, Mardyana, & Retno, 2014). Learning style is a view that reveals how a person processes data, starting from the process of collecting data to analyzing data (Argaini, 2018). Learning styles are also defined as a way of looking at carrying out thinking, processing, and understanding activities on information that is felt to be most liked, comfortable with oneself, and different from other individuals (Filayati, Novianti, and Suriyah 2019), so knowing students' learning styles will make it easier for teachers to shape students into effective problem solvers.

The learning process also needs to be considered when developing problem-solving skills. In the learning process, the learning model plays an important role in determining the success of the learning process. The Problem-Based Learning (PBL) model is a model that is currently used as the main learning model in mathematics learning (Zakaria, Maat, and Khalid, 2019). This model presents a problem as a source of student learning activities. English & Kitsantas (2013) state that PBL is expected to help students solve problems by using various learning resources. In this model, the teacher acts as a facilitator by providing guidance and relevant problems for students to solve. The learning steps with the PBL model consist of (1) problem orientation, (2) organizing learning, (3) guiding individual and group investigations, (4) developing and presenting results, and (5) analyzing and evaluating the problem-solving process. The PBL learning model is in accordance with geometric material that is applicable and related to daily life, one of which is the culture around students. Javanese culture is an example of the culture around students. In learning mathematics in a geometry material based culture, students' problem-solving skills are in a good category, characterized by having a good understanding of the problem, formulating the problem-solving plan, implementing the problem-solving plan, and providing accurate solutions according to the context of the problem (Samo, 2017). The research shows that culture has a positive impact on the ability to solve mathematical problems, especially geometry material, which is considered difficult by most students.

Learning media also affects the quality of the learning process; learning media is defined as something that makes it easier for teachers to deliver material to students (Adam & Syastra, 2015). The existence of learning media can help students' understanding of the learning material and the process of solving problems. Augmented reality-based Assemblr is an innovation in the field of technology that

is utilized in the world of education. Augmented reality (AR) is a technology that projects 2D and 3D objects in a real environment. AR helps in the representation and manipulation of 3D objects and is widely used in the learning of space geometry (Liao, Wu, & Yu, 2015). Research also suggests collaborative assignments in AR can help improve visualization, critical thinking, problem-solving, and communication skills (Ibili et al, 2019). From the description above, learning mathematics with an Assemblr-assisted PBL model based on Javanese culture augmented reality is a good innovation to develop students' problem-solving skills. Therefore, researchers conducted research that aimed to determine students' problem-solving skills in problem-based learning assisted by Assemblr based Javanese culture augmented reality and descriptions of problem-solving skills in terms of student learning styles.

METHOD

This research uses a mixed method, namely a research approach that combines qualitative and quantitative methods (Creswell, 2014) with a sequential explanatory strategy, such that collecting and analyzing quantitative data is followed by qualitative data. The sequential explanation is used to determine the improvement of students' problem-solving skills before and after learning treatment (quantitative) and then describe the improvement of them through qualitative analysis. The research stage consists of determining the population and samples, collecting quantitative data in the form of student learning style questionnaires, and then giving learning treatment. Collecting quantitative data in the form of problem-solving skills, quantifying data analysis, qualitative data collection through interviews, qualitative data analysis, and drawing conclusions from the results of quantitative and qualitative analysis are shown in the following Figure 1.

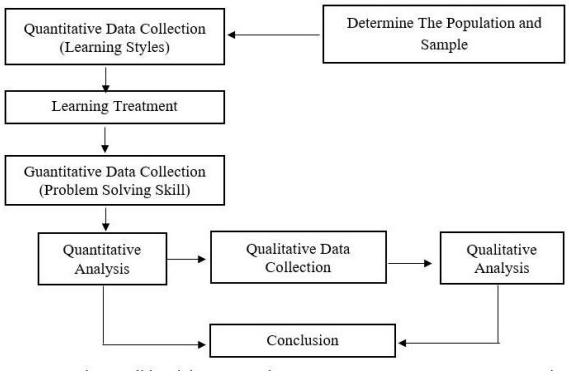

Figure 1. Research Stages

The design of this study uses *the one-group pretest-posttest design*, which only uses one research class by providing a pretest before giving a learning treatment and ending with a posttest at the end of the learning treatment. The research was conducted at SMP Negeri 22 Semarang for the 2022/2023 school year. The population in this study was composed of class VIII students with a research sample of class VIII D.

Data collection techniques are carried out through problem-solving ability tests, learning style questionnaires, and interviews. Before the study, a test instrument was carried out in the form of eight description questions and then analyzed for validity, reliability, differentiating power, and difficulty level. The validity test shows that all question items are valid, and the reliability test using the Cronbach alpha formula obtained a Cronbach alpha value of 0.851, which means that all question items are very reliable. The differentiating power test obtained 12.5% of the low-category questions, 50% of the medium-category questions, and 37.5% in the high category, while the difficulty level showed that 50% of the question items were in the medium category and 50% were easy.

Quantitative data are analyzed through statistical tests to determine whether there are differences in students' problem-solving abilities before and after learning using comparative tests. To find out the magnitude of the increase in pretest and posttest values, the statistics used are normalized gain tests, and then the degree of increase is analyzed

based on the categories proposed by Meltzer (2002). For qualitative research, research samples, hereinafter referred to as research subjects, are selected with purposive sampling techniques based on learning-style questionnaires. According to DePorter and Hernacki (2013), learning styles are divided into three categories: visual, auditory, and kinesthetic. Then students are grouped based on their learning style by considering the possibility of students having more than one learning style, and then 3 students are selected from each learning style to analyze their problem-solving skills based on a problem-solving skill indicator consisting of (1) understanding the problem, (2) formulating a problem-solving plan, (3) carrying out the formulations, and (4) re-checking the problem-solving results. Qualitative data analysis is carried out through four stages: data collection, data reduction, data presentation, and conclusion (Rijali, 2018). Besides that, triangulation techniques are also carried out by combining and comparing test results with interviews.

RESULTS AND DISCUSSION

Students will solve problems in Polya's stages that are available in the textbook. The problems presented are mathematical problems with Javanese culture nuances that are suitable for problem-solving indicators-based NCTM, such as building new mathematical knowledge through problem-solving, solving problems in various contexts related to mathematics, applying an appropriate strategy to solve problems, and reflecting on the mathematical problem-solving process.

Then, the results of the problem-solving skill test are analyzed to determine the improvement in problem-solving ability before and after learning assisted by Assemblr based Javanese culture augmented reality through the students' textbook (Figure 2), which is carried out in two steps.

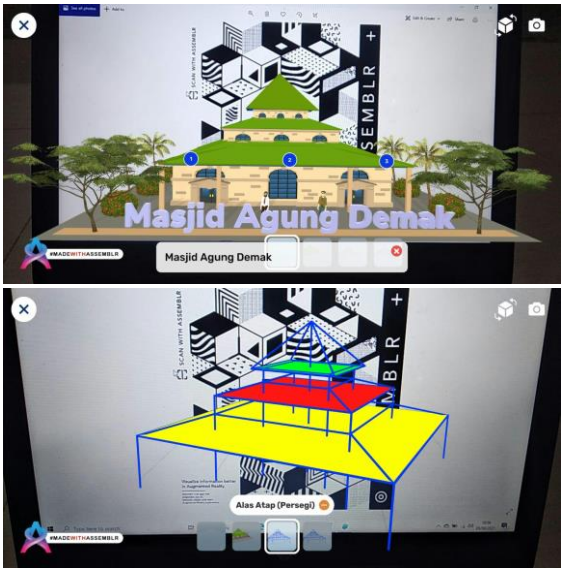

Figure 2. Augmented reality

The first step is carried out through a comparative test to find out whether there is a difference between the pretest value and the posttest. Before the comparative test, we first carried out a prerequisite test. The normality test obtained a sig value less than 0.05, which means that the data is not normally distributed. Therefore, the comparison test was carried out using a non-parametric test using the Wilcoxon signed rank test, as shown in Table 1.

Table 1. Wilcoxon Signed Rank Test

	Value
Z	-4.164
Sig. (2-tailed)	0.000

From Table 1, the result shows that the sig value is 0.000, which means that the sig is less than 0.05, which means that there is a significant difference between the pretest and posttest values. Furthermore, the normalized gain test was carried out to determine the improvement in the value of students' problem-solving skills. The gain test obtained a gain score of 0.5, which means that the increase is in the moderate category.

Students are not used to using mathematical problem-solving skills, which is one of the factors contributing to low problem-solving skills. Therefore, it is necessary to learn how to familiarize students with solving

problems so that they are accustomed to developing problem-solving skills. In learning with the PBL model, student-centered learning activities with problem investigation as the core activity of learning are used (Mustafa et al., 2016; Schettio, 2016). In PBL, students are faced directly with real problems in this study, namely problems related to Javanese culture. Through real-life problems that students can encounter in everyday life, they are faster to recognize and understand the context and mathematical concepts that exist in the problem (Agasi &Wahyuono, 2016). In addition, in this study, the process of understanding students' problems is assisted by augmented reality-based Assemblr. Augmented reality makes it easy for students to see objects from various sides. The uniqueness of AR is an attraction for students in the problem-solving process, in line with Fleck, Hachet, and Bastien (2015), who stated that students are interested in and choose AR for solving problems that require problem-solving skills. More than that, AR also helps students solve problems because it helps students' spatial understanding, which further facilitates the development of students' problem-solving abilities (Guntur et al., 2020), in line with Eh Phon, Ali, and Halim (2014), who stated that AR helps train students' thinking skills, including problem-solving skills. PBL dominates in the development of problem-solving skills, this learning model provides a good learning environment for students to practice problem-solving skills, but PBL alone is not enough. AR and Javanese culture also strongly support the implementation of PBL in developing problem-solving skills.

Furthermore, the analysis of students' problem-solving skills is viewed from the perspective of learning styles. The results of the learning style questionnaire show that there are no students with an auditory learning style and several students who have two learning styles, this is very likely to happen (Ningrat, Tegeh, & Sumatri, 2019).

Analysis of the questionnaire results showed that 24 students had a visual learning style, 4 students had a kinesthetic learning style, and 2 students had a visual-kinesthetic learning style, with the percentage shown in Figure 3.

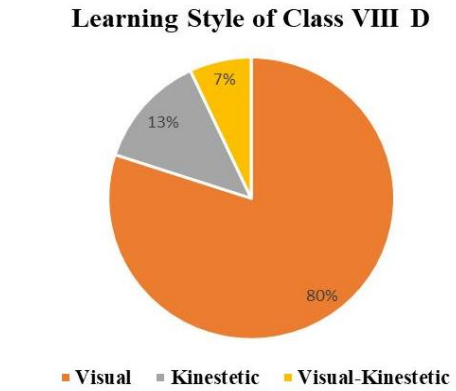

Figure 3. Students' Learning Styles

After that, 3 students with visual and kinesthetic learning styles and 2 students with visual-kinesthetic learning styles were taken for interviews. Then the results are analyzed, and triangulated techniques are carried out with the results of the problem-solving skill test to obtain a description of the student's problem-solving skill as follows.

Students' Problem-Solving Skills with Visual Learning Style

Students with a visual learning style have special characteristics, often referred to as learning style indicators, namely: (1) learning by visual means; (2) understanding well the position of shapes, numbers, and colors; (3) being neat and orderly; (4) not being disturbed by noise; and (5) difficulty receiving verbal instructions. The results of solving students' problems with visual learning styles are shown in the following Figure 4.

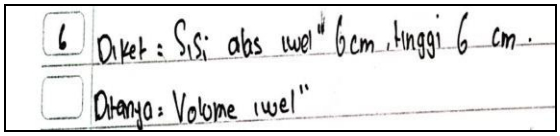

Figure 4. The Understanding of Students with Visual Learning Style

At the stage of understanding the problem, students with a visual learning style can understand the problem well, as shown by writing down the information known and asking about the problem correctly and completely, according to Figure 4 above. This can also be seen from the excerpt of the interviews between the researcher (R) and a student with a visual learning style (SV).

R: "Setelah membaca soal apa yang kamu lakukan untuk menjawab soal tersebut?"
SV: "Saya tulis apa saja yang diketahui bu, disitu kan iwel-iwel berbentuk limas persegi nah alas dan tingginya 6cm. Terus tulis apa yang ditanyakan, nah disoal itu volumenya."
Translates as follows.
R: "After reading the question, what did you do to answer the question?"
SV: "I wrote what the given information said, ma'am, there were iwel-iwels in the shape of a square pyramid, well, a pedestal, and 6 cm tall. Then, writing what's being asked, well, that's the volume."

Furthermore, at the stage of planning problem solving, students can do formulating well, namely writing down the formula that will be used, as shown in Figure 5.

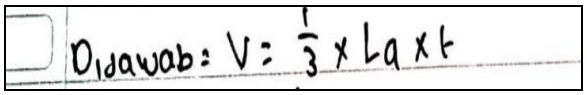

Figure 5. The Formulates of Solving Plan by Students with Visual Learning Style

In the next stage, namely implementing the formulation of the solving plan, students with a visual learning style can complete the calculation process correctly, as shown in the following figure. This is in accordance with the results of the interview, as follows:

R: "Coba ceritakan proses kamu menyelesaikan masalah tersebut"
SV: "Kalau udah inget rumusnya saya langsung menghitung bu, sesuai informasi yang diketahui"
R: "Dalam menghitung apakah ada kesulitan?"
SV: "Engga sih bu tapi kadang kalau ada pecahan saya ngitungnya lama"
R: "Setelah ketemu jawabannya, kamu ngecek kembali jawabanmu atau tidak?"
SV: "Kalau masih ada waktu saya cek lagi bu, kemarin saya ngecek sekali sih bu"
Translations as follows
R: "Tell me about your process of solving the problem."
SV: "If you already have the formula, I will immediately calculate it, ma'am, according to the given information."
R: "In calculating, are there any difficulties?"
SV: "No, ma'am, but sometimes if there's a fraction, I count it for a long time."
R: "After you find the answer, do you check your answer again or not?"
SV: "If I still have time to check again, ma'am, I checked it yesterday, ma'am."

In the interview, students can already carry out the plan of solving problems until re-checking the answers. However, in the conclusion of the answers according to Figure 6 below, there was an error in the unit of volume used.

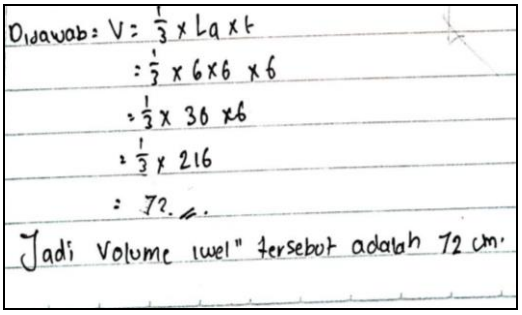

Figure 6. Students with Visual Learning Style Answer Sheet

The results of the research on problem-solving skills based on Polya's problem-solving stages in students with visual learning

styles are in line with several previous studies, such that Indrawati (2017) stated that each learning style has a different process for solving problems. Students with a visual learning style can understand the problem well (Argarini, 2018) and the research of Dewi, Asyar & Kamid (2013) that students with a visual learning style have a good understanding of the problem and formulate the solving plan. In this study, students were able to carry out the solving plan quite well and checked again but did not check in detail so there was still an error.

Students' Problem-Solving Skills with Kinesthetic Learning Styles

The characteristics of students with kinesthetic learning styles include: (1) the hand is a very effective and memorable message recipient for a long time; (2) being able to know information only by touching (for example, touching learning media); (3) not being able to stay still for a long time while studying or working; (4) learning more optimally if accompanied by physical activities; (5) having more ability as a coordinator of activity; and (6) being able to control the body's movements (Uno, 2012). Students with this learning style will prefer a learning process that invites students to try to explore the information that must be sought with movement, for example, the activity of measuring the area of the basketball court or the height of the flagpole, and all these activities are carried out in *real-time* on the object directly. The results of solving student problems based on the stages of solving Polya problems are shown in the following Figure 7.

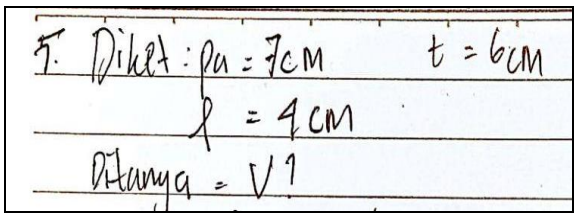

Figure 7. The Understanding of Students with Kinesthetics Learning Style

At the stage of understanding the problem, students with a kinesthetic learning style can understand the problem well, as shown by writing down the information known and asking a problem correctly and completely, according to Figure 4 above. This is in accordance with the excerpt of the researcher's interview with students with kinesthetic learning styles (SK).

P: "Setelah membaca soal apa yang kamu lakukan untuk menjawab soal tersebut?"
SK: "Menulis apa saja yang diketahui bu, di soal ada iwel-iwel berbentuk limas persegi panjang nah panjang alas 4cm dan lebarnya 7cm terus dan tinggi limas 6cm. Nah yang ditanyakan volumnya bu"
Translation as follows.
R: "After reading the question, what did you do to answer the question?"
SK: "Write whatever is given in the problem, ma'am. It is iwel-iwel with rectangular pyramid-shaped, the length of the base is 4 cm, with a 7cm width and 6cm height. Well, that's the question is volume, ma'am."

Furthermore, at the stage of formulating the plan for solving the problem, students can already formulate well, namely by writing down the formula to be used. Even so, during the interview, students stated that this formulating process takes a long time because sometimes they forget the formulas and concepts to be used, as shown by the following quotation.

R: "Setelah menulis yang diketahui dan ditanya apa yang kamu lakukan?"
SK: "Mengingat-ingat materi ibu, terus saya coba inget-inget konsep sama rumus limas bu tapi biasanya lama bu kadang saya lupa rumusnya"
R: "Setelah ingat konsep dan rumusnya langsung kamu gunakan untuk menghitung?"

SK: "Iya bu, kalau sudah ingat langsung saya pakai untuk ngitung volum limasnya. Pertama ngitung luas alas pakai rumus persegi panjang terus ngitung volume pakai rumus volum limas yang $\frac{1}{3} \times La \times t$*"*
R: "Ada kesulitan tidak saat menghitung? Diteliti lagi tidak?"
SK: "Engga bu, gampang sih. Saya biasanya ngecek berkali-kali sampai yakin, Bu"
Translation as follows.
R: "After writing the known and being asked what you are doing?"
SK: "Remembering the material, I keep trying to get the same concept as the pyramid formula, ma'am, but usually *it's taking a long time, and sometimes I forget the formula."*
R: "After remembering the *concept and formula, do you immediately use them to calculate?"*
SK: "Yes, ma'am, if I remember it, I immediately used it to calculate the volume of the pyramid. First, calculate the area of the base using the rectangular formula, and then calculate the volume using the volume formula of the pyramid, which $\frac{1}{3} \times La \times t$
R: "Any difficulty when calculating? You will be checking your answer again?"
SK: "No, ma'am, it's easy. I usually check it many times until I'm sure."

Students with a kinesthetic style can complete the calculation process easily, according to the interview results. Students state that in the calculation process, there are no difficulties, but in the settlement process, there is a slight error, namely in the calculation of the area of the base, where the student's error in writing the unit of area is shown in Figure 8. In the last stage, which is re-checking, students state that they check the answers again after finishing all the questions. This shows that students have quite good problem-solving skills; it's just that they are not careful when doing calculations and checking answers again.

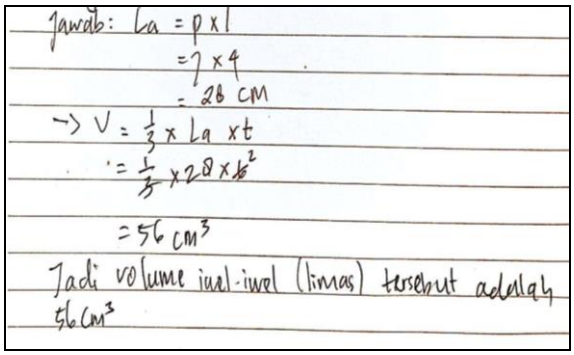

Figure 8. Students with Kinesthetics Learning Style Answer Sheet

Students with kinesthetic learning styles easily understand the learning material by touching the learning media directly. In this study, the media used was augmented reality, which allows students to interact directly with learning media so that they can understand problems well and plan the settlement process well, even though it takes a long time. This research also shows that students with kinesthetic learning styles are good enough at carrying out problem-solving plans and re-checking answers, but student accuracy is still lacking, so there are still a few mistakes.

The results are in line with the research of Umrana, Cahyono, and Sudia (2019), which states that students with kinesthetic learning styles are already able to understand problems, formulate the plan of problem-solving well, and re-check the answers obtained, but are still lacking the ability to perform calculations according to the formula used. Meanwhile, in this study, students have been able to do calculations properly and correctly, but there is a minor error regarding the unit.

Students' Problem-Solving Skills with Visual-Kinesthetic Learning Styles

It is possible that students have two learning styles (Ningrat, Tegeh, & Sumatri, 2019), one of which is in this study, namely students have visual and kinesthetic learning styles. The results of solving students'

problems with kinesthetic visual learning styles are shown in the following Figure 9.

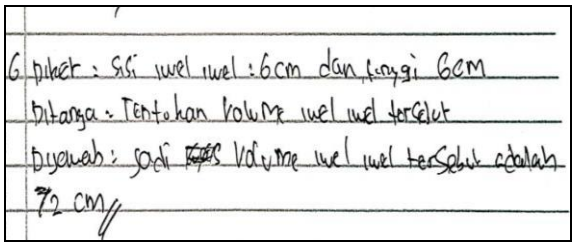

Figure 9. The Understanding of Students with Visual-Kinesthetics Learning Style

In the first stage, students with a visual-kinesthetic learning style can understand the problem well, as shown by writing down the information known and asking about the problem correctly and completely, according to Figure 8. This is in accordance with the results of student interviews, which stated that the first thing to do before answering the questions is to understand and write down what is known and asked.

Furthermore, at the stage of formulating the plan for problem-solving, students can formulate well, namely by writing down the formulas to be used. In the next stage, students with a visual-kinesthetic learning style can complete the calculation process correctly, but in the process, they have quite a bit of difficulty when dealing with fractional numbers in the calculation process. This is shown in the excerpts of researchers' interviews with students with visual-kinesthetic learning styles (SVK) and student answer sheets (Figure 10).

R: "Setelah menulis yang diketahui dan ditanyakan, apa yang kamu lakukan?"
SVK: "Itu bu menulis rumus yang akan digunakan, terus masukin angka-angkanya lalu dihitung sesuai rumus"
R: "Setelah itu kamu cek lagi tidak perhitungan dan jawabannya?"
SVK: "Engga bu, malah bingung"
Translatation as follow
R: "After writing the known and asked, what are you doing?"
SVK: "I wrote the formula to be used, kept entering the numbers, and then calculated them according to the formula."
R: "After that, do you check the calculation and the answer again?"
SVK: "No, ma'am, even confused"

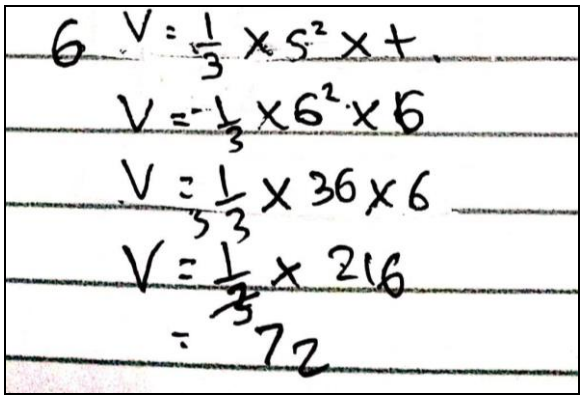

Figure 10. The Student with Visual-Kinesthetics Answer Sheet

This shows that students with a visual-kinesthetic learning style have been able to carry out problem-solving plans well, in line with the research of Purwaningsih and Ardani (2020), which states that students are able to solve problems well. Dewi, Asyar, and Kamid (2013) found that students with a visual learning style have a good understanding of the problem and formulate a solution plan, so students with visual kinesthetics also have a similar ability in terms of understanding and formulating the problem-solving process. Meanwhile, the last stage is to re-examine the students, stating that they did not check the answers according to the interview. This is in line with Immamuddin et al. (2019), who mention that the lack of knowledge of students to re-examine the answers is in accordance with the concepts and calculations carried out.

CONCLUSION

Problem-solving skills are abilities that every student must have, so this ability becomes important to develop. The innovation of the learning model, namely problem-based learning assisted by Assemblr based Javanese augmented reality, is a good alternative for

developing problem-solving skills. The results showed that this innovation can improve students' problem-solving skills, with an n-gain score of 0.5 in the moderate category. The improvement of these skills in terms of learning style based on Polya's stages shows that students in each learning style are already quite good at mastering problem-solving stages. However, students with visual and kinesthetic learning styles are still not careful in their calculations and re-checking the answer results, and students with visual-kinesthetic learning styles have not checked the answer results again. The suggestion for further research is to be able to conduct a similar and more in-depth type of research, not only problem-solving on visual and kinesthetic learning styles but also on auditory learning styles.

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