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Students' Mathematical Problem-Solving Process on Minimum Competency Assessment Test in the Context of Local Wisdom

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ABSTRACTS

Abstract: The ability of students to solve AKM problems is an important thing for teachers to know in teaching. Because the AKM framework is in line with the PISA framework, this study aims to see how the process is carried out by students in solving AKM problems within the local cultural context. Research is a qualitative study with a hermeneutic phenomenological approach. The analysis of 7 junior high school students selected by purposive sampling resulted in findings in the form of the stages of solving AKM problems carried out by students who did not fully use the Polya stage. However, the initial stage follows what Polya said: understanding the problem. When referring to Polya's four steps, the second to fourth steps are performed simultaneously, not standing alone. Students solving skills are important to continue to develop as capital for their future sustainability. Practising problem-solving skills can be done in many ways, including using the stages offered by researchers such as the Polya, Bransford, Good and Brophy, Hohn and Frey, Ormrod, and Sternberg stages.

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1. INTRODUCTION

The industrial revolution 4.0 has impacted many sectors, including job automation. Fleming (2019) refers to it as "the second machine age." The terminology describes many human jobs, both manual and cognitive and non-routine work, potentially replaced by machines (or digitization). At least 57% of jobs at the Organization for Economic Cooperation and Development (OECD) have the potential to be automated in the next 20 years, 69% in India and 77% in China (Compagnucci et al., 2019; J. Fleming, 2018). However, looking at other points of view, not all work can be converted. The global workforce is huge, and some jobs require humans as a starting point (Compagnucci et al., 2019). For instance, a psychiatrist, legal aid, or counselling. The reason is that the customer needs a human to have, for example, answered a private or private question directly.

Another example is, of course, the teacher. Since education and learning are very dynamic, it does not seem easy, even in the future, for these jobs to be substituted, even by Artificial Intelligence (AI). Thus, the potential development of human competence is always carried out as a consequence of such a paradigm.

In Indonesia, the government responded to the disruption with various policies, including in the field of education. The Ministry of Education, Culture, Research, and Technology (Kemdikbudristek) then changed the assessment procedures. These changes certainly also affect the learning process. Departing from the trend of student learning outcomes problems in Indonesia, one of which is based on the results of the Programme for International Student Assessment (OECD, 2019), it should be quite a reason for the transition from National Examination (UN) to National Assessment (AN). AN consists of three parts: a Minimum Competency Assessment (AKM), a character survey, and a learning environment survey. During this period, the application of AKM became a research trend in Indonesia (Handayani et al., 2021; Herman et al., 2022; Machromah et al., 2021; Purnomo et al., 2022; Sabara et al., 2021; Yamtinah et al., 2022). AKM emphasizes the assessment of students' basic competencies for self-development and their contribution to society (Handayani et al., 2021). Referring to the definition and function of AKM, AKM problems consist of various content, contexts, and at some level, cognitive processes that can measure students' literacy skills (Sabara et al., 2021). The AKM framework aligns with the PISA framework, which includes content, context, and cognitive level (Fortune et al., 2022). Therefore, the characteristics of PISA can also be used to build problems in AKM. The ability of students to solve AKM problems is an important thing for teachers to know in learning. Problem-solving ability, as one of the five basic abilities of learners, can be built into mathematics learning.

Among the famous theories about problem-solving, Lee and Chen (2015) mentioned Polya's theory as one of the most comprehensive. In his book "How to Solve It," Polya suggested four steps in problem-solving: (1) understand the problem, (2) devise a plan, (3) carry out the plan, and (4) review/extend (Polya, 1957; Santos-Trigo & Moreno-Armella, 2016). Problem-solving is closely related to mathematics, as most scientific and engineering problems require mathematics to solve the problem. It involves using abstraction, reasoning, and calculation (Lee & Chen, 2015; Yadav & Jadhav, 2019). Problem-solving skills become important where mathematical knowledge and skills are used at the highest level (Osman et al., 2018). Therefore, applying problem-solving mechanisms becomes crucial in learning and assessment, specifically in AKM.

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The implementation of AKM in education in Indonesia is expected to spur improvements in the quality of teaching and learning (Juliani & Bastian, 2021). Solving mathematical problems at AKM is also expected to build student literacy and numeracy to produce graduates with competencies and characters per the Pancasila Student Profile (Juliani & Bastian, 2021). This research, in such a way, aims to find out and examine the problem-solving process that grade 10 students go through in solving AKM problems based on local wisdom. Local wisdom is one of the project themes proposed by the Indonesian government as a learning context to strengthen Pancasila learners' profiles.

A review of human development, especially in science, shows that mathematics is related to many human attempts to acquire knowledge (Muhtadi et al., 2017). Meanwhile, Jeannotte and Kieran (2017) revealed that the value of mathematics related to the nature of mathematics is derived from how mathematicians from different cultures develop mathematics. These two views lead to the conclusion that mathematics and culture are inseparable parts. Mathematics produces culture but is also produced by culture (Knijnik, 2007).

Various studies related to the disclosure of mathematical concepts contained in culture have been carried out by many researchers, especially Indonesian researchers (Ika et al., 2022; Muhtadi et al., 2017; Mursalina et al., 2021; Nuryadi et al., 2020; Prahmana & D'Ambrosio, 2020; Simamora et al., 2018). The justification for the close relationship between mathematics and culture has become an interesting topic of discussion between rationalism and empiricism (Nasir, 2002). Coherence between cultural anthropology, mathematics, and mathematical modelling is ethnomathematics (D'Ambrosio, 2006; Rosa & Orey, 2013). Since ICME in Adelaide when D'Ambrosio introduced the word ethnomathematics, the notions related to it have gained considerable popularity with the various interpretations used by different authors. Ethnomathematics is a study that examines and combines mathematical ideas, methods, and techniques practiced and developed by socio-cultural people or members of different cultural groups (Rosa & Gavarrete, 2017). The idea of ethnomathematics has a broad view of how mathematics relates to the realities of human life.

Applying ethnomathematics as a pedagogical action in mathematics learning restores a sense of pleasure or involvement and can increase creativity in doing mathematics (D'Ambrosio, 2006; Prahmana & D'Ambrosio, 2020; Risdiyanti & Prahmana, 2021). Teaching mathematics by considering that mathematics is an expression of the development of human culture and thought is a relevant reason for teaching mathematics based on ethnomathematics (D' Ambrósio, 2005; D'Ambrosio & D'Ambrosio, 2013). Thus, mathematics learning needs to be started by using the real context of socio-cultural and the reality around students. Student needs are not just learning external values and rigid academic mathematical knowledge (Prahmana, 2022). For this consideration, mathematics education must contextualize mathematics with the student's cultural environment. In essence, science arises from the needs and expectations of community members in a certain culture to respond to the environment and answer various problems faced in their lives.

2. METHODS

Research Design

Qualitative research with a hermeneutic phenomenological approach was chosen as an alternative method to answer all research questions. An approach called hermeneutic

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phenomenology is based on hermeneutic and phenomenological philosophy. Phenomenology led to the discovery of the relationship between objectivity and subjectivity, which is present in every moment of human experience (Guillen, 2019). Hermeneutics explains behavior, verbal and nonverbal forms of behavior, culture, and organizational systems and reveals their meaning while maintaining their singularity (Velez-Torres & Vélez Galeano, 2019). So phenomenology and hermeneutics both complement each other. Smith et al. (2009) argue that the hermeneutic phenomenological approach is particularly relevant for researchers in the field of education. The phenomenon that will be seen in this study is the problem-solving process carried out by students in solving AKM problems.

Population and Sample/ Study Group/Participants

The selection of research subjects uses the purposive sampling technique, which is a technique where researchers choose participants who are believed to be able to provide data related to the phenomenon to be studied. In this case, as many as seven students from grade 10 of SMA were taken at one of the leading Islamic boarding schools in Cirebon City. The selection of 'pesantren' as a research site is based on its uniqueness, where many students can memorize well, but the results of learning mathematics are relatively low.

Data Collection Tools

The researcher is a key instrument in qualitative research because he collects data by observing, asking, hearing, requesting, and taking research data. The data in this study was obtained through several techniques, namely documentation studies, observations, think-aloud, interviews, and tests.

Data Collection

Documents represent a good source of text (word) data for qualitative research. Documents can be private and public records obtained by qualitative researchers about places or participants in a study (Creswell, 2015). The document referred to in this study is about AKM issued by the Ministry of Education, Culture, Research, and Technology.

Observation is collecting open-ended information by observing people and places at a research site (Creswell, 2015). The purpose of observation is to understand the cultural, setting, or social phenomena studied from the participants' perspective (Hatch, 2002). Observations in this study were made to obtain information about phenomena that occur while solving the problem. The type of observation carried out, namely non-participant observation, is that the researcher does not participate in the observed activity but only observes.

Interviews are an important way for researchers to check the accuracy of the impressions obtained from observations (Fraenkel & Wallen, 2012). Furthermore, this interview aims to uncover the structure of meaning that participants use to organize their experiences and understand their world (Hatch, 2002). In this study, the interview that will be conducted is a semi-structured interview. Interviews were conducted with participants consisting of math teachers and students. Interviews with teachers aim to extract information about all teaching activities carried out by teachers, both before teaching, during teaching, and after teaching. Interviews with students aim to reveal students' concept image of AKM questions as knowledge understood after being given a diagnostic test and to reveal learning barriers that occur in students.

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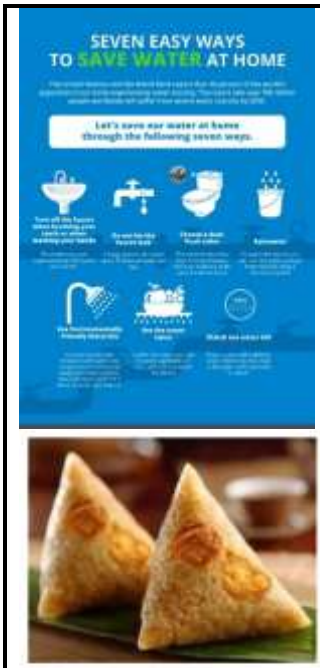
The test collects data on numeric and not verbal types (Cohen et al., 2007). The test measures an individual's knowledge or skills within a particular field or subject (Frankel et al., 2012). The test in this study is a diagnostic test used to see the problem-solving process carried out by students in solving AKM problems (Figure 1).



Water is a natural resource that is crucial for maintaining a healthy body. As humans who will always depend on water, we are supposed to take care of it. Although this water is a renewable resource, it turns out that it cannot be updated for clean water. The existence of clean water that continues to shrink every year must finally make us extra vigilant about its stocks or supplies. To maintain this stock or supply of clean water well, you inevitably have to make savings.

Traditional baking food is generally in the form of a regular triangular pyramid. For example, the *Bacang* will be made with a base side size of 6 cm and a height of 10 cm. If the mixture to make baking, one of them is rice mixed with water in a ratio of 1: 3 which means 1 liter of rice mixed with 3 liters of water. A trader will make baking by using water that is worth the savings from closing the leakage of the water tap per day, then many of the maximum *bacang* that can be made with the same shape are...

$$\sqrt{2} = 1.41; \sqrt{3} = 1.73$$

Source: https://pusmenjar.kemdikbud.go.id/

Figure 1. Appendix to AKM

Data Analysis

Data analysis is searching for meaning (Hatch, 2002). Data analysis in qualitative research takes place simultaneously with other parts of qualitative research development, namely data collection and writing of findings (Creswell, 2015; Marshall & Rossman, 1995). Data analysis procedures in this study carried out in three main stages: managing, analysing and interpreting data. The validity of the data is carried out as an effort to produce quality research. The techniques used are validity and reliability analysis. Creswell (2015) mentioned that validity in qualitative research is an effort to check the accuracy of research results by applying certain procedures, while reliability in qualitative research indicates that the approach used by researchers is consistent if applied by other researchers.

Triangulation is one of the strategies used to validate findings, Mok and Clarke (2015) mentioned that triangulation refers to the use of multiple ways to test social phenomena. Triangulation is done by collecting different sources of information data by examining evidence from those sources and using them to establish a coherent justification of themes. In this study, the form of triangulation used is data triangulation and theory triangulation. Data triangulation in this study combines data from various sources: observation, documentation study data, interview result data, and diagnostic test result data. Meanwhile, the triangulation of theories in this study was carried out by combining various theoretical perspectives to obtain accurate data. In addition, theoretical triangulation in this study is also used to validate the overall findings by comparing the findings obtained with relevant research. Creswell (2015) stated several reliability procedures in qualitative research, and

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some of them used as reliability strategies in this study include: (1) checking and ensuring that research results do not contain errors during the process; (2) ensuring there are no floating definitions and meanings.

3. FINDINGS

Many researchers have put forward various proposals related to the stages of solving the problem. In this study, we focused on what Polya offers regarding the four stages of problem-solving: understanding the problem, devising a plan, carrying out the plan, and looking back. From the selected subjects, we will describe how they solve the problem presented, whether it corresponds to the stages that Polya puts forward or exits it. Here is the explanation.

Understanding the problem

The first stage in solving the problem offered by Polya is understanding the problem, where students identify what is known, what is there, the amount, relationships, and values related to it, and what they are looking for. We agree that this is true of first-time students in solving the problems we posed. However, how they understand the problem varies. The problem we designed has two parts: the information section and the problem section. Four of the seven subjects start by reading the problem section and then looking at the information, and the other three read the problem in a structured way from the top (information) to the end.

Diketahui:
Banyaknya air = hasil penghematan dari menutup keran bocor = $75\ liter$
Bentuk bacan = limas segitiga beraturan
Panjang sisi bacan = $6\ cm$
Tinggi bacan = $10\ cm$
Air : Beras = $1:3$
$\sqrt{2} = 1.41; \sqrt{3} = 1.73$
Ditanyakan:
Banyak bacan maksimum yang dapat dibuat

Figure 2. The answer of one of the students ϑ

Based on data from teachers, we got information related to the differences in cognitive abilities of each subject. Subjects with good cognitive ability (θ) are fast enough to find the data needed to solve the problem. They mark the known information on the question sheet. In contrast, subjects with lower cognitive abilities (ϑ) wrote down all the data on the answer sheet (see Figure 2). Even then, they cannot identify which data is needed. They take a relatively long time at this stage and must read the questions repeatedly.

"I was at a loss to find data on the phrase "using water that is worth the savings from closing the leakage of water faucets per day" because there is so much data that comes up," said one of subject B during an interview. In contrast, one of subjects A explains that to find the data, they only need to look at the appropriate image and read the description. These findings confirm that the difference in the cognitive of students does not affect what they should do when facing a problem, that is, to understand the problem presented in advance.

Devising a plan and carrying out the plan

According to Polya, in the second stage, devising a plan, students must identify the operations and strategies needed to solve a given problem. What is implemented depends on what has been planned. In the third stage, carrying out the plan, in general at this stage

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the student needs to maintain the already chosen plan. Students can choose another way or plan if the plan cannot be implemented. We find that these two stages run simultaneously. When the subject finds a plan, then they execute it immediately. We cannot fully identify devising a plan when students are doing questions. However, we confirmed it during the interview and identified that the entire subject was devising a plan. Just like the first stage, the way they do it varies, the ways that arise are (1) guessing; (2) sketching; and (3) sorting data/information.

Guessing, in his guess, the student wrote down 1 litre equals 19 *bacang* (see Figure 3). When confirmed with the question, "where can I get this result from?" the student replied, "1 liter is equal to 1 cubic decimeter equals 1000-cubic centimeter. while one *bacang* requires 51.9-centimetre cubic. So, 1000 divided by 51.9 the result is about 19". From these explanations, there are indications that students are only guessing about the statement. So the final result obtained is not appropriate. This is due to the rounding of the number 19.26 to 19.

$$Luas\ segitiga = \frac{1}{2} \times 6 \times 3\sqrt{3} = 9\sqrt{3}$$

$$Volume\ limas = \frac{1}{3} \times 9\sqrt{3} \times 10 = 30\sqrt{3} \approx 51.9\ cm^3$$

$$1\ liter = 1000\ cm^3$$

$$1\ liter = 19\ bacan$$

$$100\ liter = 1900\ bacan$$

Figure 3. Answer students by guessing

Sketching, the questions presented are related to geometry, both flat building and spacious building. Some of the sketches made by the subject are equilateral triangles, right triangles, and triangular (as in Figure 3). The image yes is a manifestation of the pyramid's base, and the Figure is a cut of the image yes to identify the triangle's height. Using the Pythagorean formula, as illustrated in Figure lb, the subject can determine the height of the right triangle to determine its area. "By sketching like this, I find it easier to solve the problem," explains one of the subjects.

Sequencing data/information, students identify which data they must first process to be able to use. This is mostly done by subjects who have previously written down all the information. The data they sorted is presented in Figure 4. Then students outline the problem in two parts, namely materials and needs. First, they identify the amount of water available from the water scarcity image, then determine the amount of rice needed, identify the side width and height of the *bacang* to calculate its volume then, and determine the amount of *bacang* that can be made after determining the amount of water and rice. In the material section, "the existing data is in the form of information on the amount of water and the ratio of water and rice, which is 1:3", explained the student during the interview—added "the need to make one *bacang* equal to the volume of a triangular pyramid with a base side width of 6cm and a *bacang* height of 10cm". This we identified as a needs part. Later, they can solve the problem by dividing the results of materials and needs from these two parts.

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$$Jumlah\ air = 75\ liter$$

$$beras : air = 1:3$$

$$Kebutuhan\ beras = \frac{75}{3} = 25$$

$$Total\ bahan\ yang\ ada = 100\ liter = 100000\ cm^3$$

$$ukuran\ bacan = volume\ limas\ segitiga$$

$$Volume\ limas\ segitiga = \frac{1}{3} \times luas\ \Delta \times tinggi$$

$$Tinggi\ \Delta = \sqrt{6^2 - 3^2} = \sqrt{27} = 3\sqrt{3}$$

$$Luas\ \Delta = \frac{1}{2} \times 6 \times 3\sqrt{3} = 9\sqrt{3}$$

$$Volume\ limas\ segitiga = \frac{1}{3} \times 9\sqrt{3} \times 10 = 30\sqrt{3} \approx 51.9\ cm^3$$

$$Bacan\ yang\ dapat\ dibuat = \frac{100000}{51.9} = 1.926{,}79 \approx 1.926$$

Figure 4. Answer Student by Sorting Data/Information

Looking Back

Only one student we found specifically double-checked his answer after he finished. Meanwhile, other students still look back at their findings, but their activity at each stage is not separate from the previous three stages. When they concluded, their belief in their answer was so strong that they felt no need to look back at the results of the answer from the beginning, "I think my answer is correct," the student explained when asked why not check the answerback. Whereas our statement regarding "looking back at each stage" is based on the results of our observations which show that some of the same activities are carried out repeatedly while doing the question, such as reading the question again after they have identified the data.

4. DISCUSSION

From these findings, it is known that how students solve problems is not entirely what Polya describes. They have different ways of solving problems. However, the steps offered by Polya can be used to train students' problem-solving skills in a structured manner (Rahman & Ahmar, 2016). Whatever way students solve problems, it is very likely to be influenced by previous experience and knowledge (Winberg & Hedman, 2008). Our analysis defines problem-solving as finding a way out of difficulty (Polya, 1957). This we emphasize because there is another definition, problem-solving is a planned process that needs to be implemented to obtain a specific solution to a problem that may not be obtained immediately. This definition of "problem-solving is a planned process" leads to the conclusion that if students can solve a problem without a plan to be taken into account, they do not carry out a problem-solving process. As for us, consider that any problem is a problem, and when students try to solve it, they have practiced their problem-solving skills. This aligns with the opinion that problem-solving is a lifelong activity (Krulik & Rudnick, 1988). Thus, problem-solving is always related to experience. About how to practice problem-solving skills, many researchers have offered their models beyond the Polya model, such as (Bransford et al., 1993; Good & Brophy, 1995; Hohn & Frey, 2002; Ormrod, 2000; Sternberg, 2003).

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Mathematical problem-solving skills are important to students and should be constantly developed. Because understanding mathematics is important for everyone, they use mathematical ideas and knowledge to do their daily work. From this perspective, it can be assumed that there is a close relationship between mathematics and culture: mathematics produces culture, but it is also produced by culture (Knijnik, 2007). Knowledge and ideas of mathematics are implicitly used in cultures outside of school. Prahmana and Istiandaru (2021) argue that the idea of ethnomathematics embedded in different cultural activities mediates the understanding of school mathematics. This can be elaborated based on the theory of contextual metaphors that shows the relationship between the source and target domains for effective mathematical teaching and learning. Related cultures and practices form the source domain, which students are always familiar with, aware of, and capable of defining. The target domain considered abstract and challenging is the knowledge that must be learned: mathematical knowledge. This concept justifies that incorporating ethnomathematics ideas in classroom teaching can facilitate understanding school mathematics. Students culture and daily activities regarding ethnomathematics ideas are an integral part of education in general and mathematics learning in particular. We believe that classrooms and other learning environments are inseparable from the cultural communities in which they thrive, and students come to school with them the values, norms, and concepts they derive from their culture and environment. This suggests that it is possible to connect school mathematics through ethnomathematics ideas and the out-of-school context of learners.

Another result of this study is that we can describe the characteristics of AKM and its urgency for future challenges. AKM questions are oriented toward building higher-order thinking skills (HOTS) and building students' critical-analytical thinking skills (Auliya, 2022; Samo et al., 2017). Therefore, the AKM question is accompanied by a stimulus or stimulus before students do the questions (Damrongpanit, 2022). The form can be fictional texts (short stories, poems, and rhymes), news/information, case descriptions, pictures, graphs, tables, and others. The stimulus will later become a source or reference associated with the questions that students must answer (Minister of Education and Culture, 2020). Not every answer to the question, especially for the HOTS question, can be found in the stimulus, but the data and information contained in the stimulus need to be analyzed so that students can compile their answers by utilizing the data on the stimulus.

5. CONCLUSION

Problem-solving skills are one of the basic skills students must have in learning mathematics. Each student has a different way of solving problems. This unique difference can be a capital for students to develop other skills, such as critical thinking, creativity, and others. The results of research on solving AKM problems in the local cultural context show that how students solve problems is not entirely what Polya describes. In solving problems, the process carried out by students always begins with understanding the problem. This is in line with Polya's opinion about the stages of 'understanding the problem.' However, the next steps vary, and many students devise and carry out the plan simultaneously. It is also looking back at what is done at every stage.

6. SUGGESTION

From this result, it can be said that to practice students' skills, many ways can be done. Many researchers, including Polya's measures, have put forward various formal offers. Thus,

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the understanding of "problem-solving" associated with Polya must be changed. We have not found a definite indicator concerning how to measure problem-solving skills. So it is important to conduct further research describing indicators of problem-solving skills.

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