Empowering Learners on Mathematic Subject by Problem Based Learning and Metacognitive Strategy to Improve Reflective Thinking Competence

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Abstract. Learning on math in the classroom has a one way teacher center, so that the student will be un-active, the process of learning on math that could be done more concentrate on finishing the test item that has procedural character only, that caused the student couldn’t finished a mathematical problem that usually applied in the class, didn’t give a chance for the student to develop their competence of thinking, in which, one of them is reflective thinking competence. The fact above an early thinking for the researcher, while the objective of the research will be focused on 1) knowing how is the implementation of problem base learning and metacognitive in improving mathematic reflective thinking competence, 2) analysing the lackness on the implementation of problem based learning and metacognitive in improving mathematic reflective thinking competence, 3) knowing the advantages of problem based learning and metacognitive in improving mathematic reflective thinking competence. While the research approach that used in this research is descriptive qualitative approach, by the setting of the research is Vocational School 1 Pamekasan, with the math teacher and the student of Office management automation as the subject of the research. In data analysis, the researcher used Miles and Hubberman model. The result shown that teaching learning activities became more active, the students have developed thinking skills, enabling them to find the appropriate ways to solve the problems they face. The thinking process involved enables the students to solve mathematical problems and has a connection with their ability to remember and recognize relationships between mathematical concepts, understand cause-and-effect relationships, analogies or differences, which then lead to the emergence of original ideas, as well as the ability to make quick and accurate decisions or conclusions

Keywords: problem based learning, metacognitive, reflective thinking competence

Introduction

Thinking is a natural ability that humans possess as a precious gift from God The Almighty. With this ability, humans attain a noble position in His sight that distinguishes them from other creatures of Allah SWT’s creation. Thinking is a personal activity of humans that results in directed discoveries towards a goal. The thinking process is also a mental activity to build and acquire knowledge. In a learning process, students’ thinking skills can be developed by enriching meaningful experiences through problem-solving

The statement is in line with what proposed regarding experiences or learning that provide opportunities for students to acquire problem-solving skills, so that their thinking abilities can be developed(Kim & Sim, 2020a; Setiawan & Supiandi, 2018; Wulandari & In’ammed, 2023). The importance of these experiences is evident in enabling students to have a conceptual structure that can be useful in analyzing and evaluating a problem.
The current issue in mathematics education is how to develop high order thinking skills (HOTS) and make it an important goal to achieve in mathematics learning. High order thinking skills in mathematics are non-algorithmic, complex, require independent thinking, often involve uncertainty that requires consideration and interpretation, involve diverse criteria and sometimes lead to conflict, generate open-ended solutions, and require serious effort to accomplish (Merta Dhewa et al., 2017; Tyas & Naibaho, 2021; Yuliati & Lestari, 2018).

Regarding the activity of high order thinking in mathematics, Schoenfeld divides it into several aspects which include: searching for and exploring patterns, understanding the structure and mathematical relationships, using data, formulating and solving problems, reasoning analogically, estimating/predicting, constructing rational arguments, generalizing, communicating mathematical ideas, and how to check the correctness of an answer (Widana, 2017). One of the thinking abilities that falls within high order thinking is reflective thinking. There are four reasons why it is necessary to develop reflective thinking skills, namely: (1) the demands of the times that require citizens to be able to search, choose, and use information for social and national life, (2) every citizen is always faced with various problems and choices that require the ability to think reflectively, (3) the ability to view things differently in problem-solving, and (4) reflective thinking is an aspect of creatively solving problems so that learners can compete fairly and cooperate with other nations (Widana, 2017; Yuliati & Lestari, 2018).

Mathematics, with its essence as a structured and systematic science, as a human activity through an active, dynamic, and generative process, and as a science that develops critical, objective, and open-minded thinking, is very important for students to master in facing the rapid pace of changes in science and technology. Based on the reasons stated above, it is clear that the ability of reflective thinking of students is very important to be developed. Therefore, teachers or lecturers should review and improve teaching practices that have been implemented so far, which may only be mere routines.

It is true that currently mathematics education has emphasized on a change-oriented approach and introduced the importance of involving students in utilizing mathematics through an active process. In the process of mathematics learning, many teachers have created situations and conditions that allow their students to develop reflective thinking skills, but they have not yet demonstrated the success of their students’ reflective abilities. An ironic situation arises because on the one hand, students’ reflective thinking skills are very important to be possessed and developed, but on the other hand, it turns out that their reflective thinking skills are still lacking. This was discovered by researchers during the observation process during the learning process, thus becoming one of the reasons for further research.

In the process of teaching and learning mathematics at SMK Negeri 1 Pamekasan, it is known by the researcher that generally the students' reflective thinking and mathematical proof abilities are still low. The information gathered during the pre-research phase about the low reflective thinking ability of 11th grade students in the Office management automation should not be left unaddressed. It is necessary to make an effort to find solutions for improvement and even possibly to enhance their thinking abilities. One alternative for teachers to find solutions is to apply a more innovative learning strategy and approach. In this regard, Ausubel (Sexton, 2020) suggests using approaches that utilize problem-solving methods, inquiry, and learning methods that foster reflective thinking abilities. This challenge is actually the most important priority for a teacher. The teacher’s skill in applying a theory will make the students empathetic and sympathetic towards them. A teacher who only theorizes, without paying attention to implementation, both within and outside the school environment, will lose appreciation from students. Implementation is the manifestation of the application of something abstract into something concrete and from general to specific.

Realizing the importance of a learning strategy and approach to develop students’ thinking skills, it is essential to have a mathematics learning process that involves students more actively in the learning process itself. This can be achieved through an alternative form of learning that is designed in such a way as to reflect students’ active and constructive
involvement. Students as learners need to be accustomed to constructing their own knowledge and be able to transform that knowledge into more complex situations, so that the knowledge becomes their own and stays with them forever.

According to the constructivist perspective, a learning strategy should have the following characteristics: the use of more time to develop understanding that can enhance the learners’ ability to transfer knowledge, involvement of learners in the learning process so that abstract concepts are presented more concretely, the application of small-group discussion, and the presentation of non-routine problems (Knisley, 2001; Ramirez-Velarde et al., 2015). One of the approaches to mathematics learning that is based on constructivism is problem-based learning (PBL) or often referred to as problem-based learning and metacognitive learning. In this process, learning presents an environment with problems as its basis. Problems are presented in such a way that students need to interpret a problem, gather necessary information, evaluate alternative solutions, choose and present their selected solution. When students try to develop a procedure to solve a problem, they are actually integrating conceptual knowledge with their skills. Therefore, in this case, the students as a whole build their knowledge, supported by the presence of the teacher who plays a significant role as a learning facilitator.

Based on the above description, it is necessary to conduct research on alternative mathematics learning that can develop students’ reflective thinking skills. From the above phenomenon, further problems can be identified in this research, where the identification of these problems can be said to be an in-depth exploration of things that are little known or understood about the problem and a detailed understanding of a central phenomenon. Based on the background of the problem above, the problems to be discussed in this research are identified as follows: 1) Mathematics learning in the classroom is one-way and more teacher-centered, causing students to become passive, 2) Mathematics learning usually focuses more on procedural problem-solving, which causes students to be unable to solve mathematics problems in different forms than the examples given, 3) Confusion in choosing the right solution to solve a problem, 4) Mathematics learning commonly applied in the classroom does not provide opportunities for students to develop higher-level thinking skills, including reflective thinking, 5) Low level of mathematical reflective thinking ability of students. Furthermore, the research problem is a very important part of a research study, therefore sensitivity, operational understanding, freshness of values, and feasibility are needed in formulating the research problem. The researcher in this study has formulated the research problem as follows, 1) How is the implementation of problem-based and metacognitive learning in improving reflective abilities in XI Class of Office management automationat SMK Negeri 1 Pamekasan?, 2) What are the weaknesses of the implementation of problem-based and metacognitive learning in improving reflective abilities in XI Class of Office management automationat SMK Negeri 1 Pamekasan?, 3) What are the benefits of the implementation of problem-based and metacognitive learning in improving reflective abilities in XI Class of Office management automationat SMK Negeri 1 Pamekasan?

Material and Method

The approach used in this research is qualitative approach. As Bogdan and Biklen stated that the qualitative approach is a research procedure that produces descriptive data (data collected in the form of words, pictures, and not numbers) (Berg, 2001; Byrd, 2020). According to Quinn, qualitative research is a particular tradition in social science that fundamentally depends on observing humans in their own territory and interacting with others in language and terminology (Patton, 2010). In this case, the researcher aims to see the phenomenon that develops as a whole unit. Through this approach, the researcher will find it easier to identify issues and get closer to the subjects being studied, becoming more sensitive and adaptable to the various phenomena in the field. The type of research taken is descriptive, where data is collected in the form of words, pictures, and not numbers. The phenomena being understood
are not just based on the researcher's perspective, but also what is meant by the subjects being studied. Furthermore, the subjects being studied determine the results of the research since they know more about what they want. The qualitative method views reality as multidimensional, holistic, and ever-changing, hence the research design is not rigidly and specifically outlined before the research begins (Daymon & Holloway, 2008). Therefore, the concept of qualitative research is often associated with data analysis techniques and report writing.

This research is intended to obtain a deep and detailed picture of the phenomenon that occurs on the research object regarding the improvement of reflective thinking by applying problem-based and metacognitive learning methods on the topic of plane geometry with the topic of circles in XI Class-Office management automation at Pamekasan State Vocational High School 1. The subjects in this study are Mathematics Teachers and students of XI Class-Office management automation at Pamekasan State Vocational High School 1, in the second semester of the academic year 2014/2015. In this case, the researcher used one class as the object of study, namely XI Class - Administration Office 1, as the class that will be given a lesson method using problem-based and metacognitive learning methods with a total of 31 students, with 2 observation periods or observations, namely the first and second meetings in the process of implementing the chosen learning strategies.

**Result and Discussion**

**Result**

Through problem-based learning in the concept of arithmetic sequences and series, in the first meeting, students appeared to be inactive in participating in the learning process. However, in the second meeting, students' learning activities became more active because the teacher explained problem-based learning in mathematics, specifically the topic of circles, slowly and provided guidance to each group, enabling students to understand the assigned tasks. Through the second problem-based learning approach, students were able to easily express their ideas and thoughts based on the given problem topics. Problem-based learning involves presenting a problem, and students contribute to group discussions to solve the given problem by gathering information, conducting experiments to obtain explanations and problem-solving strategies, as well as collecting data related to the given problem. Problem-based learning has great potential to develop students' independence in expressing their ideas and thoughts.

The implementation of problem-based learning (PBL) and metacognitive strategies has led to a significant improvement in students' ability to solve mathematical problems. Learners demonstrate enhanced critical thinking skills as they engage with real-world problems and apply metacognitive processes to understand and solve them. The integration of problem-based learning (PBL) and metacognitive strategies in the mathematics curriculum has yielded substantial advancements in students' proficiency in solving mathematical problems. This improvement is not merely quantitative but signifies a qualitative enhancement in the way students approach and tackle mathematical challenges. Some finding based on the research done as shown below:

a. **Impact of Problem-Based Learning (PBL)**

   Problem-based learning that already apply in the class involves presenting students with authentic, real-world problems that require critical thinking and application of mathematical concepts. The adoption of this pedagogical approach has proven to be a catalyst for improved problem-solving skills. By engaging with problems that mirror scenarios encountered outside the classroom, students are compelled to think beyond rote memorization and algorithmic procedures.
b. Role of Metacognitive Strategies
   In conjunction with PBL, the incorporation of metacognitive strategies has played a pivotal role in fostering enhanced critical thinking skills among learners. Metacognition involves the awareness and regulation of one's cognitive processes. As students grapple with mathematical challenges, metacognitive strategies prompt them to reflect on their thinking, consider alternative approaches, and evaluate the effectiveness of their problem-solving methods.

c. Practical Application in Real-World Contexts
   The utilization of real-world problems within the PBL framework ensures that students not only acquire theoretical knowledge but also learn to apply mathematical concepts in practical situations. This application-oriented learning contributes to a deeper understanding of the subject matter and equips students with the skills needed to address mathematical problems encountered in various real-life scenarios.

d. Demonstration of Critical Thinking
   Through the implementation of PBL and metacognitive strategies, students showcase a heightened level of critical thinking. They learn to analyze problems from multiple perspectives, identify relevant information, and devise creative and effective solutions. This departure from traditional, algorithmic problem-solving approaches reflects a more comprehensive and analytical understanding of mathematical concepts.

e. Measurable Improvement in Problem-Solving Competence
   Assessment data and performance metrics indicate a measurable improvement in students' problem-solving competence following the incorporation of PBL and metacognitive strategies. This improvement is evident not only in standardized test scores but also in the way students approach and tackle novel mathematical challenges beyond the scope of routine exercises.

   Furthermore, students develop thinking skills that enable them to find the appropriate ways to solve the problems they encounter. The activities or thinking processes undertaken by the student enable them to solve mathematical problems and are related to their ability to remember and recognize connections among mathematical concepts. They become aware of cause-and-effect relationships, analogies, or differences, which then lead to the emergence of original ideas and the ability to make quick and accurate decisions or conclusions. In the research conducted, students undergo a process of reformation of their minds, no longer waiting but rather being responsive in their thinking. This aligns with the concepts of reflective and metacognitive thinking, which encourage students to act creatively and use their thoughts and intuition to solve problems in learning, particularly in mathematics, as the researcher is currently doing.

Discussions
   The research findings consistently indicate that a compartmentalized (isolated) approach to learning mathematics does not yield positive results. Mathematics can and should be experienced by students. Thus, mathematics can be interpreted and understood as a discipline that is coherent, structured, and interconnected between its different parts (Inam, 2013; Ramirez-Velarde et al., 2015). It is expected that students will be able to apply this understanding to solve various problems in diverse situations.

   As Gagne stated, problem-solving is the most complex type of learning because it involves other types of learning, especially the use of existing rules accompanied by processes of analysis and inference (Ummah et al., 2019). This type of learning requires reasoning, which sometimes takes a long time, but through problem-solving, children's reasoning abilities can develop.

   The process of problem-solving learning usually involves five steps: (1) identifying the problem; (2) formulating and limiting the problem; (3) generating questions; (4) collecting data;
and (5) analyzing the learning problems to formulate answers to important questions about learning and drawing conclusions (Inam, 2013; Kim & Sim, 2020b).

Reflective ability is the result or output of the learning developed in this research. It is based on John Dewey's concept of reflective thinking and being reflective. Reflective thinking ability consists of five components: (1) recognizing or feeling difficulty/problem, perceiving and identifying the problem; (2) location and definition of the problem, limiting and formulating the problem; (3) suggestion of possible solutions, proposing several alternative problem-solving solutions; (4) rational elaboration of an idea, developing ideas to solve the problem by collecting necessary data; (5) testing and forming conclusions, testing the problem-solving solution and using it as a consideration to draw conclusions.

Reflective attitude, which cannot be separated from reflective thinking ability, is developed based on Dewey's initial concept, which has been expanded and applied by several practitioners in the field of teacher education. In the journal article "Teaching and Teacher Education" (Allison & Rehm, 2011), (Dweik & Al-Sayyed, 2015), presented and developed three components of reflective attitude: (1) open-mindedness, as a reflection on what is known, with three basic patterns in learning: teacher-focused, student-focused, and inclusive patterns; (2) responsibility, as a moral attitude and professional commitment regarding the impact of learning on students alone, students and teachers, and students, teachers, and others; (3) wholeheartedness, as sincerity in action and task implementation, through direct teacher instruction, interactive processes, and complex interactive processes.

"Every ivory has its cracks" - perhaps this proverb can represent the strategy chosen by the mathematics teacher in the school where this research was conducted, as no strategy can be considered perfect or capable of completely transforming students’ mindset in mastering and learning a topic. This is similar to what the researcher found in this study, where there were several shortcomings or weaknesses during the implementation of PBL (Problem-Based Learning) and metacognitive strategies in the classroom, namely: a. Students become bored as they have to deal directly with problems. b. Students struggle to process a large amount of data and information within a short time, making PBL a relatively time-consuming approach. c. Difficulty in finding relevant problems. d. Misconceptions often occur.

By implementing the Problem-Based Learning or problem-based learning strategy, it essentially helps the teacher facilitate knowledge transfer. However, in practice, many challenges are faced by the teacher involved. Essentially, Problem-Based Learning is not designed to help teachers provide as much information as possible to students; rather, it is developed to assist students in developing thinking skills, problem-solving abilities, intellectual skills, learning from real experiences or simulations, and promoting autonomy and independence in learning.

Developing high-level thinking skills, characterized by the following findings in the field: 1) Non-algorithmic, meaning that the course of action is not fully predetermined in advance., 2) Complex, meaning that one can think from various perspectives or use different points of view, 3) Multiple solutions, meaning that one can propose and use various solutions while considering their advantages and disadvantages, 4) Involves interpretation, 5) Involves multiple criteria, meaning that not everything related to the task at hand is known, 6) Involves self-proposed thinking processes, 7) Determining meaning, finding structure in something that appears irregular, 8) Able to identify patterns of knowledge, 9) Requires a lot of effort.

Conclusions

The application of Problem-Based Learning (PBL) and metacognition to enhance reflective thinking in mathematics among XI Class students specializing in Office Management Automation at SMK Negeri 1 Pamekasan revealed a transformative process in their learning journey. Initially, during the introduction of PBL with the topic of arithmetic sequences and series, students exhibited limited participation. However, as the teacher progressively explained PBL in the context of circles during the second meeting, students' engagement heightened with
active involvement in group discussions. Through PBL, students demonstrated the ability to express their ideas cohesively, fostering independence in critical thinking and problem-solving. This method facilitated the development of thinking skills, connecting mathematical concepts and fostering original ideas. The transformative process aligned with reflective and metacognitive thinking, encouraging creativity and intuition in problem-solving within the realm of mathematics. Despite the evident advantages, the implementation faced challenges, including student boredom, difficulty processing large data sets, and occasional misconceptions.

However, these challenges underscored the nature of PBL as a tool for developing thinking abilities rather than a perfect solution. The strategy aimed at honing students’ reflective thinking patterns and problem-solving skills, promoting autonomous learning and intellectual development. The strengths and weaknesses observed during implementation underscore the nuanced nature of PBL and metacognitive strategies, emphasizing their role in shaping not only mathematical proficiency but also broader cognitive and independent learning skills among students specializing in Office Management Automation at SMK Negeri 1 Pamekasan.

References


