Students’ mathematical reflective thinking ability through scaffolding strategies

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Abstract. Mathematics learning at school is not yet sufficient to support students’ mathematical reflective thinking ability. Students’ mathematical reflective thinking ability can be improved by facilitating students with proper learning strategies and giving feedbacks or assistance that can support mathematical reflective thinking. One of the intended strategies is a scaffolding strategy. Scaffolding can encourage and trigger students’ mathematical reflective thinking. This study was qualitative research aiming to describe students’ mathematical reflective thinking ability through scaffolding strategies. The subject of the study was 33 second grade junior high school students. Data for students’ mathematical reflective thinking ability were obtained through three subjects interviewed. Based on the result of the students’ reflective thinking test, each subject was then categorised into high, medium, or the low ability of mathematical reflective thinking. Data obtained from the interview was analysed to describe students’ mathematical reflective thinking ability. The result showed that, in general, students’ mathematical reflective thinking ability through scaffolding strategies were still low. All students achieved the reacting phase of reflective thinking ability; meanwhile, only a few students achieved the comparing and contemplating phase. Further study and research are needed to facilitate a better reflective thinking ability.

1. Introduction
Students' mathematical thinking ability has been one of the focus of mathematics learning in school. Mathematics learning in school is not only about understanding counting operations but also to construct a logical thinking ability [1]. This statement is in accordance with the purpose of mathematics learning based on the 2013 Curriculum that requires students to have good mathematical thinking ability. One of the mathematical thinking abilities is the mathematical reflective thinking ability. Reflective thinking is a part of students’ self-regulation which involves active selection in thinking activities in doing complex tasks [2]. Reflective thinking is a systematic, rigorous, and disciplined way of thinking to make meaning out of the experience and try to relate it to the next event [3]. Reflective thinking has become a skill that contributes greatly to students’ achievement and success [4]. Besides, it encourages students to develop strategies to solve problems by exploring their experience in new and more complex knowledge [5]. Therefore, reflective thinking is significantly related to mathematical problem-solving skills [6]. Reflective thinking also helps students in developing high level thinking
skills by encouraging students to relate new knowledge with previous experience; abstract thinking and conceptual thinking; the implementation of specific strategy on new tasks; and the understanding of their own thinking and learning strategies [7]. Reflective thinking ability is considered to be an important ability for students in learning mathematics.

Students with reflective thinking ability will at least show four kinds of action, namely 1) habitual action, that is realising what has been known before; 2) understanding, that is applying available knowledge without in-depth evaluation; 3) reflection, that is the process of internal evaluation and exploration of problems by connecting with related experience; and 4) critical, which involves awareness of the reasons behind the actions taken [8].

Moreover, reflective thinking ability has three stages, namely 1) reacting, that is a reaction or initial response against events, situations, or problems; 2) elaborating, that is comparing reactions obtained by referring to experience or other situation; and 3) contemplating, that is further and in-depth explanations that are constructive toward problems or difficulties [9, 10].

As for this research, the indicator used for reflective thinking ability was based on reacting, comparing and contemplating phase. Reacting phase involves students’ ability to mention things that are known and asked from question or problem. In comparing phase, students will have to relate a problem with previously faced problems and analyse theory or method considered effective for solving the problem. Meanwhile, contemplating phase consists of students’ ability to solve a given problem and make a correct conclusion from the problem faced. If students reach these phases, students will gain mathematical reflective thinking ability.

However, mathematics learning in school does not optimally support students’ mathematical reflective thinking ability. Attention to students’ reflective thinking ability is often neglected by schools both at elementary school or college [11]. Learning is generally focused on problems that are drill, algorithmic, routine, and procedural, and do not contribute much in developing higher level thinking ability [12]. Furthermore, students have not shown satisfactory results in solving questions that measure mathematical reflective thinking [13]. This statement indicates that students’ reflective thinking ability is still relatively low and in need of serious attention in learning mathematics at school.

Teachers have to understand about the use of learning strategy and teaching approach according to a variety of student learning needs [5]. Students need feedback as a medium to support reflective thinking ability. Feedbacks given can be in the form of a question, guide, or direct instruction [2]. Indirectly, students will think about how and why and they will try to explain their decision in solving a problem so that it will encourage them to think reflectively [5].

Feedbacks, as mentioned above, are a form of scaffolding. Scaffolding can help students to become a good reflective thinker [4] and support the learning process when the students cannot do it independently [14]. Scaffolding can encourage interaction between students and stimulate their critical thinking and reflective thinking ability [13]. The form of scaffolding given to the student varies; for example, it can be in the form of a question, feedback, exemplification, and more. Scaffolding in mathematics learning can change the teachers’ role from a traditional learning approach to learning that is able to guide students to develop their own thoughts [15].

Scaffolding supports students gradually by giving them appropriate and temporary help [16]. A teacher can stimulate and generate students’ thinking ability while they are struggling and saying “what happens?” Then the students create a concept of the problem, consider and analyse the solution, and ask “what could be done?” Students experiment or act by trying to apply any available solution. Finally, the students will consider the solution if it is effective or not, and see how that solution can be further adapted [7]. That is one example of implementing scaffolding that can encourage students to think reflectively. Therefore, the study aims to describe students’ mathematical reflective thinking ability through scaffolding strategy.
2. Method
This study was qualitative research that aims to describe students’ mathematical reflective thinking ability through scaffolding strategies. The subject of this study was 33 second grade students in one of the junior high schools in Banda Aceh, Indonesia. The instruments used in this study were the mathematical reflective thinking test and interview guide. The test consisted of a problem on the prism topic and has been validated by experts. Data were scored based on mathematical reflective thinking ability indicators with a score of 0 to 3 in each indicator. The score is 0 if the answer is wrong or not answer at all, 2 if the answer is incomplete, and 3 if the answer is correct and complete. Students’ answers were grouped based on the phases of reflective thinking ability: reacting, comparing and contemplating. The data obtained were then converted, and the percentage of reflective thinking ability phases achieved by students can be made.

In addition to the test, the researchers also conducted interviews. The interview involved three students out of 33 students who had taken the test with low, medium and high test results that met the indicators of mathematical reflective thinking ability. It aimed to support students’ test results and explore students' mathematical reflective thinking ability through scaffolding strategy.

3. Results and discussions
The results showed that in the first phase, reacting, students were able to answer the questions asked, and the total score obtained is 103. In the second phase, comparing, students might be able to link problems to problems have been faced and analysed theory or method considered effective for problem solving, and the total score obtained is 55. In the third phase, contemplating, students were able to solve the given problem and make the correct conclusion from the problem, and the total score obtained is 40. The percentage of the result in each phase is presented in Table 1.

| Phase     | Percentage |
|-----------|------------|
| Reacting  | 52.02%     |
| Comparing | 27.78%     |
| Contemplating | 20.20% |

Table 1 shows that the percentage in reacting phase is 52.02%, in comparing phase is 27.78%, and in contemplating phase is 20.20%. This shows that students’ reflective thinking ability is still considered low. However, among the three phases, the reacting phase has the highest score compared to two other phases. Meanwhile, only a few students achieved comparing and contemplating phase. It indicates a good result and the beginning of a good development of student reflective thinking ability considering the limited research time. If this study was conducted in more depth and the learning process had few more lessons, the results might have been more optimal. Therefore, a further study is needed so that student mathematical reflective thinking ability can be understood better.

During the learning process, teachers used scaffolding to develop students’ thinking ability and help students to go through learning difficulties, especially in solving problems and group discussion. For example, while drawing prism nets from the existing prism, the teacher will give a guide by asking the students to observe a prism image given to them carefully.

Teacher: Pay attention to the image of prism! Imagine if the prism surface is opened, then how the prism net is formed? Remember, the prism nets drawn must be fit with the given prism, observe all the name of the prism edges carefully!

Student: (worked according to instructions from the teacher and calculated area formed by the prism nets to obtain prism surface area)

Teacher: What is the purpose of calculating the area of planes, what is its relation with the prism surface area?
Student: The prism is formed by several planes. If each area of the planes is added up, prism surface area could be obtained.

The teacher also gave several questions to stimulate students to think, for example, “what if the base of the prism is shaped by other plane figures, how would you calculate that prism surface area?” and so on.

Besides giving instructions that help to achieve learning purposes and form the students’ mindset, the teacher also occasionally asked the students’ opinions and reasons for the given solution so that the students involved more in the learning process. More often, the teacher asked the students to describe the solution strategy and students involved more in that class it will increase their mathematics understanding and achievements. It also makes the students’ mind more open [17]. However, a teacher also needs to notice that the scaffolding must not make the students passive and dependent.

After group discussion, at the end of the learning process, students were given the mathematical reflective thinking test. Then after the score of each subject was obtained, based on the scores, a student was picked as representative of each score grade: high, medium, and low. A high score student was coded with S-01, a medium score student was coded with S-02, and a low score student was coded with S-03.

In the reacting phase, student S-01 was able to reveal the information obtained from questions in their own sentences during the interview. Furthermore, the student could illustrate the information obtained in an image (see figure 1).

Translation:
Known: Quadrilateral prism 15 pieces without a lid
Size 40 cm × 40 cm × 80 cm
Made from wood sized 3 m × 20 cm
Asked: The amount of wood used

Translation:
Known: Trash bin in the shape of rectangular prism without a lid
Each sized 40 cm × 40 cm × 80 cm
Wooden board sized 3 m × 20 cm
Asked: Determine the number of wooden boards needed for 15 trash bins!
When interviewed, the S-01 explained “What is given in the problem is that there are 15 quadrilateral prisms without lids. The size is 40 cm × 40 cm × 80 cm (while drawing the prism known)”. This was done by the student to make it easier to understand the problem. S-01 added, “Size of the board to make a prism-shaped bin is 3 m × 20 cm”. S-01 could also repeat the questions correctly and mention the correlation between information known and problem asked. Together with S-02 and S-03, they could fully mention information known and problem asked. S-02 did not write the problem asked in the answer sheet (see figure 2); however, the student still mentioned it in the interview.

S-01 in comparing phase was able to relate the problems faced to the problem currently asked and explained a method considered effective to solve the problem according to the test result. As for S-02, he was less able to explain the connection or link. S-02 revealed, “The connection with square and rectangle is because the base of the prism is shaped like a square and the sides are like rectangles”. However, it will be better if S-02 add the connection to the prism surface area. But S-02 was able to explain method or steps to solve the problem although it was incomplete. Meanwhile, S-03 looked confused when asked to explain the connection to the previous problems and problems currently faced. He admitted that he was not getting used to receiving problems such as the problem given and was unable to explain the method to solve the problem. S-03 only explained, “Firstly, determine board area to be constructed to the prism, the area formula is p × l, after that I don’t know!”. The teacher then guided “Try to reread the question, understand the information known and identify the problem!”. However, the student was unable to explain it clearly.

Next, in completing contemplating phase, S-01 was able to solve the problem given along with the method. However, S-01 did not write the conclusion from the problem faced, even though in the interview S-01 was able to mention it (see figure 4) so is S-02 despite few mistakes in the problem solving process (see figure 5).

![Figure 4. S-01’s solution in comparing and contemplating phase.](image)
Figure 5. S-02’s solution in comparing and contemplating phase.

S-02 also explained the steps of the problem solving process, "First, calculate square-shaped prism base area. Next, calculate the base circumference, prism surface area, board area, then determine total boards needed to construct the prism, lastly it is known that the total boards needed is 36 boards!". Meanwhile, S-03 was unable to solve the problem given. The answer sheet was left blank so that there was also no conclusion made (see figure 6).

Figure 6. S-03’s solution in comparing and contemplating phase.

The finding showed that students’ mathematical reflective thinking ability is still considered low. However, the students are able to reach the reacting phase. A small number of students can reach comparing and contemplating phase. Contemplating is the highest phase of reflective thinking that
requires the students to solve the problem and to make the correct decision against the problems [18]. In reacting phase, it is uncommon for students to experience difficulties. Then the teacher should guide students to carefully reread the question so that the students can describe what is known and asked from the questions and its relevance. Moreover, the students will be able to distinguish which sentence can be considered as known and which sentence is asked [19]. Scaffolding strategy can make the student more active in the learning process where students can respond to every feedback given by the teacher so that it will improve students’ reflective thinking ability. This is due to that reflective thinking requires active participation from a student as a feedback receiver [2]. However, it cannot be denied that not all students can respond spontaneously to the scaffolding given. The student may not understand and cannot interpret direct feedback [20, 21]. Moreover, it also depends on each student’s needs [2]. Therefore, a skilful teacher is needed to handle such a situation.

4. Conclusion
It can be concluded that students’ mathematical reflective thinking ability, in general, is still considered as low. The students are only able to reach reacting phase from reflective thinking ability. Moreover, not all students able to reach all phases in mathematical reflective thinking ability (reacting, comparing, and contemplating). However, the scaffolding strategy is very helpful in aiding students’ difficulties during the learning process and guide the students to develop mathematical reflective thinking ability through instructions and guidance from the teacher.

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