MURRDERR strategy in developing mathematical investigation thinking skill of elementary school pre-service teacher

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Abstract. Investigation process is crucial in learning mathematics. In other words, mathematical investigation skill is important to support obtaining the objectives of mathematics learning. In this case, this study aimed at discovering the effectivity of MURRDERR (metaphor, understanding, recalling, recognizing, detecting, elaborating, reviewing, and respecting) strategy in developing investigative thinking skills of elementary school pre-service teacher. This study employed quasi-experiment that involved 119 elementary school pre-service teachers, which was divided into three groups. The data was obtained from pre-tests and post-tests. It was found that MURRDERR strategy was more effective in developing mathematical investigative thinking skill. Moreover, it would be more effective if the teaching materials have been prepared through several didactic design steps that would minimalize the barriers faced by pre-service teacher to learning. According to the findings, it could be concluded that MURRDERR strategy could be adopted as an alternative in developing mathematical investigative thinking skills.

1. Introduction
The actual issues in today’s mathematics learning are how to develop high-order thinking skills (HOTS) and to make it an important goal to be achieved in mathematics learning [1]. One of the mathematical thinking skills that belong to high-order thinking is the skill to have investigative thinking. Mathematics learning contains a process in which learners can solve the problems in their real lives in meaningful contexts, be able to communicate their ideas with mathematical language and symbols, make conjectures, and establish or test the truth of solutions they have gained [2]. The indicator of the success of the mathematics learning process is a part of mathematical investigative thinking [3, 4].

In daily life, especially in the activities of mathematics learning, learners frequently face problems that cannot be immediately solved. In fact, the problem they faced is truly essential and useful to solve. To find a solution, they need to think, make guesses, look for simple formulas, and conduct investigations by experimenting, collecting data, observing, identifying patterns, and believing by proving the truth. Moreover, if they obtain some solutions, they must be careful in selecting the best one [3, 4].

In fact, some learners still have some assumptions that mathematics is a difficult and unpopular field of study. Moreover, a particular finding showed that some students of elementary school pre-service teachers still had anxiety or fear when they join the mathematics course [5]. Only a few of them were able to explore and understand mathematics as a knowledge that can train critical, creative, and
investigative thinking skills. In fact, they know that mathematics is essential for their lives. Furthermore, the findings obtained by National Institute of Education Singapore showed that pre-service teachers were still incapacitated and unaccustomed to investigative thinking [6, 7].

One of alternative strategies that can be expected to develop the investigative mathematical thinking skill is MURRDERR (metaphor, understand, recall, recognize, detect, elaborate, review, and respect) strategy. This strategy is the modification result of MURDER (mood, understand, recall, detect, elaborate, and review) strategy [8]. The phases conducted in MURRDERR strategy is elaborated below. The first step is Metaphor. It aims at boosting the interest and motivation of pre-service teachers through a series of values delivered. The use of metaphor in the learning process is essential since it can be the trigger of creating interest, motivation, and positive thoughts of pre-service teachers. These things bring them into an atmosphere of joy, freshness, and solemnity in appreciation, and then create profound meaning in the next learning process [9, 10]. The second step is Understand. It emphasizes the process of understanding the problem and reading certain material of manuscript without memorizing. In this step, the pre-service teachers start doing individual investigation activities. The third step is Recall and the fourth step is Recognize. They are conducted by a group member to recall and recognize verbally about what they have learned. In other words, the third and fourth steps are the beginning of investigative activities in groups. The fifth step is Detect. It means that other members try to scrutinize, examine carefully, and criticize the appearance errors or omissions in the notes, or perhaps differences of views that occur among members. The sixth step is Elaborate. It means that partners in groups try to repeat steps 2, 3, 4, and 5 for next section of material/topic. The seventh step is Review. It means that pre-service teachers begin to consider and interpret the results of their work and transmit them to other partners in the group before delivering it in the class discussion forum. The last step is Respect. It implies that every pre-service teacher appreciates each other who have given some contribution.

2. Method
This research was conducted through two stages, namely: 1) preparation stage, and 2) implementation stage. In the preparation stage, the developmental research of teaching materials based on MURRDERR problem-based learning was conducted by using Didactical Design Research (DDR). DDR is a research method developed from tacit didactical and pedagogical knowledge [11, 12]. DDR has three stages, namely: didactic situation analysis, didactic metapeda analysis, and retrospective analysis [12]. After the DDR stage was complete, the research was continued by the quasi-experimental method with non-equivalent control group design since it was impossible to fully control the research sample. Hence, the subjects were not randomly grouped and the subjects situation was accepted as it was [13]. There were 119 elementary school pre-service teachers as the research samples, which were divided into three groups. The first group’s learning activity implemented MURRDERR strategy with DDR teaching material, the second group’s learning activity implemented MURRDERR strategy, and the third group’s learning activity implemented conventional strategy.

3. Findings and discussion
Based on both parametric [14] and nonparametric [15] of statistical hypotheses testing, the following results were obtained.
Based on Kruskal-Wallis test on the table 1, it is known there was entirely no difference in the initial investigative thinking skill in all three groups. If the initial mathematical investigative thinking skill were classified based on the students’ educational background, there would be IPA (Ilmu Pengetahuan Alam/Science Studies) and non-IPA groups’ students. Based on Mann-Whitney test, it is known that from the beginning, both groups (IPA and Non-IPA) had significant differences in investigative thinking skill. This difference was possible to occur because the culture built in the environment or science majors was in contrast to the culture in the non-IPA environment or majors. In line with Pavlov’s conditioning theory [18, 19], the students with IPA educational background faced more tasks that require skills to investigate a scientific problem. Thus, the frequent investigative activities formed some habits and these habits eventually contributed in the formation of abilities.

Furthermore, based on Kruskal-Wallis test followed by Multiple Comparisons between treatments, testing differences in initial mathematical investigative thinking skill was conducted among high, medium and low groups [15]. As a result, there was a difference of initial skill in mathematical investigative thinking. The tendency was that the students who already had a higher mathematical basic skill were also better in the skill of initial mathematical investigative thinking.

The rejection of statistical hypotheses regarding the differences in achievement of final mathematical investigative thinking skill in the three groups (MURRDERR-DDR, MURRDERR, and conventional) showed that deliberate treatment in the form of a learning approach had significantly different effects both in the final achievement and investigative thinking skill improvement. The test results showed that students who attended the MURRDERR-DDR learning acquired the highest achievement and enhancement, followed by students’ achievement in the MURRDERR group, and then the students’ achievement in the conventional group as the lowest attainment. These three findings provided strong guidance that MURRDERR strategy of learning was significantly more effective in helping students to achieve and develop mathematical thinking skill, compared to conventional learning. This was in line with previous findings that the learning based on strategies suppression to solve more problems could involve the learners to achieve high thinking and problem-solving skills [20].

However, it is interesting to discuss something happened in the experimental group. The students in the MURRDERR-DDR group gained better achievement and improvement in mathematical investigative thinking skill than the students who followed MURRDERR strategy only. It means that the higher quality teaching materials played an important role to improve the quality of students’

| Table 1. The Mathematical Thinking Skill of Elementary School Pre-Service Teachers |
|-----------------|--------|--------|--------|--------|----------------|--------|--------|--------|
| Factor          | Group  | Stat.  | MURRDERR-DDR | MURRDERR | Conventional |
|                 |        |        | Pre | Post | Pre | Post | Pre | Post |
| Educational     |         |         | g   | g   | g   | g   | g   | g   |
| Background      |         |         | n   | x   | s   | n   | x   | s   |
|                  | IPA     |         | 22  | 21  | 18  |      |      |      |
|                  | Non-IPA |         | 18  | 19  | 21  |      |      |      |
| Basic Mathematical Skill | High |         | 22  | 22  | 23  |      |      |      |
|                  | Medium  |         | 22  | 22  | 23  |      |      |      |
|                  | Low     |         | 9   | 9   | 9   |      |      |      |
|                  | Total   |         | 40  | 40  | 39  |      |      |      |

(Pre = Pretest; Post = Posttest; g = Normalized gain [16]
Improvement: [g ≥ 0.7] = high; [0.7 > g ≥ 0.3] = medium; [g < 0.3] = low) [17]
learning outcomes. Conducting a didactic design study would help reducing the learning barriers of learners so that the materials they learn can be more suited to their needs [12].

The effectiveness of all three types of strategies or approaches had also been measured in this research based on paired sample t-test or with Wilcoxon signed rank test if the parametric rules could not be performed [15]. As a result of the analysis in Table 1, the MURRDERR learning strategy using DDR study materials could significantly improve the critical thinking skill of elementary school pre-service teachers. The average of students’ initial skill was 20.25, while the average of students’ final skill eventually reached 67.12. The magnitude of the mean difference before and after learning activities reached 46.88. If it was calculated using normalized gain, the improvement of students’ mathematical critical thinking skill in the MURRDERR-DDR group was 0.59, which was included in the moderate improvement category.

Furthermore, in a group that used MURRDERR strategy with ordinary teaching materials, it was actually also effective in improving students’ mathematical investigative thinking skills. The average of students’ initial skill was 18.12 and the final skill reached 60.88, showing the mean difference 42.76. It means that the magnitude of its improvement based on normalized gain was 0.53. It indicated that the improvement of students’ mathematical investigative thinking skill in that group was in the medium category.

In relation to the effectiveness of conventional learning in improving students’ mathematical investigative thinking skill, it was found that conventional approaches also significantly improved a good investigative thinking skill as well. The average of students’ initial skill was 19.10 and the final skill was 53.97, the magnitude of mean difference before and after learning reached 34.87. It indicated that the improvement in investigative thinking skill with conventional learning was 0.43, showing the category of moderate improvement.

From the aforementioned findings, it is clear that both the problem-based learning approach based on MURRDERR strategy with the teaching materials of DDR and non-DDR studies and conventional approaches were significantly effective in improving critical, creative, and investigative mathematical thinking skill of students or learners in general. It showed that it was unwise if conventional learning was always blamed for learning failure when the teachers or lecturers implemented the optimal conventional learning based on their characteristics. According to Nisbet, there was no way of the most correct learning and the best way of teaching [19]. Each approach used in teaching has its own specificity that contains its advantages and disadvantages. Nevertheless, the advantages of problem-based learning MURRDERR strategy contributed to the results of better achievement and improvement of mathematical investigative thinking skill than just conventional learning.

Based on the educational backgrounds, the IPA and non-IPA students groups provided an entirely interesting variety of results in terms of final achievement and improvement in mathematical investigative thinking skill. Based on an independent sample t-test to examine the difference of the average of final achievement and improvement the mathematical investigative thinking skill, all students in the IPA group was significantly better than what had been achieved by the students in the non-IPA group.

There were interesting findings that the improvement of mathematical thinking skill of Non-IPA students in the MURRDERR-DDR group was significantly better than the conventional group. This finding reinforced the opinion that the learning, which emphasizes the problem as the fundamental process to be carried out, could play a big role in improving the students’ thinking skill in which its framing effect in the form of conflict of thought also provided the opportunity for learners to monitor their problem-solving activities [21].

4. Conclusion
The results of the discussion above provided a clear description that the learning with MURRDERR strategy could be a good alternative in developing the mathematics investigative thinking skill of elementary school pre-service teachers. In addition, the use of teaching materials based on didactic design research helped optimizing the attainment of high investigative thinking skill.
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