Developing mathematical investigative attitudes of prospective primary school teachers

M Maulana*, N Hanifah, A N Aeni, J Julia and A A Syahid
Prodi PGSD Sumedang, Universitas Pendidikan Indonesia, Bandung, Indonesia

*maulana@upi.edu

Abstract. Investigation activities are inevitable in mathematics learning. Hence, students are expected to perform their investigative attitude during their mathematics learning to achieve the learning objectives. This study aims at determining the effectiveness of the use of MURRDERR (metaphor, understand, recall, recognize, detect, elaborate, review, and respect) strategy in developing the investigative attitude of prospective primary school teachers. The research method with didactic and quasi-experimental designs was applied to 119 prospective primary school teachers. Instruments in the form of initial and final attitude scales were used to obtain respondents' investigative attitudes data. The results showed that MURRDERR strategy was effective in developing mathematical investigative attitudes, especially in terms of: discussing strategies for solving problems; trying new ideas; choosing systematic ways; noting important things; working freely and jointly; asking to acquire solution strategy; and being curious about presumption before they were proven. Based on these results, it could be concluded that MURRDERR strategy could be used as an alternative learning to develop mathematical investigative attitudes.

1. Introduction
One of the actual issues in mathematics learning nowadays is how to develop high-order thinking skills (HOTS) which are also accompanied by the development of aspects of high-order thinking attitudes or dispositions [1,2]. One aspect of attitude that is very rarely examined, but its existence is very important in a mathematical process, is an investigative attitude, or in some literature is often referred to as an investigative disposition [2].

Mathematics learning contains a process in which students can discuss strategies to solve problems; try new ideas; choose systematic ways; record important things; work freely and together; ask to obtain a form of solution strategy; curious about the allegations before being proven [3]. The indicator of the success of the mathematics learning process is part of the mathematical investigative attitude [2-5].

In fact, there are still many assumptions for some students that mathematics is a difficult and unpopular field of study, and there are even findings that many students who are prospective primary school teachers still have feelings of anxiety or fear when learning mathematics [6]. Thus, it seems difficult to develop a good investigative attitude if students still feel anxious and dislike of Mathematics. In fact, they themselves know that mathematics is important for their lives. Even the findings at the National Institute of Education Singapore show that prospective teachers are still not able and have not been accustomed to conducting investigative processes [7,8].

One alternative strategy that deserves to be suspected of developing mathematical investigative attitudes is the MURRDERR strategy (metaphor, understand, recall, recognize, detect, elaborate,
review, and respect). This strategy is a result of modification of the MURDER strategy (mood, understand, recall, detect, elaborate, and review) [9]. The phases carried out in the MURDERR strategy will be described below. The first step: Metaphor, aims to boost the interest and motivation of prospective teachers, as well as to develop character through a series of values conveyed. The use of metaphors in the learning process is very important, because it can be a trigger for the creation of interest, motivation, and positive thoughts of prospective teachers. These are things that bring prospective teachers into an atmosphere full of joy, renewed, solemn in appreciation, thus creating a deep meaning in the next learning process [10,11]. Next step two: Understand, which emphasizes the process of understanding the problem, reading certain parts of the text without memorizing. It is at this second step that the prospective teacher begins to conduct individual investigation activities. The third step: Recall and fourth: Recognize, is a step taken by one group member to remember and re-express verbally about what he has learned. In other words, the third and fourth steps are the beginning of a group investigation. Step five: Detect, other members try to observe, examine carefully, and criticize the emergence of errors or omission of records, or perhaps differences in views that occur among fellow members. Sixth step: Elaborate, meaning fellow partners in the group try to repeat the steps 2, 3, 4, 5 for the next part of the material/topic. Then seventh step: Review, prospective teachers begin to consider and interpret the results of their work, and transmit them to other partners in the group before submitting them to the class discussion forum. The final step: Respect, means that every prospective teacher respects each other who have contributed.

2. Methods
This research was carried out in two stages: a) the preparation stage, and b) the implementation phase. In the preparation stage, developmental research is carried out in MURDERR's strategy-based learning teaching materials using didactical design research (DDR). DDR is a research methodology developed from didactic tacit and pedagogical knowledge [12,13].

This DDR has three stages, namely: didactic situation analysis, metapedadidactic analysis, and retrospective analysis [13]. After the DDR phase was completed, the study continued with the quasi-experimental method with the non-equivalent control group design, because it was impossible to control the research sample fully, so that the subjects were not randomly grouped, and the subject state was accepted as is [14]. The sample in this study amounted to 119 people, which was distributed into three classes. The first class is given MURDERR strategic learning with DDR teaching materials. The second class is given MURDERR strategic courses only, and the third class receives conventional learning activities.

3. Results and discussion
Based on statistical hypothesis testing both parametric [15] and nonparametric [16], the following results are obtained.

Table 1. Mathematical investigative attitudes of prospective primary school teacher.

| Factor         | Group             | Stat. | MURDERR-DDR Pre | MURDERR Pre | Conventional Pre | MURDERR Post | Conventional Post |
|----------------|-------------------|-------|-----------------|-------------|------------------|--------------|------------------|
|                |                   |       | g               | g           | g                | g            | g                |
| Educational Background | Natural Science | n     | 22              | 21          | 18               | 21           | 22               |
|                 |                   | 𝜇     | 68,47           | 73,44       | 70,57            | 72,48        |
|                 |                   | s     | 6,79            | 5,05        | 6,96             | 6,33         |
|                 |                   | s     | 6,79            | 5,05        | 6,96             | 6,33         |
|                 |                   |       | 6,79            | 5,05        | 6,96             | 6,33         |
|                 |                   |       | 6,79            | 5,05        | 6,96             | 6,33         |
|                 | Non-Natural Science | n     | 18              | 19          | 21               | 21           | 18               |
|                 |                   | 𝜇     | 67,54           | 69,53       | 66,15            | 68,19        |
|                 |                   | s     | 5,89            | 5,56        | 4,72             | 4,64         |
|                 |                   | s     | 5,89            | 5,56        | 4,72             | 4,64         |
As the results of the analysis in Table 1, through One-Way Anova, it is known that overall there is no initial investigative attitude difference in the three groups. If the initial mathematical investigative attitude is grouped based on the educational background of students, there are students of Natural Sciences and Non-Natural Sciences. Through the t-test, it was found out that from the beginning both groups (Natural Sciences and Non-Natural Sciences) had significant investigative attitude differences. This difference is possible because the culture that is built in the environment or science majors, is different from the culture in the Non-Natural Sciences department or department. Just as Pavlov’s conditioning theory [19,20], students who have a science education background are more likely to be faced with tasks that require the skills to investigate a scientific problem. Thus, frequent investigative activities form habits, and these habits ultimately contribute to the formation of attitudes.

Then with regard to testing the differences in early mathematical investigative attitudes between high, medium and low groups, through One-Way Anova followed by Scheffe test (post-hoc) [15]. As a result, there are differences in initial investigative attitudes, with the tendency that students who have higher basic mathematical abilities are better in their initial mathematical investigative attitudes.

By using the Kruskal-Wallis test followed by Multiple Comparison Between Treatments [16], it was found that there was a rejection of the statistical hypothesis regarding differences in mathematical investigative attitudes from beginning to end in the three classes (MURRDERR-DDR, MURRDERR, and conventional). This shows that the treatment that is intentionally carried out in the form of a learning approach has significantly different influences. The test results show that students who take MURRDERR-DDR learning get the highest increase, followed by student achievement in the MURRDERR class, and the lowest achievement is students in the conventional class. These three findings provide strong guidance, that MURRDERR strategic learning is significantly more effective in helping students develop mathematical investigative attitudes, compared to conventional learning. This is in line with previous findings, that learning is based on the emphasis on strategies to solve problems more can involve students during the learning process, more active in solving problems, and developing aspects of their attitudes [2,21].

Further study regarding what happened in the experimental class was interesting to discuss here. Students in the MURRDERR-DDR class show better investigation activities during the learning process than students who follow the MURRDERR strategy only. This means that higher-quality teaching materials play an important role in improving the quality of the learning process carried out by students. By conducting a didactic design study, it will help reduce learning barriers to learners so that the material they learn can be more in line with their needs [13].

The effectiveness of the three types of strategies or approaches taken has also been measured in this study through paired sample t-tests, or by Wilcoxon signed ranks test if parametric rules cannot be implemented [16]. As the results of the analysis in Table 1, MURRDERR strategic learning by using teaching materials from the DDR study, can significantly improve the investigative attitudes of

Table 1. Cont.

| Mathematical Prior Knowledge | n | \( \bar{x} \) | s | \text{High} | \text{Medium} | \text{Low} |
|-----------------------------|---|-------------|---|-------------|-------------|----------|
| High                        | 9 | 70.05       | 7.01 | 76.30       | 5.86        | 0.21     |
| Medium                      | 9 | 68.93       | 5.95 | 75.46       | 5.06        | 0.22     |
| Low                         | 9 | 63.89       | 5.28 | 71.53       | 3.35        | 0.08     |
| Total                       | 27| 68.05       | 6.34 | 74.77       | 5.83        | 0.21     |

(Pre = Pertest; Pos = Post-test; \(<g> = \text{Normalized gain}) [17]
(Improvement: \(g \geq 0.7\) = High; \(0.7 > g \geq 0.3\) = Medium; \(g < 0.3\) = Low) [18]
prospective primary school teacher students. The average initial attitude of students was 68.05, while the average attitude finally reached 74.77. If calculated using normalized gain, the increase in students' investigative mathematical attitudes in the MURRDERR-DDR class is 0.21 or 21%.

Then in the class that uses the MURRDERR strategy with ordinary teaching materials, it is actually also effective in improving students' mathematical investigative attitudes. The average initial attitude of students was 66.27, and the final attitude reached 71.58. The magnitude of the increase based on normalized gain is 0.16 or 16%.

With regard to conventional learning effectiveness in improving students' mathematical investigative attitudes, obtained findings that conventional approaches cannot significantly improve investigative attitudes, with an average initial attitude of 68.19 and a final attitude of 70.17. This indicates an increase in investigative attitudes with conventional learning reaching only 0.06 or 6%.

From the findings above, clearly both the MURRDERR strategic problem-based learning approach which is based on teaching the results of DDR and non-DDR studies, as well as conventional approaches, is significantly effective in improving the quality of investigative attitudes of students in general. Thus, it is very unwise if conventional learning is always considered a failure in improving the quality of learning. Of course conventional learning has a good impact if the teacher or lecturer continues to carry out conventional learning with optimal characteristics. As with the old opinion of Nisbet, that there is no right way to learn, and the best way to teach [19]. Every approach used to teach has its own characteristics, which contain its advantages and disadvantages. However, there are advantages that the MURRDERR strategy has, contributing to better mathematical investigative attitudes than conventional learning.

It can be seen from the achievement of mathematical investigative attitudes of Non-Natural Science students in the MURRDERR-DDR class significantly better than conventional class. It strengthens the opinion which states that learning emphasizes the problem as the basis of the process to be carried out, framing effect these problems in the form of conflict of thought, which also provide opportunities for students to monitor the activities of problem solving, can play a major role in improving the thinking skills of the students concerned [22].

4. Conclusion
The discussion described above gives the conclusion that learning with the MURRDERR strategy can be a good alternative in developing the mathematical investigative attitudes of prospective primary school teachers, especially in seven aspects. Those aspects are: discussing strategies for solving problems; try new ideas; choose systematic ways; record important things; work freely and together; ask to obtain a form of solution strategy; curious about allegations before being proven. In addition, the use of teaching materials based on didactic design research helps to optimize the achievement of high mathematical investigative attitudes.

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