The enhancement of students' mathematical self-efficacy through teaching with metacognitive scaffolding approach

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Abstract. This research aims to investigate the enhancement of students’ mathematical self-efficacy through teaching with metacognitive scaffolding approach. This research used a quasi-experimental design with pre-post respon control. The subjects were pre-service elementary school teachers in a state university in Bandung. In this study, there were two groups: experimental and control groups. The experimental group consists of 60 students who acquire teaching mathematics under metacognitive approach, while the control group consists of 58 students who acquire teaching mathematics under direct approach. Students were classified into three categories based on the mathematical prior ability, namely high, middle, and low. Data collection instruments consist of mathematical self-efficacy instruments. By using mean difference test, two conclusions of the research: (1) there is a significant difference in the enhancement of mathematical self-efficacy between the students who attended the course under metacognitive scaffolding approach and students who attended the course under direct approach, and (2) there is no significant interaction effect of teaching approaches and ability level based on the mathematical prior ability toward enhancement of students’ mathematical self-efficacy.

1. Introduction
Self-efficacy is an important part of learning mathematics. People with higher self-efficacy have a stronger commitment to their goals than people with lower self-efficacy [1]. Students with higher mathematical self-efficacy will be more diligent when faced with difficult mathematical problems and more accurate in computing mathematics than students with lower mathematical self-efficacy. Self-efficacy is important for prospective elementary teachers [2]. This is because a student mathematical self-efficacy deals with the teachers’ mathematical ability and mathematical self-efficacy. It can be said that the development of mathematical self-efficacy of prospective elementary school teachers is very important. One effort to develop the mathematical self-efficacy of prospective elementary school teachers is to look for factors that allegedly improve the mathematical self-efficacy. One of the factors is the learning approach used by lecturers. Carpenter & Gorg recommends an approach that includes strategy, planning, monitoring, and evaluation throughout the learning process [3]. This approach is known as the metacognitive approach [4]. Although the metacognitive approach is recommended by the expert, this approach still has weaknesses, for example when the student realizes that he does not understand or cannot find a way to solve a mathematical problem, he will be silent in his own confusion. According to [5] the metacognitive approach (without scaffolding) was unable to elevate the success of mathematics learning [5,6]. In contrast, if the scaffolding approach is run on its own (does not involve metacognitive) students are weak in developing their own way of solving the problems they face [7 8].
To overcome this problem, the help of a lecturer is still needed. Thus the metacognitive approach needs to be combined with scaffolding, which is the provision of assistance from the lecturers in enhancing students' ability to deal with their tasks.

For classroom learning involving many students, usually more than 30 people, the metacognitive scaffolding approach is almost impossible to implement. Therefore, this approach needs to be combined with cooperative learning. In Cooperative Learning, students with less math skills can imitate the work habits of higher students; and in the process of explaining the material, the student with high mathematical ability can develop a stronger mastery and a deeper understanding for himself about the task at hand. There is an indication of the merging of the students' ability to work together in accomplishing mathematical tasks [9], and cooperative learning does not entirely have a positive effect on students' mathematical self-efficacy [10]. Thus, the approach of metacognitive scaffolding in the cooperative learning pattern is expected to be more student self-efficacy mathematically.

Although many studies have examined the effect of a metacognitive, scaffolding or cooperative learning approach to mathematical self-efficacy at a certain level of education, there is no research aimed at reviewing the enhancement of mathematical self-efficacy of low, medium and high mathematics students through a metacognitive scaffolding approach in cooperative learning pattern, hereinafter called metacognitive scaffolding approach. Thus, the purpose of this study is to find out the extent of mathematical self-efficacy of students after obtaining a metacognitive scaffolding approach.

Metacognitive scaffolding approach in this study is a teaching approach that is marked with several activities, namely: (1) lecturer gives mathematical problems to students; (2) students, in small groups, try to solve the problems; and (3) lecturer provide assistance to groups of students when they stuck in solving the problems, which is gradually reduced and eventually the students are able to independently assume full responsibility for the mathematical tasks that must be completed. While direct approach or conventional approach is a teaching approach that is marked with several activities, such as lecturer explains or manipulate a concept, provide an opportunity for students to ask, demonstrate completion of a problem, provide exercises that should be completed by the students, ask some students to re-write the answer on the board, give comments on the students’ answer, and provide homework if deemed necessary.

The research questions were, “Is the enhancement of mathematical self-efficacy ability of students’ who acquire teaching under metacognitive scaffolding approach better than students who acquire teaching under direct approach?” and “Is there any interaction effect of teaching approach and students’ prior mathematical ability toward the enhancement of mathematical self-efficacy ability?”

2. Methods

2.1. Research Design
The research method was a quasi-experimental. The experimental group was students who acquire teaching mathematics under metacognitive scaffolding approach, while the control group were students who acquire teaching mathematics under direct approach. The research design was a control group pre-post response, as follows

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Description:
1. O: Pre-Post response.
2. ×: Treatment in the form of teaching with metacognitive scaffolding approach.

2.2. Population and Sample
Population of the study was all students of Elementary School Teacher Education Program who received mathematics education course, at a university in Bandung. Whereas the sample was 118 students; 60 students as an experiment group and 58 students as a control group.
2.3. Research Procedure
The research was initiated by determining the sample. After the sample was set, each student was given a prior mathematical ability test. The test is intended to classify students based on prior mathematical abilities (high, middle, and low). After the experimental and the control groups were formed, the students were given a series of questions (pre respon) and after providing a treatment, they were given a series of questions (post respon).

2.4. Data Analysis
For the first research question, the data would be analyzed by using a mean difference test (t-test, t'-test, or M-W test), whereas the second one would be analyzed by using two-way ANOVA test if the conditions applied, or by using one-way ANOVA or Kruskal-Wallis test. The second research question was related to students’ prior mathematical ability (PMA) that described students’ mathematical knowledge and skills before they were included in the study as subjects. Data of PMA were obtained from the test on PMA held prior to the implementation of the research. Based on the PMA test, there were three criteria for students, namely high, middle, and low both for the experimental and the control groups.

3. Results and Discussion
3.1. Result
The results of the descriptive statistical analysis of students' mathematical Self-Efficacy are presented in Table 1 below.

| Group   | Pre-respond Mean | SD | Post-respond Mean | SD | Gain Mean | SD |
|---------|------------------|----|-------------------|----|-----------|----|
| Experiment | 25.43            | 13.45 | 55.43             | 17.75 | 30.00     | 13.09 |
| Control    | 26.45            | 13.46 | 40.71             | 16.90 | 14.26     | 12.28 |

Ideal Maximum Score (IMS) = 100.00

From the Table 1 above, it appears that the enhancement of students’ mathematical self-efficacy who received teaching with metacognitive scaffolding approach (experimental group) is relatively higher than students who received learning by direct approach (control group). The results of inferential statistical analysis for the mathematical self-efficacy of the experimental and control groups are presented in Table 2 bellow.

| Variable | Group              | Difference Test | Statistic Test | Sig. | Conclusion |
|----------|--------------------|-----------------|----------------|------|------------|
| MSE 1 (Mix) | Experiment | M-W test       | 0.874          | Not Different |
| MSE 2 (Mix) | Control           | M-W test       | 0.900          | Not Different |
| MSE 1 (Low Ability) | Experiment | t-test          | 0.082          | Not Different |
| MSE 2 (Low Ability) | Control           | t-test          | 0.012          | Not Different |
From Table 2 it can be stated that there is a significant difference in the enhancement of mathematical self-efficacy between students who received learning with metacognitive scaffolding approach (experimental group) and students who received learning by direct approach (control group), both reviewed overall (combined) and reviewed based on the level of initial mathematical ability (low and high), except on middle level of prior mathematical ability. If this result is related to the result in table 1 then it can be concluded that the enhancement of mathematical self-efficacy of students who get the learning with metacognitive scaffolding approach is higher than the students who get the learning with the direct approach.

The interaction effect between teaching approaches and prior mathematical ability toward enhancement of students’ mathematical self-efficacy would be tested by using Two Ways ANOVA. Before using the Two Ways ANOVA, it was necessary to be viewed whether the data of each factor was distributed normally. The result of Distribution Normality was presented in Table 3.

### Table 3. Data Distribution Normality of Mathematical Self-Efficacy Based on Group and Prior Mathematical Ability (The level of significance $\alpha = 0.05$)

| Group | Ability | Distribution Normality Test | Sig. | Conclusion |
|-------|---------|------------------------------|------|------------|
| Experiment | -       | Normal                       | 0.683 | Normal |
| Control    | -       | Not Normal                   | 0.001 | Not Normal |
|           | Low     | Normal                       | 0.337 | Normal |
|           | Middle  | Not Normal                   | 0.029 | Not Normal |
|           | High    | Normal                       | 0.124 | Normal |

From Table 3 it appeared that the condition for using Two Ways ANOVA was not sufficient. Therefore, the interaction effect was analyzed using test of difference of the gain among prior mathematical ability levels (low, middle, and high), both in the experimental and the control groups, as presented in Table 4.

### Table 4. Test of Difference of Mathematical Self-Efficacy between Experimental and Control Groups Based on the Ability Levels (The level of significance $\alpha = 0.05$)

| Variable | Ability Level | Difference Test | Sig. | Conclusion |
|----------|---------------|-----------------|------|------------|
| MPSA Gain of Experimental Group | Low | One-Way ANOVA | 0.542 | Not Different |
|          | Middle        |                 |      |            |
|          | High          |                 |      |            |
|          | Low           |                 | 0.775 | Not Different |
From Table 4, It can be concluded that there is no significant interaction effect between teaching approaches and prior mathematical ability toward enhancement of students' mathematical self-efficacy. The result of the study indicates that metacognitive scaffolding approach could enhance students' mathematical self-efficacy. In this approach, learning was begun with solving a mathematical problem. In case of a student stuck in solving the problem, the teacher provided a question so that he/she can related the problems with the prior problems that had been completed.

### 3.2. Discussion

The effectiveness of the metacognitive scaffolding approach supports previous findings, that metacognitive scaffolding not only improves problem solving and mathematical communication, but also improves student self-efficacy. The results of this study are consistent with the finding that is, mathematical self-efficacy is more closely related to the use of metacognition and reflection strategies than in deep comprehension and memorization strategies11. In the metacognitive scaffolding approach, the lecturer asks questions directed to the student to recall the mathematical concepts he has mastered, or his success in solving the problem. The emergence of the students' beliefs occurred after they had identified their ability, that Self-efficacy would be obtained if students identified the ability to be displayed1.

Learning with metacognitive scaffolding approach begins with the filing of mathematical problems. Through this problem, students discuss and share experiences about mathematical ideas. The interaction between students in cooperative learning provides an opportunity for him to improve self-efficacy1. The results of this study also revealed that students from the high group had the highest mathematical self-efficacy compared to the other two groups. This is in accordance with the opinion which states that the self-efficacy of a person is determined by the main sources, one of which is performance attainments10. In other words, a success in the past will affect the success and execution of subsequent tasks.

From this cooperative learning activity, students gain experience when they see their friends put forward ideas or complete mathematical tasks. This experience as vicarious experience, which is one source for enhancing one's self-efficacy12. The experience of observing the success of others in completing tasks as a modeling. By the time the student is stuck in understanding or resolving the problem, the lecturer asks a metacognitive question13. The lecturer's questions can be viewed as verbal persuasion from the lecturers, so that students can build confidence in their ability to complete mathematical tasks. This lecturer's activity is the third major source of enhancement of self-efficacy12. Metacognitive questions can also help students who feel anxious when faced with mathematical problems, thus gaining more confidence. One's stress or anxiety is included as an element of physiologic and affective states, which negatively affects self-efficacy12.

Although it is not as high as in the metacognitive scaffolding approach, there is an enhancement of mathematical self-efficacy of students who gained a significant direct approach. Lecturers explain the concept through illustrations that are easily understood by the students and provide an example of a step-by-step solution. When the lecturer gives an example of completion, it appears the students focus on it. This has a positive effect on enhancing students' mathematical self-efficacy. Through the example given by the lecturer, students find a model in completing mathematical tasks. The experience of observing the success of others in completing the task as a modeling and will increase self-efficacy12. The existence of additional exercise matter material in the direct approach makes the students have many opportunities to practice displaying mathematical ideas, thus gaining much experience in facing mathematical tasks. With increasing experience, students will gradually be able to apply relevant
strategies flexibly and precisely, and this mastery experience is a major source of increased self-efficacy.

In learning with direct approach, there is no cooperative learning, so the interaction between students is very limited, almost non-existent. Meanwhile, cooperative learning deals with strong cohesiveness within the group, meaning that students are helping each other out because they care and want joint success. The awareness of mutual success can result in students who have metacognitive scaffolding approach trying to jointly build mastery experience. In addition, cooperative learning can reduce the level of stress or anxiety of students in the face of mathematical tasks.

From the above description, it should be assumed that the presence of metacognitive questions and cooperative learning activities on learning with metacognitive scaffolding approach on the one hand, and the explanation of concepts and examples of solving mathematical problems on direct learning on the other, are factors that can explain one the result of this research is the enhancement of mathematical self-efficacy of students who get the learning with metacognitive scaffolding approach higher than the students who get the learning with the direct approach.

The results of this study also indicate an enhancement of mathematical self-efficacy of high, medium, and low prior mathematical abilities students who learned under metacognitive scaffolding approach. Metacognitive questions posed by lecturers were utilized by high prior mathematical ability students to associate severe mathematical problems with the knowledge they have mastered, so that they succeed in their ability to experience the mathematical relationship they face. Self-efficacy will awaken when students are successful in the ability to be displayed. In the meantime, metacognitive questions that lecturers or students with high-ability students can deliver to low- or middle ability students can be seen as verbal persuasions that can build confidence in the ability to complete mathematical tasks. This kind of activity can be seen as one of the sources of self-efficacy enhancement. Students with high early mathematical ability have many mathematical experience, so many awaken mathematical ideas to friends in the group. Successful problem-solving experiences are a factor in enhancing self-mathematical achievement, which Hamilton & Ghatala calls performance achievement, or Bandura calls strengthens as a mastery experience.

Interaction at the time of cooperative learning activities resulted in students with low and moderate mathematical ability to gain experience when they see their friends put forward mathematical ideas or complete mathematical tasks. It describes these experiences as vicarious experiences, and is one of the sources to improve one's self-efficacy, and that interaction between students in cooperative learning provides opportunities for students to develop knowledge and self-efficacy. Thus, it should be stated that the existence of mastery experiences in students with high prior mathematical ability on the one hand, and the existence of vicarious experiences and verbal persuasion on the students with middle and low mathematical ability are the factors that can explain one of the results of this research, a significant difference in the enhancement of mathematical self-efficacy of high, middle, and low mathematical early students who gained learning with metacognitive scaffolding approach.

As with the approach of metacognitive scaffolding, in a direct approach, high-priority math students have more experience of success in solving mathematical problems than with low and moderate early mathematical students. These success experiences are called mastery experiences. Meanwhile, low and medium-skilled students who acquired a direct approach rely on explanations of concepts and examples of problem solving from lecturers. Listening to the success of lecturers providing an explanation of concepts and examples of solutions can be seen as vicarious experiences, which is one of the main sources of self-efficacy enhancement. Thus, it should be stated that the existence of mastery experiences derived from the experience of solving mathematical problems in students with high early mathematical ability on the one hand, and the existence of vicarious experiences derived from the explanation of concepts and examples of mathematical problem solving on the students with middle and low mathematical ability is the factor which can explain one of the results of this study, i.e., there is no significant difference in the enhancement of mathematical self-efficacy of high, middle, and low prior mathematical ability of students who obtained learning with the direct approach.
4. Conclusion
From the results of the study, the conclusions are: First, there is a significant difference in the enhancement of mathematical self-efficacy between students who learn under metacognitive scaffolding approach and students who learn under direct approach. It is also known that the average score of mathematical self-efficacy at the end of learning of students who learn under metacognitive scaffolding approach is higher than that of students who learn under direct approach. Second, there is no interaction effect of teaching approach (metacognitive scaffolding approach and direct approach) and prior mathematical ability (low, middle, and high) on the enhancement of students’ mathematical self-efficacy.

These study results were only based on a specific aspect, the subject was limited, and the narrow subject matter. Even so, it was clear that the approach was effective in supporting students’ self-efficacy. In addition, the implementation of learning with metacognitive scaffolding approach did not require expensive. Therefore, the recommendation was that the teaching under metacognitive scaffolding approach could be tried in other aspects, other topics or other subject matter.

5. References
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