The mathematical self-efficacy instruments for elementary school students

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Abstract. Mathematical self-efficacy is a person's belief in his ability to solve mathematical problems received. The output of this study is to produce an instrument that can measure MSE comprehensively and accountability. Research and Development (R&D) was chosen as the research method. The sample selection was done by purposive sampling involving 20 students of the 6th-grade elementary school in Karawang. Based on the development and analysis of aspects and indicators showing aspects of MSE including personal experiences in learning mathematics, the experiences of the others about learning mathematics, verbal persuasion after doing mathematics, and psychological indexes when doing mathematics problems. Each of these four aspects consists of three indicators namely confidence can complete difficult, varied, and challenging tasks. Based on the results of testing, the validity and reliability obtained all items have sufficient validity (rxy = 0.54) and fixed reliability (r11 = 0.70). Based on these findings, 24 items can be further researched on mathematics learning in elementary school concerning 3D geometry.

1. Introduction
Mathematical self-efficacy (MSE) is one of the affective aspects that can affect students' cognitive abilities. Students with good self-efficacy will show fluency in completing their assignments even though students found difficulties in their assignments [1]. In the meaning of education, education is a conscious and planned effort to create an atmosphere of learning and learning process so that students actively develop their self-control, personality, and intelligence [2]. Based on the SISDIKNAS law, it is said that the education process must develop their personalities and intelligence. One of the personalities is MSE, as well as intelligence, which can be developed if students' MSE is high. The importance of students’ MSE is used as a predictor of student academic achievement [3]. MSE is an aspect of student motivation that has been proven to play an important role in student involvement, and retention in academic careers in science, technology, engineering, and mathematics [4]. MSE can change a person into different behaviors among individuals with different abilities in terms of MSE affecting choices, problem-solving, and perseverance [5]. Findings from the MSE studies said it affects the choice of action taken and the amount of effort when faced with difficulties and obstacles [6,7]. The essence of MSE is
a person's attitude to believe in their ability to solve mathematical problems they face. The importance of MSE must be developed in the learning process by the teacher. In developing this MSE, it needs an indicator of success through an appropriate instrument. MSE was included in the realm of attitude. Attitudes were measured using a closed questionnaire with a Likert scale [8]. MSE can be learned through four aspects, namely mastery experience, vicarious experience, verbal persuasion, and psychological index [9]. Regarding the source of MSE, people's trust in their abilities is developed in four ways. First, mastery experience, demonstrated by overcoming obstacles through persistent effort and learning how to manage failure. Second, representative experience, which can be obtained from seeing people could increase self-confidence, believe in themselves, and improve themselves. Third, verbal persuasion has a limited impact on students' MSE because the results are described, not witnessed directly, and thus depends on the credibility of the persuader. Fourth, students base their MSE assessment on their perceived physiological reactions, such as fatigue, stress, and other emotions that are often interpreted as indicators of physical disability [10].

Based on this, the instruments that can measure students' MSE is needed so that teachers can develop aspects of student attitudes in learning, one of which is MSE based on factors and aspects that are known. Based on this description, MSE is measured mathematically through aspects of personal experience in learning mathematics, the experiences of others about learning mathematics, verbal persuasion after doing mathematics, and psychological indexes when doing mathematics problems. Each of these four aspects consists of three indicators namely confidence can complete difficult, varied, and challenging tasks. Thus, this research will give birth to an instrument that can measure the MSE of elementary school students.

2. Methods
The method applied in this study was Research and Development. The MSE scale test was conducted in 6th grade as 20 students had received math material in the previous year. The MSE scale in this study served to determine confidence in their ability to succeed in the process of solving a given mathematics problem. The results of MSE measurements were obtained through a developed attitude scale that was based on four aspects of MSE. MSE scale was arranged through guidelines on a Likert scale of four answer choices including Strongly Disagree, Disagree, Agree, and Strongly Agree. The score on each statement was based. The attitude scale instrument compiled in the study was tested to measure the MSE of fifth-grade elementary school students. First, arranged the grid based on aspects, indicators, explanations, and statement items, and criteria of both positive and negative aspects. Then, discuss the grid prepared by the judgment expert on the suitability of the aspects and indicators with the statement. This was done by considering the suggestions of Elementary School Teacher Education lecturers, Universitas Pendidikan Indonesia, and Guidance and Counselling fields, as well as readability tests on students to assess whether students can understand the sentences in the statement being tested. Before the validity and reliability tests were carried out, each statement was first converted into a score using the summarized ranking method. The summation strategy on the ranking is a method of scaling a statement of attitude through the distribution of responses to a benchmark score maker on the scale. The frequency distribution of student responses will be seen in each statement of choice through student choice on each statement. Eventually, the deviation appears according to the normal distribution [11]. The scale value for the statement will match the distribution of responses for each statement item. The scaling system was implemented through several stages including 1) Counting frequency(f); 2) Calculate the proportion of answer choices (p); 3) Determine (pk); 4) Calculate (Tpk); 5) Determine the value of z through the normal distribution table; and 6) Deciding z + z*, i.e. placing the smallest point of the answer choice score with 0. Round the result of z + z* to find the integer value of each interval scale choice on each item statement. Data obtained from the results of score changes were applied to calculate the validity and reliability of MSE scale instruments. Validity was defined as the extent to which an instrument measured what it claimed to measure and the reliability of a measuring instrument is the level of consistency by which it measured whatever is measured [12]. Analysis of the validity and reliability of the students' MSE scale instruments using Annates 4.0 [13]. To interpret the validity seen
based on the correlation coefficient (r), while reliability was seen from the value of Cronbach’s Alpha. The interpretation of the validity and reliability is set out in the following Table 1 [14]:

**Table 1. Interpretation of test validity and reliability of mathematical self-efficacy instruments.**

| Correlation Index | Interpretation of Reliability | Interpretation of Validity |
|-------------------|-------------------------------|----------------------------|
| 0.80 to 1.00      | Very constant                 | Very high                  |
| 0.60 to 0.80      | Constant                      | High                       |
| 0.40 to 0.60      | Quite constant                | Medium                     |
| 0.20 to 0.40      | Not constant                  | Low                        |
| 0.00 to 0.20      | Very not constant             | Very Low                   |

3. Result and discussion

3.1. Aspects, indicators and statements of students’ Mathematical Self-Efficacy (MSE)

MSE was measured using a structured questionnaire based on indicators developed by researchers. The following questionnaire developed was set out in Tables 2, 3, 4, and 5:

**Table 2. Aspects of personal experience students' mathematical self-efficacy scale attitudes.**

| Aspects                        | Indicators                                                                 | Statement                                                                                                                                                                                                 |
|--------------------------------|-----------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Personal experience about      | Confidence can complete difficult tasks                                      | I find it easy to imagine the shape of a room or a certain box-shaped object if I have seen or touched that object firsthand. (1) (+) I am nervous about answering questions about building material that is poorly understood (2) (-) |
| learning mathematics           |                                                                             |                                                                                                                                                                                                          |
| Confident to complete different tasks | Learning mathematics using concrete objects (cardboard, pencil cases, rubrics), wasted my study time. (3) (-) Seeing directly concrete objects (cardboard boxes, pencils) makes it easy for me to make drawings of these objects. (4) (+) |                                                                                                                                                                                                          |
| Faith completes a challenging task |                                                                             | When I encounter the problem of building challenging spaces, I don't feel calm until I can do it (5) (+)                                                                                                  |

**Table 3. Aspects of other people experience students' mathematical self-efficacy scale attitudes.**

| Aspects                        | Indicators                                                                 | Statement                                                                                                                                                                                                 |
|--------------------------------|-----------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Other People Experiences about | Faith does a difficult task when it sees others capable                      | If any of my classmates can solve the problem of building volume, then I think that I am also able to solve it. (6) (+) I am usually can make mathematical calculations to solve mathematical problems with story problems in daily life if studying with friends who are good at mathematics. (7) (+) I am diligent in discussing with friends whose discussion discussions discuss lessons in class (8) (+) | learning mathematics                                                                                         |
| Confident to complete different tasks | Confidence can complete different tasks if people can do it                  | I find it easier to understand the material of webs, and, the volume of building space when I get an explanation from a smarter teacher or friend by using concrete props (cardboard box, rubrics, and other square objects) of these objects. (9) (+) I am not able to work on story problems on the volume of building space, even though I am assisted by a friend (10) (-) |                                                                                                                  |
Table 4. Aspects of verbal persuasion students' mathematical self-efficacy scale attitudes.

| Aspects                        | Indicators                                      | Statement                                                                                       |
|--------------------------------|------------------------------------------------|-----------------------------------------------------------------------------------------------|
| Verbal Persuasion after        | Confident to do difficult tasks with the         | The support of parents, teachers, and friends makes me feel able to complete difficult tasks.  |
| doing mathematics              | support of others                               | (11) (+)                                                                                       |
|                                |                                                | I feel excited and happy to learn to build space when the teacher explains its benefits every day. (12) (+) |
|                                | Confidence can complete different tasks if you  | When friends don't like the pictures that I make about the combined space-building creations, it makes me lazy to make even better pictures. (13) (-) |
|                                | get support from the surroundings                | Words from friends, that when learning to build space with concrete objects (cardboard boxes, pencils, rubrics), it is useless to learn. (14) (-) |
|                                | Confidence can complete challenging tasks when  | When parents and friends say about my results in making works about building space is good work makes me happy and proud to make the next work in the form of building space and other works. (15) (+) |
|                                | get support from the surroundings                |                                                                                                 |

Table 5. Aspects of psychological index students' mathematical self-efficacy scale attitudes.

| Aspects                        | Indicators                                      | Statement                                                                                       |
|--------------------------------|------------------------------------------------|-----------------------------------------------------------------------------------------------|
| Psychological Index when doing | Confident can complete difficult tasks when my  | I feel annoyed when working on the matter of calculating the volume of difficult cubes and blocks (16) (-) |
| mathematics                     | feelings are in a happy state                   | I am comfortable when discussing exercises or group assignments with friends (17) (+)         |
|                                |                                                | I was desperate when solving the problem of the story of building space in everyday life. (18) (-) |
|                                | Confident can complete different tasks when my | I like to make drawings of cubes, blocks, prisms, and tables in advance making it easier for me to solve the problem of waking up space in my daily life. (19) (+) |
|                                | feelings are in a state of pleasure            | Because I can't work on the volume of geometric shapes, that are put together as one structure. I feel anxious (21) (-) |
|                                |                                                |                                                                                                 |
|                                | Confident can complete challenging tasks when   | I was not calm when I was given a question by the teacher about building cubes and blocks that were put together (22) (-) |
|                                | my feelings are in a happy state                | I am happy to solve the story problem about the problem of calculating the volume of cubes and beams in everyday life (23) (+) |

The MSE scale questionnaire was developed through the three stages. The preliminary stage by analyzing problems in the students when learning mathematics in elementary school, namely the MSE scale of students in learning. Curriculum analysis in mathematics learning in elementary school was also conducted which served as the basis for developing students' MSE scale statements. MSE measurement based on mathematical learning analysis was associated with low-level thinking and high-level thinking problems that were divided into problems with difficult, varied, and challenging criteria. on the volume of cube and block material applied to the indicator. Volume is the amount of space in three dimensions [15]. The volume is represented by (V) notation. The volume of the cube is known through the product of the area of the base and height where the area of the base of the cube is square (s²) and height is (s), while the volume of the beam comes from the product between the long side (l), width (w), and height (h) along with the volume formula cubes and rectangular prism are presented below:
Low-level thinking is a matter of competence in understanding and applying examples:

Problem 1. Determine the area of base, height, and volume of a cube on the side! (s=10 cm)

High-level thinking is a matter of competence in analyzing and creating examples:

Problem 2. Obay bought 4 pieces of toothpaste, after looking at the block-shaped toothpaste wrap when all the toothpaste weighed in volume was 720 cm³, and He measured it and found a length of 10 cm and a width of 3 cm, but when measuring height suddenly the crossbar broke, can you calculate the height? How many?

Fig. 1. Representation of rectangular prism with toothpaste (Odol).

The instrument can predict scores from the state-wide test based on content-based standards [16]. The instrument will help predict and measure the degree to which the researcher processes the accuracy and success of the variables and objects being measured [17–20]. In the development phase of MSE instruments, the development of mathematical concepts, aspects, indicators, and self-efficacy lattices was integrated into the competencies and materials to be achieved in mathematics. The instrument that will be used should have good quality [14]. To get instruments that have logical validity and good quality, the first step was to break down the variables into sub-variables and indicators which were then formulated in the statement. Furthermore, to get empirical validity or experience, it was necessary to test the instrument [21,22].

3.2. Validity and reliability of students’ Mathematical Self-Efficacy (MSE)
The following is a summary of the overall validity and reliability test stated in Table 6:

Table 6. Summary of test validity and reliability of Mathematical Self-efficacy (MSE).

| Statement Item | Correlation (rxy) | Significance | rtable | Overall Validity | Reliability (Cronbach Alpha) |
|----------------|------------------|--------------|--------|------------------|-----------------------------|
| 1   | 0.968            | Very High    | Very significant | 0.3438 |
| 2   | 0.424            | Medium       | Significant     | 0.3438 |
| 3   | 0.482            | Medium       | Significant     | 0.3438 |
| 4   | 1.000            | Very High    | Very significant | 0.3438 |
| 5   | 0.435            | Medium       | Very significant | 0.3438 |
| 6   | 0.948            | Very High    | Very significant | 0.3438 |
| 7   | 0.568            | Medium       | Very significant | 0.3438 |
| 8   | 0.697            | High         | Significant     | 0.3438 |
| 9   | 0.968            | Very High    | Very significant | 0.3438 |
| 10  | 1.000            | Very High    | Very significant | 0.3438 |
| 11  | 0.430            | Medium       | Very significant | 0.3438 |
| 12  | 0.580            | Medium       | Significant     | 0.3438 |
| 13  | 0.615            | High         | Very significant | 0.3438 |
| 14  | 0.444            | Medium       | Very significant | 0.3438 |
| 15  | 0.482            | Medium       | Significant     | 0.3438 |

0.54 (Medium) 0.70 (Constant)
Table 6. Cont.

| Statement Item | Correlation ($r_{xy}$) Value | Significance Criteria | $r_{table}$ | Overall Validity | Reliability (Cronbach Alpha) |
|----------------|-------------------------------|-----------------------|-------------|------------------|-----------------------------|
| 16             | 0.663                         | High                  | Very significant | 0.3438          |                             |
| 17             | 0.427                         | Medium                | Significant  | 0.3438          |                             |
| 18             | 0.455                         | Medium                | Significant  | 0.3438          |                             |
| 19             | 0.527                         | Medium                | Significant  | 0.3438          |                             |
| 20             | 0.456                         | Medium                | Very significant | 0.3438      | 0.54 (Medium)               |
| 21             | 0.430                         | Medium                | Significant  | 0.3438          | 0.70 (Constant)             |
| 22             | 0.527                         | Medium                | Significant  | 0.3438          |                             |
| 23             | 0.561                         | Medium                | Significant  | 0.3438          |                             |
| 24             | 0.517                         | Medium                | Significant  | 0.3438          |                             |

Based on the test results of the MSE scale instrument results using Pearson-product moment obtained as many as 24 statements that can be used further to measure the MSE of elementary school students. Overall, the statement had sufficient validity ($r_{xy} = 0.54$) and fixed reliability ($r_{11} = 0.70$). Also seen five items had very high criteria (1, 4, 6, 9, 10), three items had high criteria (8, 13, 16), and the composition had medium criteria. Besides, twelve items were found to have a very significant significance and the rest were significant. The validity test showed 24 statements were considered valid with the smallest $r_{xy}$ value was 0.424 and the highest value reaches 1.000. Based on a review of the classification of validity according to Guilford [14], this value indicates the validity criteria that reach medium to high levels. A good instrument was considered in terms of the higher coefficient of the validity of an instrument [23]. Based on the reliability test, it informed the MSE instrument reliability value reached 0.70. Supporting these results, the reliability of the research instrument was considered acceptable if the alpha value was 0.70 or greater [24]. If we reviewed the classification of reliability described by Guilford [14], hence, the reliability value of the instrument reached the constant reliability category. Instruments with moderate validity criteria and consistent reliability were feasible for measuring research variables. The results of the trials in this study were not much different from the previous studies. It is also known that $r_{count} > 0.3438 = r_{table}$ for all items. If the teacher can find out the level of student confidence, it will facilitate learning. MSE was among the affective factors since students' problem-solving and academic successes indicate his likely performance [25]. How important MSE needs to be understood by the teacher in the implementation of learning. MSE can affect students' confidence in their ability to deal with problems in the context of mathematics learning and questions based on HOTS. A study explained MSE influenced the problem-solving ability [26]. Thus, the measurement of MSE must be done so that teachers can intensively develop it.

4. Conclusion

Based on the results of the MSE instrument trials it was found that 24 items of MSE scale statements can be used in research in mathematics learning in elementary schools. The development of this instrument was intended to measure the MSE of elementary school students in solving problems encountered. By knowing students' MSE, it can be the basis for the development of effective domain-based learning because MSE had a significant impact on student academic achievement.

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