The development of learning tool based on realistic mathematics education and its influence on spatial abilities of elementary school students

Nuryami¹, Sunardi¹, Susanto¹, P Rizqika¹, A Shofyan¹

¹ Department of Mathematics Education, University of Jember, Indonesia

Email: sunardi.fkip@unej.ac.id, emy.nuryami1295@gmail.com

Abstract. This study aims to develop a learning tool for mathematics based on Realistic Mathematics Education on the volume of block and cube material for grade V of elementary schools and to determine their effect on spatial abilities. Spatial abilities need to be improved since elementary school because spatial abilities are related to students' cognitive abilities. However, student experience problem in learning about space figures, beside the material is abstract, the learning process in the classroom can also affect it. Mix Method is a method used in this research with a Sequential Exploratory design, a method that combines the Thiagarajan model development and sequential quantitative method. Before the data is analyzed, first the variance homogeneity test and normality test are carried out. The first test results indicate that the data is distributed normally. So that the data were analyzed using t-test analysis. The results showed that: (1) the learning device met the criteria of being valid, effective and practical, meaning that the device was proven to be a guide for teachers to improve spatial abilities, (2) a value of significance of 0.000 (p <0.05), indicating that there is a substantial effect on the application of learning used on students' spatial abilities.

1. Introduction

Learning process in school has a very important role, because school can be a medium to develop children's abilities, both cognitive and skills[1]. One of the subjects that must be mastered by children in school is mathematics. Mathematics is the most important subject in human life[2][3]. Mathematics is the center of knowledge in the field of technology, science and other science[4]. Therefore, mathematical knowledge must be mastered as early as possible, especially at elementary school level[5]. But in fact, many elementary school students have difficulty learning mathematics, especially geometry[6].

One of the subjects in mathematics is geometry. Learning geometry, apart from having an important role in mathematics, is also influential in learning mathematics[7][8][9]. According to NCTM (2000), the purpose of geometry taught in schools is so that children can use visualization, have spatial skills and geometric modeling to solve problems[10][7]. One of the topics in geometry is shapes of blocks and cubes spaces. Shapes of blocks space and cubes space has been taught in elementary school children[11].

However, it turns out that mathematics skills, especially in spatial abilities, are still lacking, because student experiences difficulties in the learning process[11][12]. The obstacle for students in learning to build this space is not only because the material is abstract, but also because teacher's treatment in
learning process is not optimal, the basic mathematical abilities of student are less and learning environment is less conducive can also affect failure in learning geometry[13]. Spatial ability is one of the things that can be the basis for achieving success in learning mathematics, especially learning geometry[14][9][15].

Another problem related to learning geometry difficulties can be proven from the Program for International Student Assessment (PISA). Indonesia's math score carried out in 2018 was ranked 72 out of 78 countries, this score decreased from the previous score in 2015, namely Indonesia was ranked 66. One of the field of assessment in mathematics of PISA is geometry, which are geometric shapes, location, movement, and spatial[16]. Student difficulties in geometry is one of consequences of ignoring spatial abilities during elementary school[17][14][18].

Spatial ability is a collection of students' cognitive ability that can be used to see a visual object accurately[19]. Spatial ability is a mental process in observing, to construct understanding, remembering, guessing, and to create images of visual stimulus in context of the room[20]. To measure or investigate students' spatial abilities, there are three elements, those are visualizing, manipulating, and rotating a shape[21][22].

While the indicators used in this study are five elements, those are 1) Spatial Perception, which is the ability to determine the location of an object when viewed from various views horizontally or vertically. And then 2) Visualization, which is the ability to determine a change or displacement of parts of a shape or its elements. And then 3) Mental Rotation, which is the ability to determine changes in a shape that is rotated precisely and accurately. 4) Spatial Relation, which is the ability to determine the arrangement of a shape and the relationship of its parts to one another, and 5) Spatial Orientation, which is the ability to determine the shape of a shape from various points of view[23][24].

| No | Spatial Ability Dimensions | Indicator Description |
|----|-----------------------------|-----------------------|
| 1. | Spatial Perception          | Student can determine and provide reason for the volume state of the space figure in an oblique position |
| 2. | Visualization              | Students can determine other space figure that have the same elemental conditions and provide reason |
| 3. | Mental Rotation             | Student can determine the state of the space figure if it is rotated and provide reason |
| 4. | Spatial Relation            | Student can determine the part of the space figure and provide reason |
| 5. | Spatial Orientation         | Student can determine the state of a space figure when viewed from various points of view |

To be able to improve students' spatial ability, teacher need to improve performance by presenting a learning tool that engage student to find their own understanding and be able to relate to the reality of student life. Teacher helps children to develop problem-solving skills and discuss them with their friends[25]. Learning that can be used by teacher is realistic mathematics education. In RME learning, the problems given are related to the daily lives of student which play a role in the source of the emergence of mathematical concepts[26][27][28].

Mathematics is a knowledge that must be connected to the reality or the life of children, close to children's experiences, relevant to the condition of society so that it has a deeper meaning, that is human values[29]. Therefore, learning with RME is very suitable for use in mathematics learning. The principle of RME learning is that student must develop their own understanding of mathematical concepts by providing logical problems for them[30]. RME is a very promising learning approach for improving
teaching in mathematics and changing the habits of student who only receive knowledge from teacher to discover their own concepts and knowledge[27].

This study differs from previous studies[31][32][33]. The differences are beside developing learning tools, also to look for the influence of the devices used. The tools developed by the researcher are lesson plan, worksheet and achievement test based on RME that have met valid, practical and effective criteria also made as attractive as possible in order being able to motivate elementary school students in learning material volume of blocks and cubes, and to improve their spatial abilities. Improving spatial abilities is related to the children's understanding and mastery abilities of material or their cognitive abilities[34]. Spatial abilities are necessary to be improved since elementary school so that it can become provisions for the next level. Because rare to pay attention to the children's spatial abilities of elementary school. Therefore, researchers developed learning tool that teacher can use to improve spatial abilities.

In the mathematics learning process, RME can be used as an alternative learning model that can enhance the spatial abilities of students. Because RME learning relates to something that is considered real or can be imagined by students while geometry is considered something abstract, so that the RME learning model can train students to think real, logically, and can be imagined.

2. Methods

In this study, the method used by researchers is the mix method. This study combines qualitative research, namely the development with 4-D model and quantitative, namely experimental research. While the design is the Sequential Exploratory design, which can be seen from the picture below.

![Figure 1. Research Design](image)

At the initial stage of the research conducted was qualitative, namely to produce mathematics learning tools in the format of lesson plans, worksheet and achievement test based on RME that were valid, practical and effective. From the preliminary research, a hypothesis will be generated, namely the tool developed affects the spatial ability of students. In the next stage, the hypothesis is tested using quantitative methods in experimental research.

Development design chosen in this study is Thiagarajan development model or 4D model developed by Thiagarajan et al. In this research, 4-D model are stage of defining, stage of design, stage of developing and stage of dissemination[35]. After obtaining a tool that meets the validity, practicality and effectiveness, the learning device can be used in experimental research. From the table below, qualitative analysis data can be seen.

| Data               | Data Collection                                                                 |
|--------------------|---------------------------------------------------------------------------------|
| Validity           | The learning tool is said to be valid if it meets the validity criteria. The validity was carried out by 2 Mathematics Lecturers at the Teacher Training and Education Faculty, University of Jember and 1 mathematics teacher at SD Plus Alqadiri Jember |
Practicality
Learning tool is said to be practical if the observation sheet meets practical criteria. Data obtained through teacher activity observation sheet and interview results.

Effectiveness
The learning tool is said to be effective if it meets 3 aspects, namely cognitive seen from the test results, psychomotor seen from the student activity observation sheet, and affective seen from the student response questionnaire.

Students' Spatial Abilities Test
Learning tool is said to affect students' spatial abilities if they meet the spatial ability assessment criteria.

The subject in this study was grade V elementary school which was implemented at MI Nuris Jember for experimental research. Prior to sampling, a homogeneity test of all populations was carried out to determine their initial abilities. Sampling is done randomly, by selecting two classes that have the same average ability. The experimental class is taught using learning tool that have been developed, that is tool based on realistic mathematics education. While conventional learning is used by the control class. The experimental research design in this study can be seen in the table below.

Figure 2. Experimental Research Design

| X  | O₁  |
|----|-----|
|    |     |
|    |     |
|    |     |

Description:
X = Treatment
O₁ = The test score in the VA class (treatment class)
O₂ = The test score in the VB class

Quantitative data analysis was performed using the normality test. The type of statistical analysis to be used to test the research hypothesis will be determined by the decision of this normality test. After the normality test is carried out, the next step is statistical analysis. Parametric statistical analysis is used if the test value data is normally distributed, namely the independent sample t-test technique. Meanwhile, nonparametric statistical analysis is used if the test value data is not normal, namely the Mann-Whitney test technique.

3. Result and Discussion
The first thing to do in this study is qualitative analysis, namely the development of learning resources using the four-stage Thiagarajan development model, namely the definition stage, the design stage, the stage of development, and the dissemination stage. The lesson plan, worksheet and accomplishment test were the learning resources created.

Learning Assessment tool to obtain valid data was carried out by 3 validators, those are 2 lecturers and 1 mathematics teacher. Suggestion and input given are used as material to revising learning tool. Result from validator's assessment in this study state that learning tool developed by researcher are feasible and can be used in research. Following are the validation results of three validators.
Figure 3. The results of the validator assessment

From the diagram it shows that the results of the assessment of each validator on the lesson plan, worksheet and achievement test are at intervals of $4 \leq V_a < 5$, the average assessment of the three validators for lesson plan is 4.7 meaning they are in the valid category, the average assessment of the three validators for worksheet is 4.6 which means that it is also in the valid category, and the average assessment of the three validators for achievement test is 4.7 which means that it is in the valid category, to obtain this valid category requires several revisions so that finally the learning tools produced in the form of the worksheet, lesson plan and achievement test suitable for use by the teacher.

The next step is practicality analysis of learning tool that have been developed by researcher. The purpose of the practicality data for the device is data that can be analyzed so that it can be a picture of the implementation of the device. To obtain the data in question, namely the teacher activity observation sheet. The following will present a tool implementation diagram.

Figure 4. Tool Implementation Observation Result

Based on the diagram, it shows that each meeting has an increase in percentage. At the first meeting the percentage value was 87% with the category of teacher activity being good, there were only a few teacher activities that were less than perfect and needed improvement but all activities were carried out. At the second meeting the percentage value was 90% with the teacher activity category carried out very well, because it had carried out self-evaluation and input from several observers and at the third meeting the percentage value was 96% with the teacher activity category very well, because both students and teachers were getting used to it. with the device in use. Learning tools can be declared practical if the value of the teacher's activity lies in the interval $70\% \leq P_a \leq 100\%$. Upon the basis of such results it can be concluded that the developed device meets practical criteria.
Final step in qualitative research is tool effectiveness analysis. Tool effectiveness data can be obtained through student learning outcomes test, which is in this study the spatial ability test, student response data and student activity data. Test was given to 25 students with 21 students are completed, and 4 students are incompleted with the percentage of completeness reaching 84%. Student response data was carried out by giving questionnaires to students. Meanwhile, student activity data were obtained from observers who were observed from student activity observation sheets. The following will present student response data and student activity data.

![Figure 5. Student Response Questionnaire Data](image)

![Figure 6. Student Activity Data](image)

Based on the two diagrams, it shows the student response to the tool presented reaches a percentage of 81.5% who strongly agree with the good response category, while those who only agree with the percentage are 15%, quite agree with the percentage 2%, less agree with the percentage 1% and disagree 0, 5%. Based on these data, it means that the learning tools provided to students can be well received by students. Meanwhile, the analysis of student activity data showed that there was an increase in each meeting. The first meeting the percentage value is 72%, the student activity category is active, even though it is still in the first meeting, but because learning with the RME model is carried out by discussion and requires students to ask questions and express their opinions. The second meeting the percentage value is 83% with the category of active students and shows an increase from the first meeting. The third meeting, the percentage value is 90% with the category of very active students, because students have started to get used to learning using the RME model. Based on these data, the device developed meets the criteria for being effective. The final conclusion from this qualitative analysis is that learning tools in the form of lesson plans, worksheets and achievement test meet the criteria of validity, practicality and effectiveness. So that the developed device can be used in the experimental class.

Further research will be followed with quantitative research. Learning tool that have been validated and meet practical and effective criteria is used in the experimental class which is class $V_A$. Meanwhile, the control class, which is the $V_B$ class, uses learning that is usually used by teacher. Students' spatial ability test on principle subject of volume of blocks and cubes that researcher used contained 5 questions, data were obtained after post-test. Spatial ability test results in the experimental class obtained an average of 74.69 (SD = 11.017), minimum score obtained by students was 60, maximum score obtained was 100. While spatial ability test results in the control class obtained an average of 60.11 (SD = 9.315), minimum score obtained by students is 50, and maximum score obtained is 87. Based on these data, the results of spatial ability test in the $V_A$ class (experimental class) were higher than the $V_B$ class (control class).

Furthermore, to determine whether data is normal or not, a normality test is performed using Kolmogorov Smirnov test, and then Asymp results were obtained. Sig. (2 Tailed) is 0.8703 for class $V_A$ and 0.678 for class $V_B$. The Sig value in those two classes with the result is > 0.05 (level of significance).
So it can be concluded that data results of the VA class (experimental class) and the VB class are normally distributed so that Independent Sample t-test can be implemented.

| Table 3. Independent Sample t-Test |
|-----------------------------------|
| Levene's Test for Equality of Variances | t-test for Equality of Means |
| F | Sig. | t | df | Sig. (2-tailed) | Mean | Std. Error | 95% Confidence Interval of the Difference |
|---|------|---|----|----------------|------|------------|---------------------------------------|
| Equal variances assumed | .841 | .321 | 2.721 | 60 | .000 | 11.580 | 2.518 | 7.360 | 16.801 |
| EXAM RESULT | Equal variances not assumed | 2.721 | 58.64 | .000 | 11.580 | 2.518 | 7.358 | 16.803 |

Based on the table, the levene homogeneity test is obtained of 0.321 > 0.05 so that data of spatial ability test results are homogeneous. The significance value (2-Tailed) is 0.000 < 0.05. Because the value of significance is < 0.05, H₀ is rejected and H₁ is accepted. In learning about the spatial potential of learners, there is a major gap between the control class and the experimental class. This shows that the results of the students' spatial ability test in the experimental class are better than the control class. Experimental class learning uses learning methods developed by researchers in the form of a lesson plan, worksheet and achievement test. The tool has been tested for its validity and meets practical and effective criteria. Test was given in the VA class and the VB class as a post-test. Quantitative research has been performed in three meetings. The first meeting discussed elements of blocks and cubes, second meeting discussed volume of blocks and last meeting discussed volume of cubes. Meanwhile, in the control class, the model used by the teacher, namely the explanation of the material and sample questions, was then given practice questions. Just like the experimental class, the control class was also held three times.

The findings of this research are consistent with previous studies, meaning that there is a positive influence on students' ability to use learning with RME. Such as studies performed by Ulandari et al. (2019) that mathematics learning tool based on realistic mathematics education (RME) meet the effective criteria and can improve their problem-solving and student self-efficacy skills[31], the results of research by Doli & Armiati (2020), namely learning tool based on realistic mathematics education (RME) which are developed are valid, practical and effective and are able to increase students' interest in vocational school learning[32], and the results of research by Putri, et al (2019) stated that learning tool with realistic mathematics education model were able to enhance the spatial abilities of students in grade IX of middle school and were able to motivate students to learn[33].

The learning process in the experimental class was carried out by discussing together to solve problems in the worksheet. Students are more active because they can ask each other and give opinions, suggestions and solutions. In the experimental class do good teamwork, exchanging opinions, and students who understand the material well will help their friends to get understanding. Student activities in asking and giving opinion can be shown in the picture below. (taken on one of the groups).
Figure 7. Discussion activities in the experimental class

Description:

- Student answering question
- Student giving opinion
- Student asking

The discussion went well in the experimental class, student 2 asked student 1. Student 1 was the group leader and answered questions from student 2, student 3 and student 4 gave their opinion on student 1's answer, student 3 also gave answers to student's question 2. So, they share their opinions so that the discussion runs well. Those who understand are ready to share their knowledge with other friends, with a brave and confident attitude they hold discussions together. The interaction of students in groups helps them to gain a better understanding than what the teacher presents. The learning process that goes well with usage of the RME model can improve students' spatial abilities. This is proven by the spatial ability test which is given about 84% complete. The following is a student worksheet about spatial abilities in the volume of blocks and cubes. Based on the students' test acquisition, it was obtained three categories of spatial abilities, namely as follows.

Category of student who has high spatial ability.

Student is able to answer correctly and provide appropriate and logical reasons.
The development of mathematics learning tools that have met the criteria of validity, practicality and effectiveness can be used by teachers to become tools that can improve the spatial abilities of elementary school students. This is proven by experimental research that has been conducted by researchers that the learning tools that have been developed has a positive influence on the spatial abilities of students. This is also differentiates it from previous research.

The development of learning tools carried out by researchers has actually been done by other researchers. The difference with this research is that in addition to developing tools in the format of a lesson plan, worksheet and spatial ability test based on realistic mathematics education, also to know their effect on spatial ability of elementary school student, so this study is a mix method research. Worksheet that are presented contain questions that exist in everyday life, according to their experiences or something that student can imagine. So that students are able to understand the elements and volume of block and cube based on their own efforts and can be accepted by children's thoughts of elementary school which are still at concrete stage. Meanwhile, the relationship between RME and student's spatial abilities is shown in the figure below.
Figure 8. Relationship between RME and students' spatial ability

This picture aims to show the relationship between learning with realistic mathematics education and students' spatial skills. RME learning consists of RME steps as well as RME principles and their characteristics use questions related to students' daily lives, according to student experiences or something that can be imagined. It plays a role in being the source of the emergence of mathematical concepts. The purpose of using RME learning is to encourage students to construct their understanding of the materials of the volume of blocks and cubes so that they have a good understanding and are obtained on their own efforts. This is related to spatial ability, because spatial capability is one of the cognitive capabilities associated with the ability to imagine a shape. One of the bases for having the ability to imagine is having a good understanding, especially in this study of the volume of blocks and cubes.

Development of mathematics learning tool with realistic mathematics education has the advantage so that it is able to understand mathematical concepts well and can practice students' spatial ability. In addition, the development of this tool also affects students' spatial ability, in contrast to previous studies.

4. Conclusion
Based on the research outcomes, it can be concluded that the development of learning tool in the form of lesson plan, worksheet and achievement test meets the valid, practical and effective criteria and the use of learning methods developed by researchers has an important impact on the spatial abilities of students. The significance of the t test shows $0.000 < 0.05$ means that $H_0$ is rejected and $H_a$ is accepted. The students' spatial ability in the experimental class was better than the control class. Based on these results, it shows that learning with the realistic mathematics education (RME) approach is an important thing that needs to be considered in an effort to enhance the spatial abilities of elementary school students. Thus, it is hoped that elementary school mathematics teachers can use learning with the RME
approach in the classroom. For junior high and high school students, the development of learning tools with a RME approach is also proposed to be introduced or used for them.

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