Development of Learning Tool with Contextual Teaching and Learning (CTL) Approach to Improve Student Mathematical Connection Ability

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Abstract. The ability of mathematical connections must be possessed by students when studying mathematics. However, the ability of students' mathematical connections is still very poor and restricted among mathematical topics only. Therefore, it is necessary to develop learning tools that can improve students’ ability of mathematical connections by using a meaningful learning approach. This study aimed to produce learning tools by using Contextual Teaching and Learning (CTL) approach which are valid, practical, and effective. This development research only focussed on valid aspect and used 4-D model. This research involved 35 Year 7 students from one of the high schools in Banda Aceh. The developed learning tools included lesson plans, student worksheets, and a test on quadrilateral topics. The development of learning tools was validated by four experts until the learning tools were considered eligible for use in the learning activities. The results showed that the learning tool with CTL approach by using 4-D development model could be used on quadrilateral topics with minor revision. Therefore, the developed learning tools with CTL approach in this research can be used by teachers in the quadrilateral topic to foster students’ mathematical connection. Also, the result of this study may be used for further analysis on practicality and effectiveness phases.

1. Introduction
Mathematics plays a vital role in elementary and junior high school students since it contributes positively to intellectual development to respond to an increasingly progressive change. There are five basic mathematical skills that become the standard of learning, including problem-solving, reasoning and proof, communication, connection, and representation [1]. Accordingly, this study used one of the basic capabilities, which is making the connection. The ability of mathematical connections is one of the abilities that must be possessed by students when studying mathematics. This ability helps students to understand the relationships among mathematical topics, between mathematics with other sciences, and mathematics with real life. Nevertheless, the reality showed that geometry was not fully mastered by some students. There were still many students who had difficulty in learning geometry. Similarly, student achievement in geometry was still not satisfactory. Students have a lack of understanding on geometry topics, such as in recognizing and understanding the geometry and its elements [2]. Many high school students have difficulty in
In one of the tasks of the Program for International Student Assessment (PISA) in 2012, only around 20% of Indonesian students answered the task correctly. The task required students’ ability to understand the questions and prior knowledge to solve the problem, which was the knowledge to measure the circumference of a square, rectangle, and parallelogram. Besides, students needed to be able to apply mathematical knowledge in a new situation. Students who failed to respond to the task probably could not connect mathematics topics with real life [4]. Similarly, [5] stated that some students could not understand or solve problems that include more than one mathematical concept. Also, some students found difficulties when dealing with mathematical problems in daily life. Another study also showed that students had a lack of mathematical connection ability [6]. To improve students’ mathematical connection abilities, suitable learning tools and learning methods should be used to meet the students’ needs. Therefore, teachers need to arrange learning tools that can construct students’ knowledge, in which students will be trained to discover their concepts and knowledge [7].

Successful mathematics learning can be achieved by applying the learning approach. The potential approach needs to support students’ ability to think contextually, in which mathematical context is associated with students’ real life. In the learning process, students need to find out by themselves the concept of the topic learned so that the understanding will be embedded well. In addition, the cooperation between students can also support them to have good strategic competence. All the learning practices above can be provided by Contextual Teaching and Learning (CTL) method [7]. In relation to the aspects of mathematical connection capability as well as the characteristics of the CTL approach, it is believed that the use of CTL approach can improve students’ ability of mathematical connection. Therefore, this study aimed to a valid develop learning tools that use CTL approach to improve students’ ability of mathematical connection.

2. Research method

This study was designed as a developmental research. The product of this research was the development of learning tool to improve students' mathematical connection ability through CTL approach. The learning tool development model was by modifying the 4-D model from Thiagarajan. This research focused only on the development stage, which was until the experimental activities of learning tools. Learning tools that were developed included lesson plans, student worksheets, and tasks or questions related to students' mathematical connection ability. The developed learning tools emphasized the quality of the product.

The experiment involved 35 Year 7 students in one of MTsN in Banda Aceh on the topic of area and circumference of quadrilateral and was conducted twice. Three aspects were used to assess the developed learning quality, including valid, practical and effective [8]. However, this research only focused on validity aspect. The validity was assessed by four validators, including 1 mathematics education lecturers, two experts on learning tools development, and a mathematics teacher. Data to assess quadrilateral learning tools were obtained from research instruments. A validation sheet was used as the research instrument, consisting of lesson plan validation sheet, student worksheet, and mathematical connection capability test. The criteria used to assess the module developed are based on Nieveen’s [9].

| Table 1. Criteria of validity score |
|------------------------------------|
| 4 ≤ VS ≤ 5                       | Highly valid   |
| 3 ≤ VS ≤ 4                       | Valid          |
| 2 ≤ VS ≤ 3                       | Less valid     |
| 1 ≤ VS ≤ 2                       | Invalid        |
3. Result and discussion
The development stage is the stage of product realization. Activity undertaken at this stage was to develop learning tools with CTL approach based on the design framework on the design stage. The products have met the valid criteria, based on the results of the assessment by experts, teachers, and peers. Stages of composing learning tools include a lesson plan, students worksheet, and test on mathematical connection capability. Furthermore, this learning tool product was validated by experts and practitioners. The instruments to validate the learning tools consisted of validation sheets for each type of the learning tools. Overall validation of all instruments can be categorized well. The average of lesson plan validation is 2.9 with a very good category. Students worksheet is 2.7 with a good category, and mathematical connection capability test is 2.8 with a very good category. In other words, the developed learning tools could be used after minor revision. The results of the validation conducted on the three quadrilateral learning tools in Table 2.

| Table 2. Revision results on lesson plan and worksheet |
|-------------------------------------------------------|
| **Mistakes**                                           | **Validators’ Suggestions**                         |
| Lesson plan                                           | The validators suggested to connect with contextual issues so that the lesson plan becomes eligible to use. |
| The lesson plan designed was not in accordance with the CTL approach and did not involve contextual issues; thus, students were less motivated in learning. |                                                         |
| Worksheet                                             | The validators provided suggestions and improvements to make student worksheet more contextual in order to connect students with real life and make the learning process becomes more enjoyable and meaningful. Student worksheet aims to help the teacher in teaching and learning process and help students to understand the mathematics concept. Therefore, the worksheet needs to be designed carefully, so the task given could meet the criteria of learning objectives. |
| The student worksheet did not engage students actively in a contextual learning process |                                                         |

The initial draft of the student worksheet consisted of one question only, which was: “Write down the quadrilateral traits: Rectangle, Square, Parallelogram, Rhombus, Trapezoid, and Kite!”. After the revision as suggested by the validators, the question was displayed in a table, as shown in Table 2. The complete worksheet was changed as: “Look at each quadrilateral in Figure 1, then note the things associated with the shape such as sides, corners, and diagonals. After that, please complete the following table, which indicates the properties of each quadrilateral. Hint: write (✓) if any statements below fulfill the properties of each quadrilateral.”

![Figure 1. Quadrilateral figures](image-url)
Table 3. The revision of student worksheet

| No | Quadrilateral Trait | PP | P | JG | BK | TR | LL |
|----|---------------------|----|---|----|----|----|----|
| 1. | Opposite sides are parallel | ✔ |    | X |    |    |    |
| 2. | Opposite sides have equal length. |    |    |    |    |    |    |
| 3. | All sides have equal length. |    |    |    |    |    |    |
| 4. | Opposite angles are equal. |    |    |    |    |    |    |
| 5. | All angles are equal. |    |    |    |    |    |    |
| 6. | Each diagonal divides the quadrilateral into two |    |    |    |    |    |    |
| 7. | The diagonals bisect each other. |    |    |    |    |    |    |
| 8. | The diagonals formed a right angle. |    |    |    |    |    |    |
| 9. | Only a pair of sides is parallel. |    |    |    |    |    |    |

Explanation:

- ✔ = exist
- X = do not exist
- JG = Parallelogram
- LL = Kite
- PP = Rectangle
- P = Square
- BK = Rhombus
- TR = Trapezoid

Furthermore, the connection test is designed according to mathematical connection indicators, which are (1) connected between mathematical topics, (2) connected with the real world, (3) connected with other disciplines. The validators provide an assessment and suggestion or input based on the mathematical connection test. Below is the example of the revision made by the researcher based on validator suggestions.

Table 4. Revision results of mathematical connection test

| Initial Plan (Problem no.1) | Revision (Problem no.1) |
|-----------------------------|-------------------------|
| A piece of paper is rectangular, with its length and width is 110 cm and 90 cm. How many sheets of paper are needed to make 70 kites with diagonal size 30 cm and 45 cm? | Mr. Mamat wants to make 70 kites for sale. Each kite has a diagonal size of 30 cm and 45 cm. If the available paper is rectangular, each sheet of paper is 110 cm in length and 90 cm wide. How many pieces of paper does Mr. Mamat need to make those 70 kites? |

In the test of mathematical connection ability, the revision of the task was done only in question number 1. The number 1 hint given in the initial draft was not appropriate to assess students’ ability of mathematical connection related to the rectangular material. There was still an ambiguous language, so the researcher considered the advice given by the validators and discussed with the mentor to change the form of the problem. Another revision was the lack of complete guidance for scoring, so the researcher must complete it with the alternative scoring guideline that provides the solution of the problems. The study concludes that scoring guidelines are required, in order to see to what extent students’ grade is assessed. This is in accordance with the explanation which states that students’ grades should be based on the student’s effort in the form of test or other activities if there is no grade, then the students feel the activities that have been done not something important or useful [10]. Therefore, the scoring system should be clear in the workforce because it reflects students’ abilities. Description of activities in the learning of quadrilateral materials through CTL approach [11].

During the treatment, the students’ learning motivation was developed in which the average motivation was 2.8. This score means that students had excellent motivation in learning quadrilateral topics. Based on the consideration and comments from the experts and practitioners on the
development of learning tools through CTL approach, the tools were valid. After the treatment, it was found that the learning tool based on CTL approach in this study was feasible to be used after some input from experts, practitioners, and students.

4. Conclusion
This research produced a learning tool on quadrilateral topics by using CTL approach that was valid. This validity was indicated by the average presentation of the validity which was very good. In addition, there was an increase in the mathematical connection ability of the students, indicating that the learning tool was appropriate to be used. There was also an increase in student's motivation when they learned using the learning tool. Therefore, it could be concluded that the development of learning tools through CTL approach has met the valid criteria.

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