Helping students mathematical construction on square and rectangle’s area by using Sarong motive chess

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Abstract. The aim of this study is developing the learning trajectory to construct students' understanding of the concept of the area of square and rectangle by using Sarong Motive Chess. This research is a design research which is consists of three stages. The stages are preparing for the experiment, designing experiment, and making a retrospective analysis. The activities started by the activity of using sarong motive chess as the manipulative measurement unit. The Sarong motive chess helps students to understand the concept of area of square and rectangle. In the formal stage of cognitive level, students estimate the area of square and rectangle by determining the square unit at the surface area of sarong through many ways. The result of this study concludes that Sarong motive chess can be used for mathematics learning process. It helps the students to construct the concept of a square and rectangle’s area. This study produces learning trajectory to construct the concept of a square and rectangle’s area by using Sarong motive chess, especially for elementary school students.

1. Introduction
Elementary school teachers should understand the cognitive development level of their students because they need to apply the appropriate strategies of learning for the students. Piaget stated that the logical stages consist of pre-operational, operational concrete and operational formal stages [1]. Elementary school students in Indonesia are children whose ages are 7-11 years old. Based on Piaget’s logical stages, elementary school students are classified to the operational concrete stage of Piaget’s cognitive theory [2]. However, teachers have a key role to manage the classroom instruction [3]. A teacher has a major impact on student’s learning activities. Kemendikbud [4] stated that many teachers in Indonesia have not involving their students in teaching and learning process. Students, as the subject of education, have not actively participated in the learning process. Thus, teacher, especially in elementary school, should aware to their students that they are children who have still in operational concrete stages. In fact, teaching and learning process in mathematics at the elementary school is still delivered by the teacher using abstract concept [5–7]. The elementary school teacher was just only giving the concept or formula, giving examples and doing exercises. This condition makes students only memorize the given formulas, substitute what is known and unknown variables into the formulas and then calculate it [4]. Consequently, the process of constructing concepts of mathematics, the
competence of students’ reasoning and problem-solving were not well-established. Besides, the literacy of Indonesian students in mathematics subject is still in the lower grade. it can be seen on PISA’s and TIMSS Study derived by Stacey [8] that in 2015, the average score on mathematics, Indonesian students only reach 386. This result ranks the competence of Indonesian student in literacy is in 65th of 72 countries. Moreover, Indonesian score on TIMSS 2015 only reaches score 397. This condition ranks Indonesia in 45th of 50 countries.

In the elementary school, subject matter such as mathematics, science, civic, social science, and Bahasa Indonesia subject have been integrated into thematic learning process. The teacher will be able to teach and decides the best learning strategies according to the cognitive levels of their students, especially in the operational concrete stage of Piaget’s cognitive theory [9]. Students, whose still in the operational concrete stage, are more interested in manipulating objects [10]. The teacher has a responsibility to prepare the learning strategies which is appropriate with student’s cognitive level. Learning strategy by using manipulative is a way for a teacher to teach mathematics materials by considering the cognitive level of students whom still in the operational concrete stage. Many research [10–12] had shown that manipulative were used effectively, students are able to construct their own mathematical concept through a valuable learning experience. In the topic of the area of the plane figure, the square unit is a unit area that most widely used [13]. In that topic, the teacher can mix the concept of the square unit using manipulative. Sarong is Indonesian famous traditional cloth. it has many motives. One of them is chess motive like used by Balinese. The chess motif of Sarong can represent the concept of the square unit. It can be used to help students in constructing the concept of square and rectangle’s area. The aim of this study is to develop a learning trajectory of a square and rectangle’s area by using sarong motive chess.

2. Method
The type of this research is a design research study. The process of design research, as well as in the educational design process, consists of analysis, design, evaluation, and revision [14-16]. This process is a cyclical process that ends until theory and practice has the same result [14, 16]. Design research is a methodology which has some characteristics. They are interventionist nature, process-oriented, a reflective component, cyclic character, and theory-oriented [17]. There are two important components of a design research, Hypothetical Learning Trajectory (HLT) and Local Instruction Theory (LIT). Both of them will exist on learning activities that may be taken by students in their learning process [18]. The learning trajectories are underlying the curriculum [19]. Because of that, learning trajectories must be prepared in the learning process through the level of thinking [20]. There are some components at Hypothetical learning trajectory: the goal of learning, the learning activities, and the thinking in which students might hypotheses about the process of students’ learning [17].

The stages of design research are described as follows. Firstly preparing for the experiment, in this stage, the hypothetical learning trajectory (HLT) is created as a learning activity. While formulating HLT, a preliminary design is required which implements the initial idea derived from the literature review before designing the learning activities, discussions with experienced teachers, researchers and experts in the related fields, secondly is design experiment to collect data which is used to answer the research question, and lastly is retrospective analysis (analysis of data obtained from previous stages), in this stage the researchers analyzed the data which is obtained from the experimental design. Then, the data is used based on the results of the analysis to develop the next design.

3. Result and discussion
The result of this study indicates that learning design of square and rectangle’s area, in mathematics learning process; by using sarong motive chess have an important role to construct the concept the area of a plane. The square unit, as a motive of Sarong, can help the students to determine the area of square and rectangle.
3.1. Preliminary design

The first stage of design research is preliminary design. The aim of this stage is constructing the concept as a result of conjectured Local Instruction Theory (LIT) which is consisting of three components: (a) learning objectives for the students, (b) planning of the instructional activities and the tools or the manipulative, and (c) a hypothetical learning trajectory (HLT), so that the teacher is able to anticipate students' thought and to understand which instructional activity that can be used in the classroom. In the first phase, the process has begun by formulating the objectives of learning, combined with the experimental anticipatory thinking activities. The teacher as a learning designer imagines how the process of teaching and learning activities is conducted in the classroom [21]. Preliminary design consists of the following steps. Firstly, researcher determine the objective of learning. The objective of learning is helping students’ construction process to build the concept of square and rectangle’s area by using Sarong motive chess. Secondly, researcher determine some instructional activities. In this instructional activities researcher measuring the area of square and rectangle using Sarong motive chess and determine the HLT.

The area of a plane is a measure of the amount of space a two-dimensional shape. That is the space that is enclosed by its boundary. Constructing the concept of area of a plane, students activities is derived as follow. First, students must understand the characteristics of the area of a plane before they were measuring it. Second, they cut the plane into two parts then rearrange it into many various shapes. It showed up that the shapes have the same area, before and after they cut it. In measuring area, the students use a unit area. Using a square unit as the unit area is a common way to help students to build the understanding of a concept of a topic in mathematics [22]. Some people can use colored square tiles, the other can use square pieces of cardboard. In measuring the area, the students used sarong motive chess. The square and rectangle’s area construction showed at Table 1 and Table 2.

| No | Square | Side | Square unit | The area |
|----|--------|------|-------------|----------|
| 1  |        | 1    | 1           | $1 = 1 \times 1$ |
| 2  |        | 2    | 4           | $4 = 2 \times 2$ |
| 3  |        | 3    | 9           | $9 = 3 \times 3$ |
| 4  |        |      |             | $\text{Area} = s \times s$ |

The square and rectangle’s area construction showed at Table 1 and Table 2.
Table 2. Rectangle’s area construction

| No | Square | length | width | Square unit | The area |
|----|--------|--------|-------|-------------|---------|
| 1  | ![Square](image) | 2      | 1     | 2           | 2 = 2 x 1 |
| 2  | ![Rectangle](image) | 4      | 2     | 8           | 8 = 4 x 2 |
| 3  | ![Rectangle](image) | 5      | 3     | 15          | 15 = 5 x 3 |

In the instructional activity, researcher derived the Hypothetical learning trajectory (HLT) of the square and rectangle’s area for elementary school students (Table 3). The HLT was formulated as the teaching and learning activities (Figure 1).

Table 3. HLT of square and rectangle’s area by using sarong motive chess

| No | Learning objectives | Learning activities | Hypothesis | Concept |
|----|---------------------|---------------------|------------|---------|
| 1  | Students are able to recall the square and rectangular shape | By observation, students observed a few plane and then matched sarong with suitable plane | - Students are able to mention the accuracy of shape of the plane while they find the right frame of square and rectangle of plane: | - There are inverted concept between square and rectangle |
|    |                     |                     | - There are inverted concept between square and rectangle | |
| 2  | Students are able to find the concept of plane’s area | By experiments, students find the concept of the plane’s area. | - Students are able to find the concept of area and differentiate with perimeter concept | - There are inverted concept between area and perimeter |
| 3  | Students are able to find the concept of square and rectangle’s area | By experiments using sarong motive chess, students find the concept of square and rectangle’s area. | - By experiment, students can determine the square and rectangle’s area by using sarong motive chess. | - There is an inaccuracy of the concept of square and rectangle’s area |
3.2. Teaching Experiment

The learning activities were formulated in the previous phase. Teaching experiment was conducted for the 3rd-grade students of 1 Pati Kidul Elementary School. Researchers are assisted by the team, teacher of the class and undergraduate students of Universitas Muria Kudus. The teacher, as the partner in the research, observes the management of class as well as contributes giving questionnaire response. The research team observes students’ learning activities, and some undergraduate students make photograph documentation of learning activities. The learning stages are described as follows. Firstly, researcher uses sarong motive chess as realistic problem context to discover the concept of square and rectangle’s area. Secondly, researcher use of models for progressive mathematization. In this stage researcher is assisted by discovery board concept of the square and rectangle’s area. Thirdly, researcher uses student construction result, in this condition students use the given context to obtain the concept of square and rectangle’s area. The student’s paperwork and construction result were used as the basic knowledge of the development of mathematical concepts. The next step, researcher develop interactivity and character. At the learning process occurs social interaction between students to students and students to the teacher. Social interaction is one example of character education for students to respect the opinions of others and be democratic. The demands of presenting the idea of the discovery rectangular area concept in the discussion developed into a form of awareness and responsibility in communicating ideas to the environment. Lastly is intertwining concept. In this stage, while students were discovering the concept, several interrelated mathematical concepts such as geometry concept, square area, and multiplication are used.

3.3. Retrospective Analysis

Student’s activities, in constructing the concept of the square and rectangle’s area by using Sarong, have different steps with the common activities which are implemented in class before. In this study, Sarong motive chess is used as a context to build the concept of the square and rectangle’s area. Both researchers and teacher conduct a retrospective analysis which is used to reflect and analyze the learning process. Both of them were also comparing the HLT and the instructional design with the reality that occurs in teaching and learning process. Overall, the learning process is well-organized. Some findings which were related to student activity in constructing the concept of square and rectangle’s area is described as follows.
3.3.1. Observation Activity of Sarong Motive Chess to find the concept of square and rectangle
Rani, a student who sat in front of the class, was asked to mention two shapes in the Sarong. She was able to answer the shape in Sarong, which is a square and a rectangle, but Rani confused to point out which one is square and rectangle. Fortunately, Soleh helps Rani by pointing out that the rectangle has long edges (called the length) and short edges (called the width) while the square has the same edges of the length.

3.3.2 The concept of Area
Based on the observation conducted by the researcher, it is difficult for students to derive the concept of Sarong’s area. After the teacher gives a hint, Ifana, one of the students in the class, was able to answer that the area of Sarong is the surface itself. Then, the teacher asks the students what the surface area it was? The students answer that the surface area of Sarong is its fabricants. By using these guided questions, students are able to construct the concept of area of a plane. Students explained that the surface area of Sarong is the surface area of its fabricants.

3.3.3 The concept of Square and Rectangle’s Area
In this activity, each group tried to find the concept of square and rectangle’s area by using Sarong and student’s discovery board (Figure 2 and 3). Teachers have a role as mentors and facilitators. The student’s paperwork presented the work belonging to several groups of students (Figure 4).

Figure 2. First group’s cardboard
Figure 3. Second group’s cardboard
Figure 4. Students’ paperwork

There are three activities to construct the concept of square and rectangle’s area by using Sarong motive Chess. There are determining the number of the square unit as a motive at Sarong one by one, determining the number of the square unit as a motive at Sarong based on the number of rows, determining the number of the square unit as a motive at Sarong based on the number of columns. By doing this activity, students
are not afraid to give new ideas, share with each other about their ideas, and produce products [23, 24]. In addition, based on the student's paperwork, it shows that the student was able to show how many square units indicate the side and length, and how many square units indicate the width and the square and rectangle’s area which is indicated by the number of square units in it.

In comparison with the previous studies, students used Caping to construct the concept of the area of a circle [11]. It found that the implementation of manipulative helps students to construct the concept of area of a plane as well as Sarong. Since Sarong can represent the square unit of a plane. It should be possible for researchers to implement it in the circle for the further study. The process of mathematization constructed by the students through the use of a model is illustrated in the iceberg of the invention square and rectangle’s area in Figure 5.

![Figure 5. Iceberg of Students Construction on Square And Rectangle’s Area By Using Sarong Motive Chess](image)

4. Conclusions
Based on the data can be concluded that sarong motive chess can be used for mathematics learning process. It helps the students to construct the concept of a square and rectangle’s area. This study produced learning trajectory to construct the concept of a square and rectangle’s area by using sarong motive chess, especially for elementary school students.

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