The Use of Magnetic Cube and Sticks Media in STEM-Based Learning (Science, Technology, Engineering, and Mathematics)

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Abstract. This research resulted in a method or learning path that is appropriate for learning mathematics about number patterns using magnetic cube media and STEM learning. The method of this research is design research with three stages, namely: preliminary design, experimental design, retrospective analysis. With the research subjects 32 students of class VIII.7 in SMP Negeri 27 Palembang. Data was collected through observation sheets, video recordings, interviews, photo documentation, and student activity sheets. The data collected was then analyzed retrospectively collected on HLT (Hypothetical Learning Trajectory). From the results of data analysis, it can be concluded that this research produces a mathematical method or trajectory for the subject of class VIII number patterns that are valid and reliable. Valid from HLT and traceable. Reliability is seen in data triangulation, namely from field notes, observation sheets, and video recordings. Where by using magnetic cube media that combines using STEM students are happier and excited in learning because they use knowledge, technology from the media, their ability to use media so that it brings out the expected mathematical knowledge

1. Preliminary

Today, in the 21st century, global competition requires human resources to have integrated capabilities in the working world, one must have the ability of more than one field of science. Studies by Trilling and Fadel show that high school, diploma and higher education are still less competent in terms of: oral and written communication, critical criticism and problem solving, work ethic and professionalism, work in teams and collaborate, work in different ways, use technology, and project management and leadership [1][2]. The 2014 ASEAN Business View Survey reports the results of its research and states that Indonesia considers investment destination countries and is not one of the main destinations of the ASEAN region. This survey also addresses the facts that are not good, the fact that Indonesia has a low-skilled and cheap workforce. [3][4]

This fact is supported by the results of a survey conducted by international institutions such as the Trends in International Mathematics and Science Study (TIMSS) and the International Student Assessment Program (PISA) which places Indonesia in an unsatisfactory position among the countries surveyed [5]. The cause of the low human research based on TIMSS and PISA is the lack of skilled career skills to fill jobs in the STEM field (science, technology, engineering, mathematics) [6][7]
For this reason, the learning in schools must be adapted to the needs expected at this time. Project-based learning (PjBL) is one of the most recommended learning models at present [8]. Namely the learning model that emphasizes contextual learning through complex activities [9], based on questions and problems that are very challenging and guide students to design, solve problems, make decisions, conduct investigations, and provide opportunities for students [10].

This learning model is very compatible with the STEM approach which is integrated learning and requires students to think creatively because it is directly related to one field of science with another field of science [11]. Beer states one learning approaches that can be used to practice creative thinking skills are STEM learning approach [12]. The results show that STEM-PjBL can increase scientific literacy, motivation, material understanding, creative thinking ability, effectiveness, meaningful learning, and supports future careers [8].

STEM-based learning consists of four elements, namely science, technology, engineering, and mathematics which can improve the relationship between all STEM elements so that learning can be more meaningful. STEM-based learning is expected to foster student interest in liking and mastering science, technology, engineering and mathematics [13]. Learning through STEM integration can make students better prepared for STEM field work [14][15]. In this research, researchers used the media in studying number patterns. Several studies have shown that STEM-based learning using instructional media is applied in formal education [11]. Mathematical education media which are more likely to be called mathematical manipulative material can be defined as teaching aids to be integrated with the aims and content of teaching [16]. The media used were magnetics cube and stick in the form of pieces of magnet that can be used to load shapes as desired, just like playing a block or Lego. The selection of the use of magnetic media is caused by magnetic media is a very concrete media, simple and attractive for children because of its power which is able to attract objects - certain objects especially objects which contains metal elements [17].

Magnets have attractive and repulsive properties. This trait is studied in physics science. So the teacher can provide science knowledge in learning this number pattern. To build a building from a magnet, it requires attractive properties to glue the pieces of the magnet together. So that the use of magnets is quite efficient because students do not need an adhesive to make a building.

Then the use of this magnetic media requires students to be able to think about how to produce work that has regularity in its form. To produce this work students must have the ability to assemble these magnetic pieces so as to produce a neat work. This shows that the arrangement of magnetic shapes students have the engineering ability to assemble pieces of magnetism so as to form a building that has regularity in shape.

Because of the above, this research aims to produce Learning trajectory in numbers pattern learning. But in this artikel, the researcher only discusses the use of media namely magnetics cube and sticks.

2. Research Method

This research is used design research method, which has three stage of research namely preliminary, teaching experiment, retrospective analysis (See Nieven, Mc Kenney, and Van den Akker, 2006) [18]. The cyclic process is the process of thinking experiments to learning experiments in the form of diagrams with illustrations of Gravemeijer and cob experiment ideas [18]. The subject research were 32 students of class VIII.7 SMP 27 Palembang.

In the Preliminary stage, the researchers conducted a literature review of number patterns on class VIII, reading syllabi, determining the basic competencies and core competencies that will be used, making indicators and learning objectives as a foundation in developing learning trajectory in learning number patterns in class VIII. Then, the researcher designed the HLT (Hypothetical Learning Trajectory) as an illustration flow of learning number patterns. In this HLT was developed learning activity number patterns using the Project Based Learning model with STEM approach and some guesses that consist of learning purpose, learning activity and hypothesis student’s thought allegation.
In the second stage of the design experiments (experimental experiments and teaching experiments) the researcher tested the HLT that had been designed on 6 students of non-research subjects. In addition, there is a revision in HLT as a guide for the next stage of teaching experiments. In the teaching experiment stage, HLT that has been improved and tested in research subjects is class VIII.7 with 32 students. After a series of activities are carried out, the researcher observes and analyzes things that occur during the ongoing learning process. Researchers evaluate the allegations found in learning activities.

Then in the third stage of retrospective analysis, the data obtained in the second stage are analyzed whether it is in accordance with the allegations that have been designed and the results will be used to develop activities in subsequent learning. The purpose of retrospective analysis in general is to develop Local Instructional Theory (LIT). The researcher analyzed and compared HLT with actual learning to answer the problem formulation in the study.

Data collection techniques used were video recording, interviews, documentation, field notes, and written tests that were collected and analyzed to improve HLT. The analysis was conducted by researchers to improve the reliability and validity of this study.

3. Result and Discussion
The learning design of numerical patterns in this study was made in 3 activities consisting of (1) pattern activities on plants, (2) numerical pattern rule activities, and (3) first n-term number activities. And cube magnets are used in the second activity of the number pattern rule activity. Following is the activity of number pattern rules using magnetic cube:
The learning objectives carried out in this activity are students able to be creative in making cube magnetic patterns and determine the rules of number patterns. Activities carried out by students were provided with magnetic sticks and cubes in each group. Then students were instructed to work together to make a building that is orderly in shape. They should find the rules of the number pattern according to the instructions on the activity sheet.

The following are the processes and creations of the cubes and magnetic sticks obtained for each group

![Figure 2. Students worked together to create magnets buildings and the result of each group](image)

The figure 2 shows the student working and the results of activities using magnets. From 5 groups of students obtained 5 different building creations. This shows students were able to be creative in constructing pieces of magnets into buildings that have regularity in their arrangement. This requires the ability to think creatively, the ability to instruct / construct / assemble magnets (engineering), and the ability to work in groups. Next students observe the magnets that are formed and calculate the magnets pieces that are used in each step of the making.
Following are the results of students' calculations in finding the rules of number patterns from the results of the created magnetics.

Figure 3 above shows students' understanding in finding the rules of number patterns seen from the ability of students to describe patterns to determine n-th patterns. Then students determine the counting strategy for each pattern so that the n-th pattern is derived from a sequence of numbers.

For example for the figure 3.c shows that the group could draw what they have made from the magnetics. Then the students count how many magnets were used at each step of the patterns found. We can see from the picture, they found at every step was 1, 4, 9, 16, …, 100. And at the last column or last step, they must think together what is the rule of the number pattern that they have found. And they wrote the rule step by step namely 1 = 1, 4 = 2 x 2, 9 = 3 x 3, 16 = 4 x 4, …, 10 x 10, …n x n. And at last they made the conclusion that for n-th term the rule is nxn = n².

After carrying out this activity, students continued to determine the number of the first n-terms in the order that was obtained in the previous activity. The teacher gave a number pattern and the student
worked together to find the sum of the first n-terms. These are the results of student activities in determining the sum of the first n-terms:

**Figure 4. Students’ strategies in finding the formula for the sum of the first n-term number.**

Figure 4 shows the strategies made by students. There are some differences in strategy but have the right answer even with different algebra writing. At the figure 4.a, 4.b, and 4.c the number patterns is 4, 8, 12, 16, 20 and the rule of number pattern is 2 x n. They had to find the sum of the first n-terms. Each group have different strategy, figure 4.a for group 1 wrote 4 = 1 x (2+2x1), group 2 and 3 wrote 4 = 1 x 2 (1 + 1), until they found for n-terms group 1 found the rule of the first n-terms was n x (2+2n), and group 2 and 3 found the rule of the first n-terms was n x 2(n+1). It was show that the student have some differences in strategy but it was true answer. It means the student had thinking creatively in finding rules, and make a good team work.
Students were tested on their abilities with questions related to real life every day. The following are the results of the work on the questions by several groups.

![Image](image.png)

**Figure 5.** The strategies of students’ answers to solve problems in real life problems.

The last activity above in Figure 5, students could find strategies to solve mathematical problems in real life. They use the rules of numerical patterns and determine the first n-term numbers even with different strategies but have the same end result.

### 4. Conclusions

From all of the activities that have been carried out by students, the use of magnets is very influential on students' motivation in learning because it increases their enthusiasm in "playing” building / assembling magnetic pieces. The use of magnets also enhances students' creative abilities by creating building works that have certain arrangements or patterns. Each group produces a variety of work.

With the success of students completing all activities, this shows students can find the rules of number patterns, the sum of the first n-terms and be able to solve real problems in real life.

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