Students’ Spatial Ability through Open-Ended Approach Aided by Cabri 3D

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Abstract. The use of computer software such as Cabri 3D for learning activities is very unlimited. Students can adjust their learning speed according to their level of ability. Open-ended approach strongly supports the use of computer software in learning, because the goal of open-ended learning is to help developing creative activities and mathematical mindset of students through problem solving simultaneously. In other words, creative activities and mathematical mindset of students should be developed as much as possible in accordance with the ability of spatial ability of each student. Spatial ability is the ability of students in constructing and representing geometry models. This study aims to determine the improvement of spatial ability of junior high school students who obtained learning with open-ended approach aided by Cabri 3D. It adopted a quasi-experimental method with the non-randomized control group pretest-posttest design and the 2x3 factorial model. The instrument of the study is spatial ability test. Based on analysis of the data, it is found that the improvement of spatial ability of students who received open-ended learning aided by Cabri 3D was greater than students who received expository learning, both as a whole and based on the categories of students' initial mathematical ability.

1. Introduction
Spatial ability is one of the skills or mathematical skills that must be mastered by students. Coxford [1] defines mathematical spatial abilities as a feeling of intuition for form and distance that includes the ability to recognize, visualize, present and alter geometric shapes. Piaget & Inhelder [9] mentions that spatial abilities are abstract concepts that include dimensions of visual relationships, terms of reference, projective relationships, distance conversion, visual representation, and mental rotation. The spatial ability can be obtained by the students through the developmental path based on topological spatial relationships (imitating images, perceptions of spatial position), projective (measuring the ability to coordinate a number of different points of view) and euclidis (the ability to coordinate the axis symmetry of the point pair, the rotation of the two-dimensional geometry image).

Lin and Petersen [8] say that spatial abilities refer to skills in representing, transforming, generating, and remembering symbolically. McGee [8] divides spatial abilities into two main factors: spatial visualization and spatial orientation. Spatial visualization is the ability to imagine, manipulate, spin, rotate, or flip objects without referring to a person. While spatial orientation is considered as a person's ability to imagine the appearance of objects from different perspectives.

Maier [7] says the following five spatial abilities: 1. Spatial perception, i.e. spatial perception requiring a vertical or horizontal location, 2. Visualization, i.e. the ability to visualize the position of
an existing object of movement or displacement. 3. Mental rotation, i.e. to rotate 2D or 3D objects quickly and accurately. 4. Spatial relations, i.e. the ability to understand the position of objects or parts of an object and its relationships, and 5. Spatial orientation, i.e. the ability to physically or mentally fit in space.

Based on some of the opinion of the theorists and mathematicians described above, the spatial ability used in this study is the ability to concretize something abstract with the indicator is to imagine the position of an object geometry, accurately predicting the actual shape of the geometry that is perceived from a particular point of view, determines the actual size of the visual stimulus of an object, as well as constructing and representing geometric models drawn on plane.

Spatial ability is a complex concept. It means spatial ability is not a single ability but a set of abilities. Dixon and Olson [4] say that spatial ability is closely related to visual thinking but are not a single unity. This resulted in no single pattern of learning characteristics that will make itself to realize the spatial abilities intact. In other word, spatial ability will not be realized entirely by using only one model or learning approach.

The determination of a mathematical model or approach is the initial key as a teacher's attempt to improve students' math power. A varied learning model or approach that provides many learning options enables the development of potential learners. Therefore, learners are given the opportunity to develop in accordance with the capacity, learning style, and learning experience.

In connection with the above problems, the effort to improve the learning process through the effort of selecting the model or the appropriate and innovative learning approach in learning mathematics is a requirement. One of the learning approaches alleged to be used to improve the quality of learning processes and outcomes is open-ended learning.

Learning through open-ended approach can be interpreted as a learning that builds interactive activities of students with teaching materials, so the idea to develop a solution strategy can emerge. An open-ended approach is a learning approach that presents a problem that has more than one answer or settlement method [5]. Learning with an open-ended approach can give students the opportunity to acquire knowledge, experience finding solutions, solving problems in several ways. An open-ended approach can give students the opportunity to acquire knowledge, experience of finding, recognizing, solving problems with several techniques so that students' thinking can be well trained [6].

Computer technology also allows students to learn mathematics more easily and more easily, especially on materials that are not easily taught by ordinary teaching or aids, because the computer can bring a lot of media such as text, images, graphics, tutorials, video, animation, simulation and games. Emphasizes that high-level concepts and skills that are linked between one element and another are difficult to be taught through books alone, since books have limitations that are presented [3]. Collen and Steven [2] say that students use computers every day to improve basic math skills, to develop effective problem-solving strategies, or to learn more complex concepts.

Learning through open-ended approach with the aided of Cabri 3D is a learning approach involving optimally active students, enabling students to investigate to improve spatial abilities that integrate thinking skills and conceptual understanding. In this lesson, it exposes the students to various challenging problems that can present the students' thinking activities in solving the problem.

2. Method
This study is a quasi-experimental study involving two classes as an equivalent sample that is, the experimental class and the control class. The sample classes are determined by using existing classes, not by randomly assigning research subjects to the sample classes. In the experimental class using learning through open-ended approach aided Cabri 3D, while the control class using expository learning. The design of this study using non-randomized control group pretest-posttest design.
3. Result and Discussion

Spatial ability is obtained through pretest and posttest. From the pretest and posttest scores, then calculated the mathematical spatial N-gain in the experimental class that received the learning with the open-ended assisted approach of Cabri 3D and control class which received expository learning.

The results of the significance difference test of N-Gain ability of spatial ability of students based on learning and initial mathematical ability (IMA) using two-track ANOVA test are presented in Table 1 as follows.

Table 1. Two way anova test result data of N-gain spatial ability based on learning and IMA

| Source                     | Sum of Square | df  | Mean Square | F     | Sig.  | H0  |
|----------------------------|---------------|-----|-------------|-------|-------|-----|
| Teaching Method            | 0.180         | 2   | 0.180       | 11.419| 0.000 | Rejected |
| IMA                        | 4.106         | 1   | 2.053       | 130.163| 0.000 | Rejected |
| Teaching Method*IMA        | 0.040         | 2   | 0.020       | 1.236 | 0.293 | Accepted |

Table 1 above shows that the probability (sig.) Value of 0.000 is less than 0.05 or p (sig) <0.05, which means an increase in spatial ability of students' ability in both learning classes between high, medium and low IMA groups Differ significantly. As for the interaction of Sig> α = 0.05, 0.293, so H0 is accepted, it indicates that there is no interaction between learning (open-ended learning approach with Cabri 3D and expository) and early mathematical ability (high, medium and low) to the improvement of students' spatial abilities. To know which IMA groups are significant, then the post-ANOVA (Post Hoc) post test is presented in Table 2 as follows.

Table 2. Data of post hoc test result on N-gain data spatial ability based on IMA

| (I) IMA | (J) IMA | Mean Difference (I-J) | Sig.  | H0  |
|---------|---------|-----------------------|-------|-----|
| High    | Medium  | 1.226                 | 0.003 | Rejected |
| Low     |         | 2.913                 | 0.004 | Rejected |
| Medium  | High    | -1.226                | 0.003 | Rejected |
| Low     | Medium  | 1.725                 | 0.001 | Rejected |
|         | High    | -2.913                | 0.004 | Rejected |
|         | Medium  | -1.725                | 0.001 | Rejected |

Table 2 above suggests that significant differences in spatial abilities increase occurring in high IMA groups with moderate IMA groups, high IMA groups with low IMA groups, and moderate IMA groups with low IMA groups.

Based on the data above, the 3D Cabri software provides an opportunity for the experimental class students to explore their own existing problem solving, and disclose their findings with various alternative answers, since the use of computer software for learning activities is very unlimited. In addition, many students received training during the inquiry phase of student activity sheets. At this step they collect information, investigate the meaning of the non-routine problem presented and solve the problem itself.

Learning with the open-ended approach aided by Cabri 3D, students are able to find a concept that ultimately can be used to solve more complex problems. While for the control class, the spatial ability of the students is trained at the time of the use of the concept on the exercise given problem. The presentation of the concept is fully done by the teacher.
Obstacles occurred in learning with the open-ended approach aided by Cabri 3D such as students are not accustomed to start learning with a problem and the desire to solve problems themselves. As a result, at the first meeting, students feel difficult in the process of solving the problem. However, these obstacles can be overcome at subsequent meetings by encouraging students to understand the proposed situation, starting from what the students know.

4. Conclusion
The spatial abilities improvement of students who received learning with the open-ended approach aided by Cabri 3D were better than students who received expository learning either overall or based on their mathematical early abilities, and there was no interaction between learning (the open-ended approach aided by Cabri 3D and expository) with initial mathematical abilities (high, medium, and low) in improving the spatial ability of students.

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