The effect of concrete-pictorial-abstract learning strategy on spatial sense ability

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Abstract. This study aimed to determine whether the spatial sense ability of 8th grade students who got learning with Concrete-Pictorial-Abstract (CPA) learning strategy were better than those who got conventional learning. The population in this study was all the 8th grade students at SMP Negeri 4 Negara in second semester of the academic year 2017/2018 so that there were 240 students. The sample of this research was determined by cluster random sampling technique so that there were 29 students as experimental group members and 28 students as control group members. This research was categorized as quasi-experimental research with pretest – posttest control group design. Based on data analysis which has done were obtained \( t_{\text{count}} = 3.5365 \) and \( t_{\text{table}} = 1.6730 \). Therefore it can be concluded that the spatial sense ability of 8th grade students who got the learning with Concrete-Pictorial-Abstract strategy (CPA) were better than those who got conventional learning.

1. Introduction

In the syllabus of mathematics for 8th grade students of the junior high school, both the 2013 curriculum and the school-based curriculum put the learning of geometry into the three main subjects of the five main subjects that exist in the second semester namely Pythagoras, Circle, Polyhedron, Statistics, and Probability. Thus the success of math of 8th grade students will be largely determined by the success in learning geometry.

Sutiarso [1] states that geometry is more difficult for student than algebra and statistic and more than 40% of the material difficult math is geometry. Rizkianto [2] states that “in making comparisons, children fail if the shapes are in different orientation, ratio, skewness, or size.” That mean students have a bad spatial ability. Ludovikus [3] states that every student must have a good spatial ability to solve problems in three-dimensional. It is because in the three-dimensional matter many questions are not realized in the actual form or plane. The shape of the solid is only visualized or depicted in a two-dimensional form. This is what makes students confused because the visualization of the three-dimensional into a two-dimensional form requires imagination and student abstraction.

Anita [4] states that spatial abilities are one of the multiple intelligences that humans possess such as musical intelligence, kinesthetic intelligence, logical-mathematical intelligence, linguistic intelligence (language), visual intelligence-spatial (picture and space), interpersonal intelligence, and naturalist intelligence. Spatial intelligence can be defined as the capacity of a person to recognize and perform a description of an object or pattern received by the brain. As stated in Jayantika [5] people with spatial intelligence will have the capacity to manage images, shapes, and three-dimensional solid with the
primary activity of recognizing shapes, colors and solid as well as recognizing images both mentally and realistically.

The elements of spatial ability will be encountered in geometry subject both plane geometry and solid geometry. So the ability of spatial sense is needed in the geometry subject. The importance of spatial sense becomes the focus of the world. It is proven by the spatial ability problem in PISA test every year. Here is one example of a PISA problem related to the spatial sense ability as shown in Figure 1 and 2 below.

![Figure 1. Construction dice](image_url)

![Figure 2. Building block](image_url)

In Figure 1, what is tested is the spatial orientation ability in which students are asked to determine the number of points they can see if the dice construction is viewed from a different perspective. While on the Figure 2 it tested the spatial relation ability where the students are asked to determine the number of small cubes needed to create a large cube in the picture. Concrete problems that require spatial sense is a problem that is closely related to geometry. Thus, there is a close connection between geometry and spatial sense.

But in fact, the ability of spatial sense is very rarely become the center of attention of teachers when learning geometry. This is because teachers often have concerns about not being able to convey topics that need to be taught according to the time available. As a result teachers prefer to teach in the traditional way by using only lecturing methods and give exercise about mathematical problems that are mechanistic with drill method. Learning in school is not enough to provide opportunities for students to develop their spatial sense abilities. Students are not trained to utilize their visualization because learning is presented in abstract form. Though, geometry is a learning that is closely related to the real world. This resulted in the ability of students in the geometry subject is very low compared with other fields of study in mathematics.

CPA strategy consists of three stages, namely Concrete (learning through real objects), Representational / Pictorial (learning through image representation), Abstract (learning through abstract notation). Some research results show that CPA strategy is effectively used in learning mathematics. First, research which conducted by Flores [6] which says that learning with CPA effectiveness strategy is used in purchasing the concept of subtraction. Second, research conducted by Watt [7] which states that the CPA can improve the ability to understand the concept of students who have learning difficulties in learning algebra. Third, the results of research conducted by Frederick [8] states that the learning of CPA is more effective to improve the ability and learning outcomes of students on the subject of geometry and algebra compared with learning with the setting in general (conventional). Fourth, research that conducted by Putri et al [9], shows that the achievement of a spatial sense of students receiving learning with CPA strategies is better than students learning in conventional strategies. However, this study is limited to three-dimensional spatial sense ability only and is still limited to elementary students. While spatial sense of ability is one of the skill that tested in the national exam of junior high school students and the content that appears on the PISA problems involves spatial ability, it is necessary to further research about the influence of CPA strategy on the spatial ability of junior high school students in term of the five dimensions of spatial sense ability with the instrument based on PISA.

From the explanation above, the authors are interested in carrying out a research on "The Effect of Concrete-Pictorial-Abstract (CPA) LearningStrategy on Spatial Sense Ability (KSS) of 8th grade students." The objective of this research is to know whether the spatial sense ability (KSS) of 8th grade students who follows the learning with CPA strategy is better than the spatial sense ability (SSA) of students who follow the learning with conventional strategy.
2. Methods

The population in this study is the entire 8th grade classes of SMP Negeri 4 Negara that consisting of 8 classes with a total of 240 students. The sampling technique in this study uses cluster random sampling where the sample selection is not based on the individual but rather based on the group. Sampling is done by cluster random sampling with drawing system. From the 8 existing classes, 1 experimental class and 1 control class are selected. In the experimental class where the learning strategy of concrete-pictorial-abstract (CPA) is applied and while the control class will only be taught by the conventional strategy of cooperative learning. So that, VIII B class selected as experiment class, and VIII G class elected as control class. This research is a quasi-experiment.

The research design used was pretest-posttest only control group design described in Table 1 below.

| Table 1. Research design |
|--------------------------|
| R | O₁ | X | O₂ |
| R | O₃ | - | O₄ |

Information:
R= group selected randomly
X = treatment or something tested
O₁ = pretest result of the experimental class
O₂ = pretest result of control class
O₃ = posttest result of the experimental class
O₄ = posttest result of control class

The independent variable in this research is the concrete-pictorial-abstract strategy (CPA) applied to the experimental class. While the dependent variable in this research is the spatial sense ability of the students of class VIII SMP Negeri 4 Negara.

The data in this study is a score of spatial sense ability of students that collected through the essay test. The tests given are tests that have been tested and declared valid and reliable. Content validity test is done by two lecturers who have qualified professor and doctor and two mathematics teacher of SMP Negeri 4 Negara so that the quality of accuracy of the instrument can be trusted. The indicators that become the reference in scoring the results of the students' spatial sense ability tests can be seen in the scoring rubric as follows.

| Table 2. Scoring rubric of spatial sense ability test |
|-----------------------------------------------|
| No | Indicator of Spatial Sense                                      | Criteria                                      | Maximum Score |
| 1  | Be able to imagine the position of geometry object after the geometry object is rotated. | No answer at all, or wrong answer              | 0             |
|    |                                                               | Correct answer, no reason, or wrong reason   | 1             |
|    |                                                               | Right answer and reason are right            | 2             |
| 2  | Be able to compare the logical connection of the elements of a solid. | No answer at all, or wrong answer              | 0             |
|    |                                                               | Correct answer, no reason, or wrong reason   | 1             |
|    |                                                               | Right answer and reason are right            | 2             |
| 3  | Be able to accurately predict the shape of an object that is    | No drawing at all or all the pictures are wrong | 0             |
Spatial Sense ability test is given in two stages, that is pretest and final test (posttest). Pretest were performed to determine the pre ability of the students before being given treatment. While the final test done after the treatment. Normalized gain score between before and after given treatment is analyzed to see whether or not the effect of treatment given that is Concrete-Pictorial-Abstract strategy to the spatial sense ability that the students have. The normalized gain score formula that is used as follows.

$$GS_n = \frac{GS}{Max \ Score - Pretest \ Score}$$  \hspace{1cm} (1)

Information:
GS: gain score (posttest and pretest score difference)
GSn : normalized gain score
Firstly, the data obtained are tested by assumptions testing include the normality of data distribution by using Kolmogorov-Smirnov test, homogeneity test of variance using F test. Furthermore, the hypothesis test is done by using t-test with 5% significant level.

3. Results and Discussion

3.1. Results

The aim of data analysis was to answer the research question “Is it true that the spatial sense ability (KSS) of 8th grade students of SMP Negeri 4 Negara who follows the learning with CPA strategy is better than the spatial sense ability (KSS) of students who follow the learning with conventional strategy? The answer to the question is presented below.

The data about spatial sense ability score of students in sample class can be seen in Table 3 below.

| Variable | Experimental | Control |
|----------|--------------|---------|
| N        | 29           | 28      |
| $\bar{Y}$ | 0.4240       | 0.1230  |
| SD       | 0.3613       | 0.2737  |

From Table 3 it can be seen that the average normalized gain score of students’ spatial sense ability toward the sample class that is the experimental class and control class shows that the mean score of students' sense spatial ability in the experimental class is higher than the control class.

The summary of the data normality test in the experimental and control groups can be seen below.

| Class       | D-test | D-table | Description       |
|-------------|--------|---------|------------------|
| Experimental| 0.1891 | 0.246   | Normal Distribution |
| Control     | 0.2104 | 0.250   | Normal Distribution |

From Table 4 above it can be seen that the D-test of both groups is smaller than D-table in the class related thus $H_0$ is accepted and it shows that each class has a normalized gain score for normal distributed spatial ability.

Furthermore, the results of the homogeneity of the data score of students' spatial sense ability can be seen below.

| Sample       | $S^2$    | $F_{test}$ | $F_{table}$ | Description |
|--------------|----------|------------|-------------|-------------|
| Experimental | 0,1305   | 1,7427     | 1,8975      | Homogeneity |
| Control Group| 0.0749   |            |             |             |

Based on the Table 5 for a significance level of 5% with df numerator = 28 and df denominator = 27 obtained $F_{table} = F (0.05) (28.27) = 1,8975$. Since $F_{test} < F_{table}$ then the normalized gain score of the spatial sense ability of the students in the experimental group and the control group had a homogeneous variance.

Based on the normality data distribution and homogeneity test of variance, in the experimental group and the control group is normally distributed and has homogeneous variance. Therefore, the hypothesis
test is performed by t-test of one party (right side). The summary of t-test analysis results is shown below.

| Group            | N  | Df | $\bar{X}$ | S    | $t_{test}$ | $t_{table}$ |
|------------------|----|----|-----------|------|------------|-------------|
| Experimental     | 29 | 55 | 0.4240    | 0.3613| 3.5365     | 1.6730      |
| Control          | 28 | 55 | 0.1230    | 0.2737|            |             |

Based on t-test analysis for normalized gain score of students’ spatial sense abilities data in Table 6 shows $t_{test} = 3.5365$ and $t_{table} = 1.6730$ for $df = 55$ with 5% significance level. Based on the test criteria, because $t_{test} > t_{table}$ then $H_0$ rejected and $H_1$ accepted. That is, the Spatial Sense ability of students who are learned by using CPA strategy is better than students that is taught by conventional strategy.

3.2. Discussion

Based on the results of hypothesis test obtained $t_{test} = 3.5365$ and $t_{table} = 1.6730$ which indicates that $t_{test} > t_{table}$. Therefore, $H_0$ is rejected and $H_1$ is accepted which indicates that the spatial sense ability of students that follows learning with Concrete-Pictorial-Abstract strategy (CPA) is better than the spatial sense ability of students that follow conventional learning. This happens because the CPA strategy provides three stages of learning that train their spatial sense ability. Students get a fun learning experience and train creativity because it involves concrete objects, then students are also invited to represent concrete objects into the picture before directing the students to the abstract stage.

The effectiveness of the CPA strategy has been proven by many researchers (Frederick [8]; Cook [10]; Putri, H.E. [9]; Putri; Flores [6]; Hoong [11]; Hughes [12]; Watt [7]). The study noted that CPA is very effective in teaching a variety of mathematical materials and can overcome difficulties in solving mathematical problems including in improving the spatial sense abilities of elementary students conducted by Putri, H.E., et.al. [9]. But of all these studies there has been no research that reveals the influence of CPA strategy on the spatial sense ability of junior high school students. This spatial sense ability is one of the skills that tested in the national examination for junior high school since the 2013 curriculum is applied. This spatial sense ability test is raised in the national examination for Indonesian students to be familiar with the questions tested in PISA. The Program for International Student Assessment (PISA) is tied to 15-year-old students where they are still in junior high school. However, from 2000 to 2012, PISA noted that Indonesia is always at the bottom 10 ranks and students’ critical thinking skills are still at a low level (Suardana et al [13]). It certainly can not be left continuously. “Mathematics teachers have the potentials to help their students to develop their critical thinking skills” (As’ari [14]).

Research on the influence of CPA strategy on spatial sense ability of grade VIII junior high school students who have conducted is one of the researches that can complement the existing research. The difference of this research with existing research lies in research indicators, research samples and research instruments. Indicators of this research include the five dimensions of spatial sense ability such as spatial perception, visualization, rotation, relationships and orientation. In contrast to previous studies that included three indicators of spatial ability. For the sample of research, the researcher chose class VIII junior high students because at this stage students are required to master space and shape in the learning of solid geometry which in solving the problem of mathematics requires the five dimensions of spatial sense ability. While the research instrument used is a spatial sense ability instrument based on PISA for students to be familiar with PISA questions.

In the Concrete-Pictorial-Abstract (CPA) learning strategy, the stages contained in it allow students to learn more actively and familiarize students with their creativity to construct space. There are three stages of learning in this Concrete-Pictorial-Abstract (CPA) strategy: (1) concrete stages, (2) pictorial stages, (3) abstract stages. The application of mathematics learning with Concrete-Pictorial-Abstract (CPA) strategy at the concrete stage is that each student in the group is given a set of concrete objects related to the subject matter or subject at the meeting. These concrete objects can be manipulated to assist them in solving problems on group LKS. With this concrete object, students exercise their
creativity directly in solving the problem. Students also gain a pleasant learning experience and demand their skills and activities. This certainly bring the spirit and high interest in learning because the learning atmosphere is no longer abstract and not boring.

Next is the pictorial stage where each student in the group represents the concrete objects in front of them into an image. In drawing the concrete objects, students are freed to be creative with attractive colors. However, the student remains in the direction that the resulting two-dimensional image can represent the original object although viewed from different sides. At this stage, students begin to use critical thinking skills and begin to practice their spatial sense ability. After that, students are directed to the third stage of the abstract stage. At this stage, students only use numbers and symbols to solve problems on LKS. The numbers that used are obtained from the size of the concrete objects they have. At this stage students use the critical thinking skills and basic mathematical concepts they already have to find the expected outcomes. Given these three stages, students can be sure that the results or answers they get are not the result of the formula memorization alone, but rather the concrete results they have already seen.

This is in line with the opinion put forward by Delvin (as cited in Cook [10]) that for students to understand basic concepts, students must learn abstract concepts in concrete things first. In this study, the manipulative concrete objects in mentioned are objects that can be touched and moved by students. Manipulative concrete objects are believed to be effective for improving students' math skills with all the difficulties. As Sutiarso [1] said that “...concretize the form of wake up is an important part in understanding the geometry”. The existence of concrete objects will greatly assist students in the transition to the pictorial and abstract stages. For example, in determining the pyramid volume formula, students use several pyramids and then modify them into a cube. The students then found the relationship between the volume of the pyramid and the cube.

Learning with this CPA strategy provides an opportunity for students to train all the competencies that expected in the 21st century which known as 4C (critical thinking, creativity, communication, and collaboration). At the concrete stage, students train their creativity. In the pictorial stages students train creativity and critical thinking, and in abstract stages, they train their creativity and critical thinking skills. While the ability of communication and collaboration is used in all stages of learning because they learn in groups.

In learning with the CPA strategy, the role of the teacher is only as a facilitator and motivator, not as the final answer to the problem. The main responsibility as a facilitator is to make math simple, straightforward, plausible, interesting and relevant (Aljabut [15]). While on conventional learning, in the early stages teachers deliver materials to students so it is still dominated by teachers and students only receive information from teachers. Furthermore, the teacher distributes LKS to the students and discussed it with a group of 4-5 students. In solving the problems in the LKS, students do not use concrete objects but follow the flow or instructions that exist on the LKS. The provided LKS has been completed with an image representing a concrete object. However this cannot make the students focus and eager in following the learning process. In the working on the LKS, students appear to have difficulties in understanding the problems given especially in representing the geometry problems that exist in the LKS. Based on the observations of researchers, even in the presentation of the LKS has been equipped with images of real objects around them, they still have trouble imagining the object. It suggests that students' spatial sense ability is still very low. There are only a few students who look active, while other students are just waiting for their friend's answer without participating in the discussion. Therefore, the effort to improve the spatial sense ability of student is still less than optimal.

Judging from the analysis of the students' spatial ability test results showed that students who follow the learning with CPA strategy are better in representing a problem into the form of images and can recognize the shape of the object correctly even though the object is changing location or manipulated its position. Students also look happy in learning because each student gets their own learning experience through concrete objects that they can hold directly. With CPA learning strategy students will be accustomed to draw or represent a problem which in this case is the problem of solid geometry.
In general, the implementation of learning with CPA strategy can work well and in accordance with the plan. However, in the implementation in the class did not escape from the obstacles. The obstacles faced are as follows.

Require better time management in preparation and implementation of learning process with CPA strategy. This is due to the three stages in the CPA must be run sequentially, so to go to the abstract stage students must complete the concrete and pictorial stages that are highly depend on the speed and creativity of students, where the student's speed level is different so that it needs a good time management.

At the concrete stage, students are very interested and excited so difficult for them to control the volume when discussing with their friends and there are some students who only consider this stage as a stage of play only. At this concrete stage, the teacher's ability in managing the condition of the class in order to remain the class conducive and to conduct individual guidance to the students who play.

When the group representative is asked to present the results of the discussion in front of the class, the student still looks hesitant and is not confident to express his or her opinion. Those who dared to show their opinion only a few people.

However, these obstacles can be handled properly. The first obstacle can be handled by making the lesson plan before the class. The lesson plan is very important to improve the quality of teaching. According to Nuha et al [16] "plan and do stages have roles for teachers to create valid teaching tools. After teaching tool was valid then it can be done with good teaching in the classroom ". From the quotation it can be concluded that good teaching is a teaching that is really prepared. In the implementation of the lesson plan described in detail the allocation of time that available for each stage. Teachers also prepare responses to all possible questions or obstacles of students. Then, to train students' self-confidence, the teacher provides motivation and appreciation to students who dare to state opinion, ask or appear to the front of the class. The teacher must condition the student to remain conducive by reminding the students to reduce their voice volume during discussion.

4. Conclusion
Based on the problem, the objectives, the results of analysis, and the discussion that has been described above, it can be concluded that the Spatial Sense ability of 8th grade students of SMP Negeri 4 Negara who given Concrete-Pictorial-Abstract (CPA) strategy is better than conventional learning. Based on the conclusions above, some suggestions can be given as follows.

1. Educational practitioners, especially those who involved in mathematics learning, are advised to use learning with Concrete-Pictorial-Abstract (CPA) strategies, especially in geometry materials or other materials that require object visualization.

2. This research was conducted on limited sample and learning materials. Other researchers who interested are encouraged to do a research the Concrete-Pictorial-Abstract Strategy (CPA) on broader learning materials to determine the effect of applying this learning strategy in more in-depth mathematics learning.

3. This research is still using conventional props in the form of paper, wood, and glass in which vulnerable to break. Other researchers who interested are encouraged to research the Concrete-Pictorial-Abstract Strategy (CPA) by demonstrating concrete tools or concrete media based on computer technology.

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