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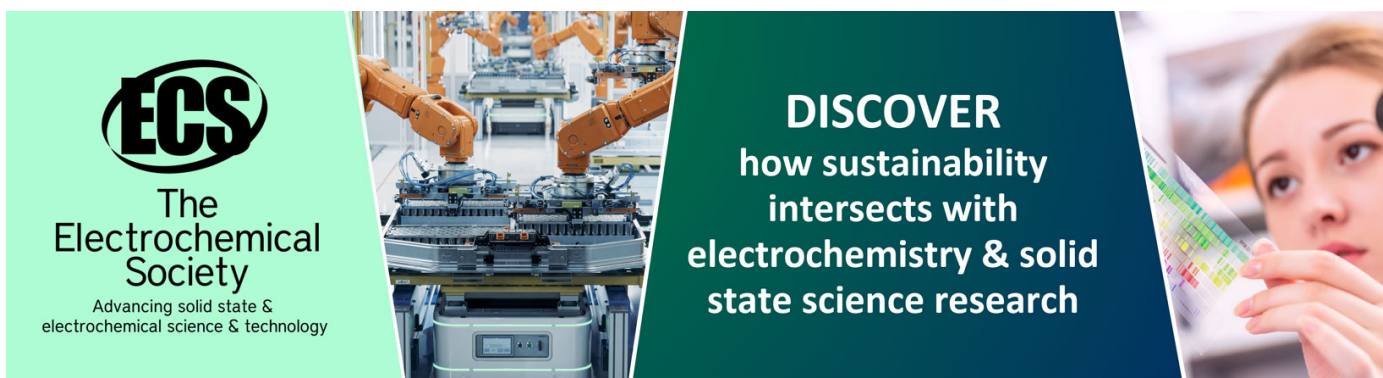
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Influence of concrete pictorial abstract approach to the improvement of spatial sense ability of elementary school students

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Abstract. This study aims to investigate the influence of Concrete Pictorial Abstract (CPA) approach to the improvement of Spatial Sense Ability (SSA) of elementary school students' which can be seen from Mathematical Prior Ability (MPA) and as a whole. It is a quasi-experiment with control design of pretest and posttest in Mathematics in the topic of 3-dimension geometry (3D geometry) to 74 elementary school students in Cikampek, West Java. The present study is conducted by using two study groups, group which implements CPA learning approach as the experimental group and group which implements conventional learning as the control group. Both descriptive and inferential data analysis show that the improvement of students' SSA is better in students with CPA learning approach rather than students with conventional learning, seen as a whole and in every MPA. Therefore, CPA learning can improve elementary school students' SSA.

1. Introduction

SSA is a very important knowledge in the improvement of human civilization today. It is in-line with [1] which states that SSA is important one of humans' eight multiple intelligences. i.e. linguistic, logical-mathematical, spatial, bodily-kinaesthetic, musical-rhythmic, intrapersonal, interpersonal, and naturalistic. Five Mathematics standards of content, one of them is geometry. In the national curriculum, unit of education started from the elementary school to the university level is required in mastering 2D (2 dimension) and 3D (3 dimension) geometry which are tightly related to SSA [2]. Students' spatial sense ability and sensory should be developed properly because spatial sense ability is very beneficial in understanding characteristic and relationship in geometry which can be used to solve mathematical problems and daily problems [3]. Spatial ability is a 3 dimension ability which can be stated as an ability to visualize picture and to understand goods and shape correctly [4]. The necessity of SSA in fact is in the opposite with actual students' competence who is still lack of understanding in geometry. It is in line with the analysis of TIMSS in 2015 [5]. With the study population of grade 4 *SD/MI* (elementary school) students, Indonesia is in rank 45 out of 50 participating countries, which considered difficult by Indonesian students is geometry. Therefore, it can be observed that Indonesian students are still lack of the skill of solving geometry problems. It can be caused by the lack of Indonesian students' SSA. This lack of SSA is in line with the study of Saptini which states that the elementary school students' competence in solving geometry problems is still low [6]. It is based on the pilot study of 3D volume conducted by Saptini in certain of elementary school [6].



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Survey of programme for International Student Assessment (PISA) shows that students are weak in geometry, especially in understanding volume and shape. After an interview with the students was conducted, it is figured out that the students do not like Mathematics because the learning is not interesting and not fun. It is because the Mathematics conventional learning which is teacher-centered and lack of teaching media used in class [7]. There is an approach considered effective in improving students' SSA i.e. the Concrete-Pictorial-Abstract (CPA). It is in corresponding with the study of Witzel et al. on the implementation of CPA approach to develop the basic skills in Mathematics of students with learning difficulty [8]. It is also in-line with the study of Witzel et al. that CPA is beneficial to all students as it is proven to be very effective for students with mathematical difficulties [9]. CPA approach was chosen because it has several stages which are appropriate with elementary school students' cognitive development. Witzel et al. and Putri explain that CPA is a three phases approach begins with the use of manipulated concrete goods as the first stage [9,10]. The second stage is by manipulated pictures which still have relation to the concrete goods mentioned earlier. The last step is learning with abstract notation such as symbols and numbers. Teaching students with these three stages is proven beneficial for the students who have difficulties in learning Mathematics.

Based on the previous explanation, the research questions of this study are as follows: Is the improvement of elementary school students' spatial sense ability better in the students receiving CPA approach than the students receiving conventional approach seen from: All students (whole) and Students' Mathematical Prior Ability (MPA) (high, middle, and low)?

2. Experimental Method

This study was conducted from March to November 2017. This study is a quasi-experiment with pretest and posttest control designs in Mathematics. Pretest is given in the beginning of the learning process to know students' prior knowledge before the treatment. After that, students are given 5 times learning treatments. At the end of the learning process, students are given posttest to know their understanding of the learned material.

The participant are 74 elementary school students in the area of Cikampek, West Java, Indonesia. The 37 students of the experiment group receive a learning with CPA approach, and the 37 students of the control group receive a learning with conventional approach. The sample selection process was conducted by using purposive sampling method. The purposive sampling method carried out by selecting fifth grade students as the samples. The sample selection was considered based on: (1) the fifth-grade students as the high class in the range of age from 10 to 11 years old. In this range of age, the student was assumed in the concrete operational phase in accordance with the Piaget theory that 7 to 11 years of students are being at a concrete stage of thinking. Furthermore, in this range of age, of course they still really need a learning approach that uses their concrete thinking, (2) will not interfere with the school program in preparing students to take the final exam.

The analysis in this study was conducted in two ways including descriptive analysis and inferential analysis. Descriptive analysis is useful to explain or to describe about the subject that investigated through the data gathered from sample or population [11]. Descriptive analysis of the students' SSA improvement is observed from the analysis of normalized gain score. Students' SSA improvement is determined in three improvement categories i.e. low ($N\text{-gain} \leq 0,3$), middle ($0,3 < N\text{-gain} \leq 0,7$), and high ($N\text{-gain} > 0,7$) improvement [12]. Inferential data analysis in this study was conducted through statistical test. If the distributed data has a normal and homogenous distribution, then the statistical test of the hypothesis will be conducted through parametric test (t-test). If the data is in normal distribution but not homogenous, t-test will also be conducted. However, if the data is not in normal distribution, the statistical measurement will be conducted by using non-parametric test (Mann-Whitney test).

The hypothesis that was used in the inferential test for various students' SSA improvement is as follows:

$H_0: \mu_1 = \mu_2$ There is no difference of students' SSA improvement between students receiving CPA learning approach and students receiving conventional approach as a whole.

$H_1: \mu_1 > \mu_2$ The improvement of students' SSA is higher in the students receiving CPA learning approach than the students receiving conventional approach as a whole.

Assessment criteria: If p-value (sig.1-tailed) is higher than 0,05, it means that H_0 is accepted, and the vice versa means it is rejected.

Hypotheses of average difference test of SSA improvement for high MPA group as follow:

$H_0: \mu_{1T} = \mu_{2T}$ There is no difference of students' SSA improvement between students who receive CPA learning approach and students who receive conventional approach seen from high MPA group.

$H_1: \mu_{1T} > \mu_{2T}$ The improvement of students' SSA is better in students who receive CPA learning approach than students who receive conventional approach seen from high MPA group.

Hypotheses of average difference test of SSA improvement for middle MPA group as follow:

$H_0: \mu_{1S} = \mu_{2S}$ There is no difference of students' SSA improvement between students who receive CPA learning approach and students who receive conventional approach seen from middle MPA group.

$H_1: \mu_{1S} > \mu_{2S}$ The improvement of students' SSA is better in students who receive CPA learning approach than students who receive conventional approach seen from middle MPA group.

Hypothesis of average difference test of SSA improvement for low MPA group as follow:

$H_0: \mu_{1R} = \mu_{2R}$ There is no difference of students' SSA improvement between students who receive CPA learning approach and students who receive conventional approach seen from low MPA group.

$H_1: \mu_{1R} > \mu_{2R}$ The improvement of students' SSA is better in students who receive CPA learning approach than students who receive conventional approach seen from low MPA group.

Criteria of the test: If p-value (sig.1-tailed) is more than 0,05 then H_0 is accepted, and if vice versa, it is rejected.

3. Results and Discussion

3.1. Results

Students' SSA improvement is can be seen from normalized gain (N-gain). The students' SSA improvement is higher in those receiving CPA approach rather than students receiving conventional approach. The SSA improvement is in the criteria of middle (N-Gain=0,578) for the CPA learning group; meanwhile, the conventional learning group is in the low criteria (N-Gain=0,294). The summary of SSA N-gain analysis based on the learning approach and MPA group is presented in Table 1.

Table 1. Students' SSA N-gain based on the learning approach and MPA group.

MPA Group	Learning Approach	N-gainScore		$\bar{x}$	Sd	N-gainCriteria
		Smallest	Highest			
High	CPA	0,60	1,00	0,776	0,204	High
	Conventional	0,26	0,59	0,421	0,108	Middle
Middle	CPA	0,38	0,78	0,581	0,115	Middle
	Conventional	0,22	0,44	0,287	0,067	Low
Low	CPA	0,33	0,63	0,539	0,116	Middle
	Conventional	0,15	0,35	0,237	0,050	Low

The average difference test result of the students' SSA improvement based on the learning approach as a whole is presented in the Table 2.

Table 2. Test of average difference of students' SSA improvement based on the learning approach as a whole.

Learning Approach	Average	t_{observed}	df	t_{table}	$p\text{-value}$ (sig. 1-tailed)	Note
CPA	0,5822	10,024	72	1,993	0,000	H_0 rejected
Conventional	0,3043					

Based on the presented data in Table 2, students' SSA improvement is significantly higher in students receiving CPA learning approach than the students receiving conventional learning as a whole.

Average difference test of the students' SSA improvement based on the types of learning approach seen from MPA group (high, middle, and low) is presented in Table 3 and 4.

Table 3. Result of average difference test of students' SSA improvement seen from MPA group.

MPA Group	Learning Approach	Average	T_{observed}	df	t_{table}	$p\text{-value}$ (sig. 1-tailed)	Note
High	CPA	0,777	3,959	11	2,201	0,0005	There is a difference
	Conventional	0,429					

Table 4. Result of Mann-Whitney test of students' SSA improvement seen from MPA group.

MPA Group	Learning	U Mann-Whitney	Z	$p\text{-value}$ (sig. 1-tailed)	Note
Middle	CPA	2,500	-4,487	0,000	There is a difference
	Conventional				
Low	CPA	1,500	-4,504	0,000	There is a difference
	Conventional				

Based on Table 3 and 4, students' SSA improvement is significantly better in students receiving CPA learning approach than students receiving conventional approach seen as a whole and from MPA group (high, middle, low).

3.2 Discussion

3.2.1 CPA approach learning. The learning with CPA approach in this study is designed to develop and improve students' SSA. The tasks in this learning are presented in the form of Group Worksheet (GS). Every GS is designed based on the material of Mathematics in the topic of 3D geometry, SSA indicator, and the learning stage in CPA approach. The involved students in the CPA learning approach are set in small groups students with heterogeneous ability.

CPA approach learning in this study is a learning which focuses on the students' active participation to construct their own knowledge through the learning stage using concrete goods (manipulative), pictorial stage, and abstract stage. The stages give an opportunity for the students to build a new knowledge by making a connection with their prior knowledge. These three CPA stages support each other and the implementation is conducted in integration. Group discussion activity gives a room for each student to add or confirm their knowledge by asking and answering their friends' questions coming from their group or from the other group who have varied mathematical prior ability. When students face a dead end or there is a difference of opinion between groups, the teacher will help the students by giving them guidance or suggestion.

Based on the learning in class, the students receiving CPA learning are more enthusiastic than the students receiving conventional learning. Students who receive CPA learning approach are seen to be able to draw 3D geometry better than the conventional students' group who is seen to face more difficulties. However, it does not happen directly in the first meeting. In the first meeting, the students of the experiment group are also seen to face difficulty in visualizing varied 3D geometry. However in

every meeting, there is improvement in the students' SSA. These findings are in-line with Riccomini who notes that if a student has not mastered the concept/skill in one of the stages (concrete, pictorial, or abstract) in CPA approach, teacher should repeat the last stage that the students have not understood [13]. Students' difficulty in the beginning of the meeting is also because the students have not been familiar with the new approach implemented in the learning. It is in line with Brunner who shows that in implementing new learning/method in the class, the teacher will face difficulty because the students need some time to adapt with the new situation they are facing [14].

3.2.2 Mathematical Prior Ability (MPA). Mathematical Prior Ability (MPA) is students' mathematical knowledge before the learning process of the present study conducted. Students' MPA data is derived from the test regarding required material related to the material in the present study. MPA test is aimed at grouping the students based on their ability (students with high, middle, and low ability) and to observe the equality of the students' mathematical prior ability in the two student groups of study i.e. the group of students receiving CPA learning and the group of students receiving conventional learning.

The result of the MPA test in the present study shows that there is no difference of students' mathematical prior ability in both student groups involved whether in terms of MPA group (high, middle, and low) and as a whole. It means that there is an equality of students' MPA in both of the study groups. This condition fulfills the requirement to give different treatment to the aforementioned groups. Therefore, if at the end of the learning there is a difference of students' SSA occurred in the two groups, it is possibly caused by the different treatment not because of the prior ability. It is in line with [14] who says that the equality of MPA between the two groups in a study (the experiment and the control groups) is an important element. It is a prerequisite to be able to give different treatment to the groups. Furthermore, the categorization of students based on the MPA will be used to answer some issues regarding the students' SSA investigated in the present study.

3.2.3 Spatial sense ability. The findings show that the SSA improvement of students receiving CPA approach learning is significantly higher than the students receiving conventional learning, seen as a whole and from MPA group (high, middle, low). It is in line with the study of [8] who concludes that students who learn to solve the transformation of the equation of algebra through CPA approach obtain higher result than the students receiving traditional learning. Furthermore, the study of American Institutes for Research Yuliawaty states that students who learn by using concrete material develop more accurate and comprehensive mental representation, often show more motivation and do the task well, understand mathematical ideas, and implement ideas for the daily life situation better [15].

This finding refers to the stages of CPA approach which are in line with the cognitive development of elementary school students. Polya argues that the strategy that uses concrete goods and then change the object to simple model like pictures can develop the students' visualization in learning to solve mathematical problems [16]. As suggested by Riccomini, there are three important aspects of CPA learning, they are: (1) learning to manipulate concrete goods by using appropriate concrete goods; (2) learning from manipulated pictures (based on the concrete goods previously), using appropriate pictures; and (3) using appropriate approach to facilitate the students to the abstract concept understanding because it is not easy to understand the change between pictures to abstract notation (symbols/numbers) without the guidance from the teacher [13].

The highest SSA improvement is reached by students with high MPA followed by students with middle and low MPA. It is not surprising because, according to the observation and documentation of CPA learning activity, students with higher MPA are more active in completing the tasks given in the work sheet. They often lead the group discussion to finish the GW. the presentation and discussion, the students with higher MPA are more active in giving opinion about the solution of the mathematical problems. In line to the situation, Arends states that students' ability to learn new ideas depends on their prior knowledge [17]. To master mathematical concept, students need to master the basic mathematical concepts related to the material that will be learned. From the explanation above, it can be concluded that CPA approach can be used as a way to improve students' SSA.

4. Conclusion

It can be concluded that students' SSA improvement is better in the students receiving CPA learning than in the students receiving conventional learning, seen as a whole and from MPA group (high, middle, low). In high MPA group, the students' SSA improvement of students receiving CPA learning is in the high criteria; meanwhile, the improvement of students receiving conventional approach is in the middle criteria. In the middle and high MPA, the students' SSA improvement in students receiving CPA learning is in the middle criteria and the students receiving conventional learning is in the low criteria. The students' SSA improvement in the high MPA group who receives CPA learning is better than the middle and low MPA group who also receive CPA learning. The SSA improvement in the students of middle MPA group receiving CPA learning is better than the students of low MPA group who also receives learning with CPA approach. CPA approach can be used as an alternative of learning approaches to develop students' SSA. Even though there is no one best approach to be used in a heterogeneous class, the finding of the present study shows that the students' SSA improvement is significantly better in the students receiving CPA learning than the students receiving conventional learning.

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