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The Effect of Concrete-Pictorial-Abstract (CPA) Approach on Improving Elementary School Students' Spatial Sense Ability

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Abstract. The spatial sense ability of elementary school students is still low. Concrete-Pictorial-Abstract (CPA) approach is considered able to improve students' spatial sense abilities. This research aims to find out the increase of spatial sense of elementary school students who learned with CPA approach and conventional learning in terms of overall students as well as categories of high, medium, and low Mathematical Prior Ability (MPA). This research uses a quasi-experimental method with pretest and posttest control design in Mathematics subject with the topic of 3D geometry for 131 fifth grade elementary school students in Kotabaru District, Karawang Regency and Cipeundeuy District, Subang Regency. This research was conducted by dividing the students into two groups, namely students who received learning using CPA approach as the experimental group and students who received conventional learning as the control group. Descriptive analysis and inferential analysis results showed that there was an increase of spatial sense in students who learned with CPA approach, which was better than students who received conventional learning. Thus, learning using the CPA approach can improve and develop spatial sense abilities of elementary school students.

Keywords: Concrete-Pictorial-Abstract (CPA), conventional learning, Spatial Sense Ability (SSA), Mathematical Prior Ability (MPA), elementary school students.

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INTRODUCTION~ Spatial Sense Ability (SSA) is an important cognitive ability in human life. This ability supports a person towards a three-dimensional (3D) world and refers to one's awareness of space, so that this ability requires an understanding of the nature of objects, relative positions and all things related to space (Sari, 2015). SSA, according to Gardner (2003), is one of the eight multiple intelligences that is important for every individual. The National Council of Teachers of Mathematics (NCTM) in the United States has included SSA as one of the competencies that must be developed in studying geometry, which is contained in the Pre-college Mathematics Educational Standards (NCTM, 2000). SSA is needed to solve various kinds of problems encountered in daily life, such as reading maps, driving, putting objects in boxes, reflecting, and so on. The reality shows that students' SSA is still low and many students have difficulty learning geometry (Yeni, 2011; Julianti, 2017).

Because of the importance of SSA improvement and the reality that does not meet expectations, learning should use approaches that can provide opportunities and encourage students to have self-confidence to successfully complete all learning tasks. Kristanti and Widyawati (2014, p. 55) explained that inappropriate methods in learning

Mathematics can result in students not understanding the materials. A way to apply the correct method is to choose a learning approach. One approach in learning Mathematics that is considered to be in line with the characteristics of Mathematics and the expectations of the curriculum is the Concrete-Pictorial-Abstract (CPA) approach.

Concrete-Pictorial-Abstract (CPA) approach is an approach in learning Mathematics which is done in stages. Each stage is built on the previous stage and must therefore be taught sequentially. The CPA approach consists of three stages of learning namely learning through physical manipulation of concrete objects, followed by learning through pictorial representations of manipulation of concrete objects, and ends with solving problems using abstract notation (Witzell, 2005). Several research support the effectiveness of this approach, including research conducted by Witzell, Mercer, and Miller (Sousa, 2007) mentioning that students who use the CPA approach in learning have fewer procedural errors when solving algebraic variables compared to students who get conventional learning. The results of Putri's research, Julianti, Adjie and Suryani (2017) showed that elementary students' mathematical problem solving abilities can be improved by applying the CPA approach. Canada Ministry of Education for Ontario (2014) also clarified the involvement of the CPA approach in dealing with students' spatial sense abilities, including manipulating objects, visualizing, creating or designing objects, and finding solutions to a mathematical problem by imagining objects or their numbers proportionally.

In addition to the learning approach factor, there are other factors that are thought to have an influence on increasing students' spatial sense, namely the Student's Mathematical Prior Ability (MPA). This is in line with Arends' (1997) statement which that students' ability to learn new ideas depends on their initial knowledge and the mastery of a mathematical concept requires the mastery of other basic mathematical concepts.

Another important matter in selecting learning approaches to meet the students' learning needs to improve their SSA is the preparation of teaching materials that are designed according to the stages of elementary students' thinking development and the stages of learning with the CPA approach. Then, to measure the level of success in applying the CPA approach, it is also necessary to develop test instruments to find out the increase in SSA.

From this background, the hypothesis proposed in this study is the increase of SSA of elementary school students who received learning with CPA approach is better than students who received conventional learning in terms of overall students and Mathematical Prior Ability categories (high, medium, low).

Today, much research on SSA has been carried out, especially on using the CPA approach to measure students' SSA, such as Putri (2015) who conducted research on using the CPA approach to improve SSA in samples of undergraduate students of elementary school teacher education study program. Putri (2019) also conducted research on using the CPA

approach to measure the increase in SSA by using a sample of 74 5th grade elementary school students in Cikampek District, Karawang Regency, West Java, which concluded that elementary school students' SSA using the CPA approach is better than students who use conventional learning. However, when analyzed further in terms of research results, several students only had and increase of SSA in the moderate category, namely students who have moderate, and low MPA. Therefore, there is a need to reexamine the effect of increasing students SSA in Subang and Karawang Regencies to see and further analyze the increase of students' SSA at high, medium, and low MPA levels so that all students have the opportunity to achieve maximum SSA improvement.

METHOD

Research Type and Design

This research uses a quasi-experimental design with control pretest and posttest. This type of research is used because the sample was selected using purposive sampling technique (conditional sample). This is in accordance with Gribbons and Herman (1996) who explained that quasi-experimental research is usually used in the evaluation of educational programs when random assessment is not possible.

Pretest was given before the treatments (learning activities) began. The treatments were given seven times and each treatment contained materials related to geometry of cubes and blocks. At the end of the learning, the students were given a post-test.

Sample

The sample was 131 elementary school students in Subang and Karawang Regencies, West Java, Indonesia. 66 students received learning with the CPA approach and 65 students received conventional learning.

Sampling Technique

The sample was taken using a purposive sampling technique (conditional). The considerations in choosing the sample in this research including: 1) students who were studying in the fifth grade. They were chosen because they were aged 10-11 years old and were still in the concrete operational stage. According to Piaget's learning theory, children who are in this stage are still developing their thinking through concrete things; 2) the research did not disturb the school program in preparation for the final examinations.

Data Analysis

The data analysis techniques used in this research are descriptive and inferential analysis.

Descriptive Analysis

Sugiyono (2012) explained that descriptive analysis serves to explain or provide a description of the subject under investigation based on data collected from samples or populations. Descriptive analysis of students' SSA improvement was based on the average N-Gain. Student SSA improvement was determined in three achievement criteria, namely low, medium, and high improvement. The criteria was prepared using the grouping rules proposed by Hake (1999) which are presented in Table 1.

Table 1. N-Gain Criteria

Interval	Improvement Criteria
(<g>) ≥ 0.7	High
0,7 > (<g>) > 0.3	Medium
(<g>) ≤ 0.3	Low

note: (<g>) = *N-Gain* score

Inferential Analysis

Inferential analysis of the data in this research was carried out through statistical tests. If the data were normally distributed and homogeneous, the statistical test of the hypothesis would be carried out using the parametric test (t-test). If the data were normally distributed, but not homogeneous, a t-test would also be performed; However, if the data were not normally distributed, the statistical calculations would be carried out using a nonparametric test (Mann-Whitney test).

RESULTS

Student SSA improvement was measured using descriptive and inferential analysis. The following are the results of the descriptive and inferential analysis:

Descriptive Analysis

Table 2 presents the results of the descriptive analysis of the students' overall SSA improvement:

Table 2. Descriptive Analysis Summary of Overall Students' Overall SSA Improvement

Test Type	Learning	Score		$\bar{x}$	*Sd*	*N-Gain*
		Smallest	Largest			
Pretest	CPA	12	42	24.42	6.24	0.77
Postest		34	57	50.29	5.77	
Pretest	Conventional	12	43	27.19	6.58	0.44
Postest		17	54	40.64	8.45	

Table 2 shows that the average ($\bar{x}$) pretest score of the CPA learning group is smaller when compared to the average ($\bar{x}$) pretest score of conventional learning group. As with the average ($\bar{x}$) posttest score shows that the score of the CPA learning group is better than conventional learning groups. This condition is also supported by the improvement shown by the N-Gain score for the CPA learning group (high) which is greater than the conventional learning group (medium). To further strengthen the description of overall student SSA score improvement, the following diagram presents an increase in the average students' SSA score:

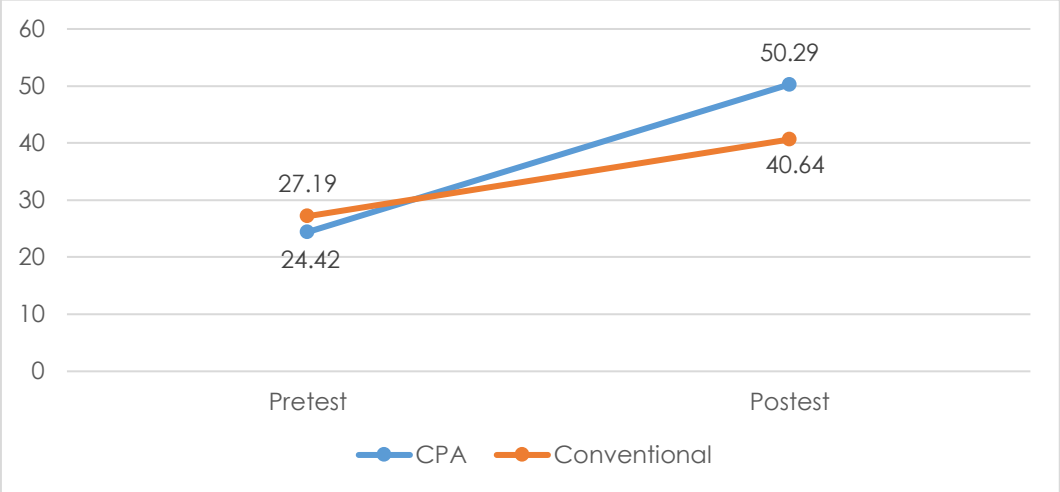

Figure 1. Overall student SSA score improvement

Next, the results of the descriptive analysis of students' SSA improvement based on high, medium, and low MPA is presented in Table 3 as follows:

Table 3. Summary of Analysis of Student SSA Improvement Based on Mathematics Prior Ability (MPA) Group

MPA	Test Type	Learning	Score		$\bar{x}$	sd	N-Gain
			Smallest	Largest			
High	Pretest	CPA	21	42	29.40	5.76	0.76
	Postest		41	57	51.20	4.34	
	Pretest	Conventional	20	43	30.10	7.37	0.46
	Postest		30	54	42.90	8.45	
Medium	Pretest	CPA	15	36	24.78	5.50	0.77
	Postest		35	57	50.21	5.46	
	Pretest	Conventional	16	40	27.35	6.21	0.45
	Postest		22	50	41.13	7.26	
Low	Pretest	CPA	12	31	19.79	5.82	0.79
	Postest		34	57	49.86	7.66	
	Pretest	Conventional	12	31	23.11	6.23	0.36

Postest	17	49	35.67	12.61

Table 3 Shows that the two learning groups (CPA and conventional approaches) experienced a varied increase. There is an increase in the students' SSA who learned with CPA approach is greater than students who learned with conventional learning. This can be seen from the distribution of N-Gain scores in Table 3 which shows the increase in SSA of students learning with CPA approach is in the high category and the increase in SSA of students using conventional learning is in the medium category. The following diagram also presents an increase in students' SSA scores based on high, medium, and low MPA using N-Gain scores:

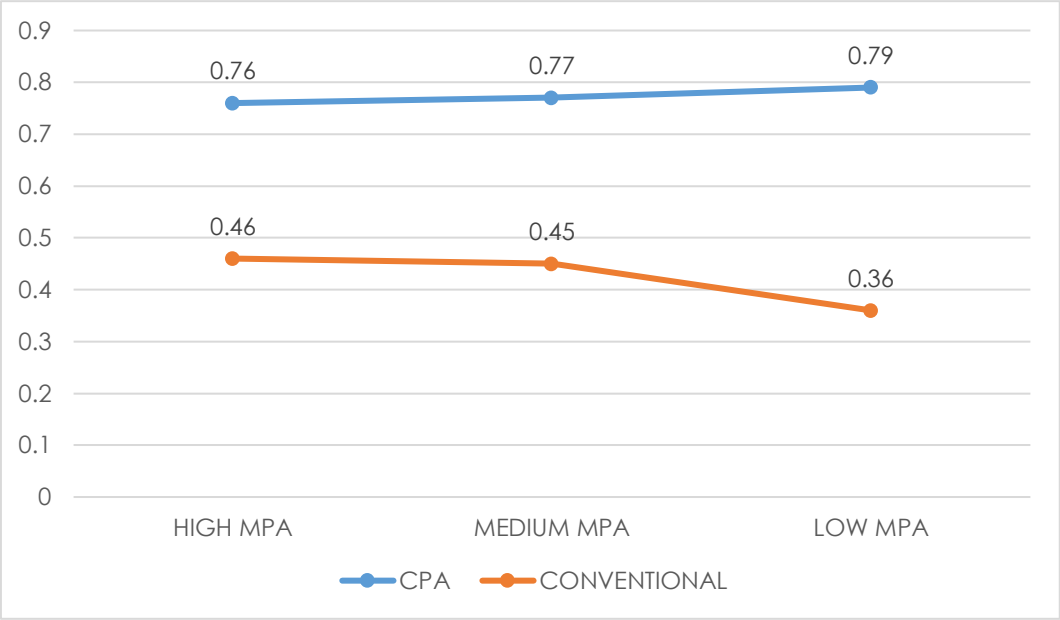

Figure 2. Diagram of Students' SSA Score Improvement Based on Mathematical Prior Ability (MPA)

Inferential Analysis

The descriptive analysis results showed that there was an increase in students' SSA in both learning groups (CPA and conventional approaches) and the increase in learning groups with CPA approach was better than of he conventional learning group. Inferential analysis in this research was used to test the significance of students' SSA improvement based on overall and MPA. To find out the significance, the average difference test as used.

Inferential Analysis of Students' SSA Improvement based on Overall Student

Before the average difference test, the initial step taken was to conduct a normality test. The results of the normality test showed that the data of overall increase in student SSA score

data were not normally distributed. The next step taken was testing the average difference using the Mann-Withney U test. The test hypothesis proposed was as follows:

H_0: $\mu_1 \leq \mu_2$. The improvement of spatial sense ability of elementary school students who received learning with the Concrete-Pictorial-Abstract approach is not better than students who received conventional learning based on student overall.

H_1: $\mu_1 > \mu_2$. The improvement of spatial sense ability of elementary school students who received learning with the Concrete-Pictorial-Abstract approach is better than students who received conventional learning based on student overall.

The criteria used in the test of average difference in this research are as a condition of acceptance of the hypothesis, including the following:

1) H_0 is accepted if: $\frac{p-value\ (\text{Sig. 2 arah})}{2} >$ a or 0,05

2) H_0 is rejected if: $\frac{p-value\ (\text{Sig. 2 arah})}{2} \leq$ a or 0,05

The following are the results of the test of the average difference of the improvement in the SSA score students overall:

Table 4. Summary of Average Difference Test Results of the SSA score Improvement of Students Overall

Learning	Mann-Withney U	Z	p-value (sig. 2 tailed)	(p-value (Sig. 2 tailed)):2	Interpretation
CPA Conventional	688.000	-6.715	0.000	0.000	H_0 rejected

Table 4 provides information that all categories $\frac{p-value\ (\text{Sig. 2 tailed})}{2}$ are smaller than 0.05. From the results of this average difference test it can be concluded that the improvement in spatial sense ability of elementary school students who received learning with CPA approach is better than students who received conventional learning in terms of overall students.

Inferential Analysis of Students' SSA Improvement based on Mathematical Prior Ability

The normality and homogeneity tests were the statistical tests carried out before the average difference test. After the normality test was carried out, it was concluded that the high MPA group data were normally distributed but not homogeneous. Thus, the average difference test use the t-test. For the medium and low MPA group, since the data were not normally distributed, it can be directly tested using the Mann-Withney U test. The following table is the

summary of the test results of the average difference in the improvement in students' SSA scores based on the high MPA group:

Table 5. Summary of Mean Difference Test of Students' SSA Score Improvement in High MPA Group

Learning	*t'*	*df*	*p-value (sig.* 2 tailed)	Interpretation
CPA Conventional	2.762	13.440	0.016	H_0 rejected

From Table 5, it is seen that the t score obtained is 2.762 and has a p-value (sig. 2 tailed) below 0.05 and rejects H_0. Thus, it can be concluded that the improvement of SSA of elementary school students who received learning with CPA approach is not better than students who received conventional learning in terms of overall students and students with high MPA category.

Next is the difference test of the average improvement of SSA using the Mann-Withney U test in the medium and low MPA groups. The hypotheses proposed are as follows:

a) Hypothesis for SSA score improvement in medium MPA group

H_0: $\mu_1 \leq \mu_2$. The improvement of spatial sense ability of elementary school students who received learning with the Concrete-Pictorial-Abstract approach is not better than students who received conventional learning in medium MPA student category.

H_1: $\mu_1 > \mu_2$. The improvement of spatial sense ability of elementary school students who received learning with the Concrete-Pictorial-Abstract approach is better than students who received conventional learning in medium MPA student category.

b) Hypothesis for SSA score improvement in low MPA group

H_0: $\mu_1 \leq \mu_2$. The improvement of spatial sense ability of elementary school students who received learning with the Concrete-Pictorial-Abstract approach is not better than students who received conventional learning in low MPA student category.

H_1: $\mu_1 > \mu_2$. The improvement of spatial sense ability of elementary school students who received learning with the Concrete-Pictorial-Abstract approach is better than students who received conventional learning in low MPA student category.

The criteria used in the test of average difference in this research are the condition of acceptance of a hypothesis, are as follows following:

1) H_0 is accepted if: $\frac{p-value\ (\text{Sig. 2 arah})}{2} >$ a or 0.05

2) H_0 is rejected if: $\frac{p-value\ (\text{Sig. 2 arah})}{2} \leq$ a or 0.05

The following are the results of the average difference test of SSA improvement based on student MPA group (moderate and low) using the Mann-Whitney U test:

Table 3. Summary of Average Difference Test Results for SSA Improvement in Moderate and Low MPA Group

Category	Learning	*Mann-Withney U*	Z	*p-value (sig.* 2 tailed)	*(p-value (sig.* 2 tailed)):2	Interpretation
Medium MPA	CPA / Conventional	291.000	-5.647	0.000	0.000	H_0 rejected
Low MPA	CPA / Conventional	22.000	-2.588	0.010	0.005	H_0 rejected

Table 6 provides information that all categories obtained $\frac{p-value\ (\text{Sig. 2 tailed})}{2}$ smaller than 0.05. From this results, it can be concluded that: (1) the improvement of SSA of elementary school students who received learning with the CPA approach was better than students who received conventional learning in terms of students' MPA in the medium category; (2) the improvement of SSA of elementary school students who received learning with the CPA approach was better than students who received conventional learning in terms of overall students and students with low MPA category.

DISCUSSION

The findings showed that the improvement of SSA of students who received learning with the CPA approach was significantly higher than students who received conventional learning when viewed as a whole and the MPA group (high, medium, low). Compared to the research of Putri (2019), there was a higher increase in students' SSA. In this research, the students who had high, medium, and low MPA had high improvement of SSA. Basically, every student have different abilities. However, these differences are not a problem if the teacher can use appropriate learning strategies, so that they can meet all students' needs and even exceed the standards or predictions (Levy, 2010). Furthermore, Witzel (2005) concluded that students who learn to solve transformation of algebraic equations with the CPA approach obtain higher results than students who receive traditional teaching. Furthermore, Putri, et al. (2017) stated that the achievement of SSA of students who received learning with the CPA approach is better than students who received conventional learning; reviewed as a whole and in each MPA group.

The significant improvement of SSA in students' who received learning with the CPA approach is possible because the stages of learning with the CPA approach provide opportunities for students to understand the concepts taught more easily. The learning stages that begin with manipulating concrete objects then continued with the representation of concrete models or commonly called pictorials, and then to the abstract stage in which mathematical concepts are modeled symbolically to help students store memory about a concept, then form a picture of the concept's understanding process into their way of thinking. This is consistent with Anstrom's opinion (in Yuliawaty, 2011) which stated that learning with the CPA approach allows students to internalize the problem solving process and provide the ability to imitate the process. CPA also provides a problem-solving process that applies to every age group in formal and informal learning situations. Such process will strengthen the students' prior abilities and grow their confidence in making approaches using reason and making relationships to solve more complex problems.

The first stage in learning with the CPA approach, namely the use of concrete objects that can be manipulated, will help students prepare to learn more abstract concepts. This is in accordance with Skemp's notion (in Turmudi, 2012) that providing manipulative objects in learning can be used as a basis for further learning at a more abstract level. In line with this, Bruner (in Suwangsih, 2012) stated that interactions with manipulated concrete objects reinforce understanding of concepts and help students to more easily remember ideas learned and apply them in real situations appropriately.

In the second stage of CPA learning, namely pictorial, students are trained to shift their mathematical abilities from concrete things to symbolic representations (abstract). At this stage, students are trained to represent various mathematical ideas by making drawings, diagrams, graphs, tables, symbols or mathematical models, compiling story problems, making questions or explanations verbally and in writing in their own language related to the process and results of mathematical problem solving. This is consistent with the opinion of NCTM (2000) which stated that representations such as physical objects, pictures, diagrams, graphs, and symbols help students communicate their thoughts.

Such learning conditions in the stages of CPA approach help students succeed in developing and improving their learning outcomes, especially Spatial Sense Ability, more than students who received conventional learning.

The results of the increase in students' SSA who received learning with the CPA approach showed a change in the order of the initial ability. The low MPA student group had a higher SSA improvement than the medium MPA group. However, the SSA improvement in the high MPA student group remains in the high category. The results of this research are in line with the results of Yuliawaty's (2011) research which stated that in learning with the CPA approach, the improvement of mathematical understanding of low-ability students is better

than medium-ability students.

The SSA improvement of the low MPA student group being better than the medium MPA after learning with the CPA approach is possible because the stages of learning with the CPA approach provide opportunities for low-ability students to understand the concepts more easily. The learning begins with manipulating concrete objects, followed by representations of concrete models, which are usually pictorial such as circles, points, or geometric images, and then to the abstract stage where mathematical concepts are modeled symbolically to help students store memory about a concept, and then form a picture of the concept into the way of thinking. This is in accordance with the opinion of Jordan, Miller & Mercer (in Sousa, 2007) which stated that the CPA approach benefits the majority of students and has proven to be very effective in helping students who have difficulties in learning mathematics, because the CPA approach moves gradually from actual objects and then through images and subsequently symbols. Thus, it is clear that the three stages in learning with CPA provide opportunities for students with low ability to develop their spatial sense abilities.

From the discussions above, it can be concluded that the application of learning with the CPA approach is a way to develop and improve students' SSA. To gain a maximum increase in student SSA in learning using the CPA approach, it requires a considerable amount of time to discuss the subject matter provided at each stage of learning with the CPA approach. Therefore, students can thoroughly learn the material in each stage (concete, pictorial, abstract). The use of varied manipulative (concrete) objects and challenging the students' mindset are also needed so students are not trapped in monotonous and boring learning situations. Additionally, Hoong, Kin, and Pien (2015) also expressed that the CPA approach is used to help students who have difficulties in learning, Mathematics and CPA approaches have also been reported to be effective in recovering deficits in basic Mathematics calculations.

CPA has its own characteristics and strengths. Colham Manor Primary School & Children's Center (2016) recognized that the CPA approach is a mainstay of Mathematics learning in Singapore. In the country, the CPA approach is included in the Mathematics learning syllabus for elementary school level. This is consistent with the presentation of the Curriculum Planing and Development Division (2012, p. 33) which stated about increasing conceptual understanding through the use of the Concrete-Pictorial-Abstract (CPA) approach in learning in Singapore.

CONCLUSION

The improvement of Spatial Sense Ability of students who received learning with the CPA approach is significantly better than students who received conventional learning, when viewed overall and based on the MPA group (high, medium, low). The SSA of overall students who received learning with the CPA approach as a whole students were in the category of

high improvement, while the SSA for students who received conventional learning was in the category of medium improvement. Furthermore, when viewed based on MPA, the group that experienced the highest increase in SSA was the low MAP group, followed by the medium and high MPA groups with a high increase category in the overall MPA group. As for the MPA group that received conventional learning, the highest increase in SSA was achieved by the high MPA group, followed by the medium, and low MPA groups with an increase in the three groups being in the medium category.

The application of learning with the CPA approach can be an alternative solution to develop and improve students' SSA because the results of this research indicate that the improvement in students who received learning with the CPA approach is significantly better than students who learn with conventional approach.

This research can be a material of scientific reference for researchers. This research explained that the SSA score with the CPA approach gained a high level of improvement, however, the largest scores were successively achieved by students with low, medium, and high MPA. Hence, this opens up opportunities for researchers to look for other factors that influence these results.

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