Improving mathematics learning of geometry through the concrete-pictorial-abstract (CPA) approach: collaborative action research

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Abstract. The purpose of this research is: 1) describe the steps in the application of the CPA approach, 2) improve mathematics learning through of geometry the CPA approach, and 3) analyze the constraints and solutions of applying the CPA approach. This research is a collaborative classroom action research conducted in two cycles. The subjects were teachers, and students of class IV amounted to 21 students. Data collection techniques using observation, interviews, and tests. The validity of the data uses the triangulation of methods and sources. Data analysis techniques include data reduction, data presentation, and conclusions. The results showed that: 1) the application of the CPA approach to improve mathematics learning about the circumference and width of the flat structure was carried out with the steps of a) concrete, b) pictorial, c) abstract; 2) the application of the CPA approach can improve mathematics learning based on observations and test cycles I and II; and 3) constraints in applying the CPA approach is that the teacher directly demonstrates abstract situation measurement and has not shown modeling of abstract situation measurement to all students, while the solution is to explain examples of abstract situations to students first then explain how to measure abstractly.

1. Introduction

Indonesian National Curriculum (2013 Curriculum), at the level of primary education, contains eight subjects, one of which is Mathematics. Mathematics itself is formed from the thought process, which is the subject of research of arithmetic, geometry, and algebra, as well as problem-solving with the aim of developing thinking creativity and thinking skills and can improve the ability to construct new knowledge [1][2][3]. The National Council of Teachers of Mathematics establishes standards for mathematical skills such as problem-solving, reasoning and proof, communication, connection, and representation, which students should have [4]. The purpose of learning mathematics is to understand mathematical concepts, explain the interrelationships between concepts and apply concepts or algorithms, flexibly, accurately, efficiently, and precisely, in problem-solving [5][6]. The purpose of learning mathematics in elementary schools is to develop creativity, train students to think systematically, logically, critically, creatively, and consistently and increase the ability to construct new knowledge [7][8][9].

However, the facts on the ground show that the goal of learning mathematics is still not achieved. Based on observations obtained information: 1) students are less enthusiastic in learning and pay less attention to the teacher's explanation; 2) student participation is not comprehensive, it can be seen when there are questions from the teacher, only some students dare to convey their answers; 3) concrete media
are rarely used when learning in class; 4) the learning approach applied at the time of learning activities is not in accordance with the stages of student cognitive development; 5) the approach step in learning activities is still limited to providing information/knowledge and not yet optimal in understanding concepts because the delivery of material directly in abstract form, while based on the stages of student development at that age entered in the concrete operational step. This is reinforced by the Mid Term Semester (PTS) data for even Mathematics subjects in the 2018/2019 school year with an average student score of 60.7. The average value is still relatively low because it does not exceed the Minimum Mastery Criteria (KKM), which is 70.

Based on the problems of learning mathematics, learning needs to be improved. One solution is to apply an approach that can influence students to be active and comfortable to understand the material and by the stages of development in Mathematics called the Concrete Pictorial Abstract (CPA) approach. The CPA approach is a significant learning approach to teach mathematical concepts by actively involving students in exploration activities such as practicing, demonstrating, and manipulating teaching aids that are appropriate to the stage of student development so that students can construct their meanings and understandings [10][11][12][13]. Witzel argues that the CPA approach uses hierarchical stages that provide opportunities for students to reconstruct their knowledge; these stages are Concrete (learning through real objects) - Pictorial (learning through the representation of images) - Abstract (learning through abstract notation or symbols) [14][15]. In line with this opinion, Sousa argues that the CPA approach is learning by physically manipulating concrete objects, learning by drawing representations of substantial manipulation, and solving problems using abstract notation. CPA steps used in this research are Concrete as a stage of the manipulation process, Pictorial as the connecting stage of the manipulation process, and Abstract as an explanation that mathematics is learning that uses symbols, symbols, and numbers [16][17].

Some experts state that the application of the CPA approach can improve mathematics learning such as the results of Yulianto, Putri, and Rahayu's research which states that the application of the CPA approach can improve the ability of mathematical connections and learning outcomes in learning in class V Elementary Schools [18]. These results are also strengthened by other studies that using CPA learning models can improve the process of understanding mathematical concepts and improve mathematics learning in the classroom [19]. This is in line with some experts who claim the advantages of CPA for primary school student learning, such as Putri's opinion, which states that the CPA approach by manipulating concrete objects is advantageous in helping students who have difficulty in understanding mathematical concepts [20]. Furthermore, the CPA approach provides stages of learning that help students form meaningful relationships between abilities at the Concrete, semi-concrete, and abstract levels [21].

This research is a continuation as well as reinforcing previous research that the CPA approach can improve learning outcomes, especially mathematical connections [18][19][21]. Furthermore, this research is a means of implementing the concept of the CPA Approach, which includes the Concrete Pictorial Abstract [20][22]. This research is essential because elementary school mathematics requires many implementations of learning approaches that are appropriate to the development of student learning [23][24]. From the description above, researchers and teachers to carry out collaborative action research by applying the CPA approach to improve mathematics learning of elementary school students. Where the purpose of this research is: 1) describe the steps in the application of the CPA approach, 2) improve mathematics learning through the CPA approach, and 3) analyze the constraints and solutions of applying the CPA approach.

2. Methods
The method used in this research is the type of collaborative action research [25][26][27]. In this research, the researcher and teacher did the planning, the teacher implementing the teaching, the researcher made the observation, and the researcher and teacher did the reflection. The subjects of this research were the teacher and grade IV students totaling 21 students consisting of 12 female students and nine male students. In this collaborative research, researchers designed the action while the teacher
to design and carry out the act. Data collection techniques in this research are non-test and test techniques. Non-test techniques consist of observation, interviews, and document studies, while the test techniques used are written learning outcomes tests consisting of multiple-choice questions and descriptions. In this research, non-participatory observations were made when the teacher and students carried out the learning process to collect data about teacher activities, responses, and student participation through the application of the CPA approach. The observations are accompanied by a teacher and student observation sheets arranged according to the learning scenario of the CPA approach. Then, interviews are conducted in a structured manner with interview sheets that have been compiled by researchers and carried out after the learning process. The document research in this research is an analysis of the learning outcomes of the initial conditions before the study.

The data of this research were tested for validity by triangulation techniques. The research triangulation technique consisted of source triangulation and technique triangulation. Source triangulation is used to test data by correcting and matching data from various sources such as interviews, observations, photos, and videos during CPA learning, and learning achievement test data. In comparison, triangulation techniques are used to test the validity of the data by checking and matching the data with a variety of different data collection techniques. The method used is by interview, observation, and test results of learning. All data obtained from various sources and methods are then compared and concluded to receive valid data.

This research uses data analysis of the Miles and Huberman model with a description of the steps of data analysis consisting of 1) data reduction, 2) data presentation, and 3) drawing conclusions [28]. Data reduction in question is the activity of summarizing, focusing, selecting, categorizing, and looking for patterns so that research data provide a clearer picture. After being reduced, the selected data is then presented in a presentation of information that can be in the form of tables, graphs, diagrams, to narratives. Based on the results of the expression of these data, the data is then concluded in general with an objective and valid. The performance indicators of this research are 1) the implementation of CPA approach learning with a targeted percentage of 85%; 2) 85% of students follow the learning process following the steps in applying the CPA approach, and 3) the achievement of student learning outcomes with 85% of students having grades above the KKM after the research action.

This research was carried out through stages: 1) planning, 2) implementation, 3) observation, 4) reflection [29][30]. The planning stage is the process of preparing CPA learning scenarios, learning implementation plans, media and learning resources, student worksheets, and evaluation sheets by researchers with the guidance of implementing teachers. Then, the implementation phase is the process of implementing action planning, which consists of initial activities such as opening greetings, praying, checking attendance, apperception, references, and motivation, and the core activities of observing, asking, trying, reasoning, communicating by applying the Concrete Pictorial Abstract approach. The observation phase is carried out by the observer while the learning takes place based on the observation sheet. Finally, the reflection stage is the process of reviewing and analyzing the strengths and weaknesses of the research actions undertaken by the teacher so that the action of the research at the next meeting is better and structured. The relationship between the four components indicates a cycle or repetitive activity. This research consists of two cycles, each cycle consisting of 2 meetings. This research can be said to be successful if it reaches research performance indicators.

3. Results and discussion

3.1. Implementation of the CPA approach

The implementation of the CPA approach undergone various improvements in the learning process to achieve maximum results. A comparison between cycles of observations can be seen in the following table 1.
Table 1. Comparison between cycles of observation results implementation of the CPA.

| Research subject | Steps to the CPA Approach | Cycle I (%) | Cycle II (%) |
|------------------|---------------------------|-------------|--------------|
|                  | 1<sup>st</sup> Meeting    | 2<sup>nd</sup> Meeting | Average | 1<sup>st</sup> Meeting | 2<sup>nd</sup> Meeting | Average |
| Teachers         | Concrete phase            | 91.66       | 91.66        | 91.66       | 91.66       | 91.66     |
|                  | Pictorial phase           | 83.33       | 88.88        | 87.49       | 89.16       | 89.16     |
|                  | Abstract phase            | 83.33       | 83.33        | 83.33       | 91.66       | 87.49     |
| Average          | Concrete phase            | 91.66       | 91.66        | 91.66       | 91.66       | 91.66     |
| Sudent           | Pictorial phase           | 83.33       | 83.33        | 83.33       | 83.33       | 87.49     |
|                  | Abstract phase            | 83.33       | 83.33        | 83.33       | 83.33       | 85.41     |
| Average          |                           | 86.10       | 86.10        | 86.10       | 88.88       | 90.27     | 89.55     |

Based on Table 1, information is obtained that the observations of the application of the CPA approach to the subject of teacher research; at the abstract stage of the cycle, I have not yet reached the research performance indicators. However, in the second cycle, all steps in implementing CPA have exceeded the research performance indicators with achievements above 85%. There is an increase in the percentage in the pictorial and abstract stages, but the concrete stage has not increased. On the other hand, the results of observations of students at the Concrete stage remain, but at each cycle, the indicators of research performance have reached. So, overall the average value of statements of teachers and students in each cycle has increased and reached research performance indicators.

In the research conducted, the first stage of the CPA approach is the Concrete stage. At this stage, the teacher brings abstract material into concrete material and practices it with concrete media to provide an understanding of mathematical concepts in a tangible form to make students more enthusiastic in learning and also by the stages of elementary school student development. This is in line with Sari's opinion, which states that the CPA approach uses a model or teaching aid as a bridge of student understanding so that it can help understanding teaching material and be able to put out students' mathematical ideas in thinking [31]. The use of concrete media in learning can evoke conceptual ideas so as to reduce the possibility of misconceptions, provide an understanding of concrete basics and concepts so as to minimize verbalism understanding, provide real experiences that stimulate student learning motivation and make the learning process deep and diverse [32][33][34][35].

In the pictorial stage, the teacher changes the concrete model to be semi-concrete by involving drawings from concrete media so that students will draw concrete objects according to their size. In this second stage, students will broaden the understanding that has been obtained from the previous stage and can build strong memories in understanding mathematical concepts in semi-concrete situations. This is in line with the opinion of some researchers that learning by using this method helps students interpret the meanings of abstract symbols using concrete objects and allows students to build memories about images that can be used when it is difficult to interpret abstract symbols [34][36].

At the abstract stage, all learning material and media are already in an abstract form, and students will learn to understand mathematical concepts through symbols, number notation, and mathematical symbols. With the understanding that has been obtained from the previous stage, students will get stages of learning that help students form meaningful relationships between abilities at the Concrete, semi-concrete, and abstract levels. This is in line with Fauziah's opinion which states that students' understanding starts from the concrete level with visual experience to build understanding. Next students expand their understanding through image representation of concrete objects. Then students move to the level of abstract understanding [12][21][37].

Furthermore, the pictorial and abstract stages in cycle I have not yet reached research performance indicators, then in cycle II they have risen and reached research performance indicators. This is because there are obstacles that are experienced that are after the problem is presented, students do not understand the problem and do not ask questions and when working on problems, some students do not
discuss with their group friends. Then, when viewed from the comparison of percentages between CPA stages, the abstract stage has the lowest percentage compared to other stages. This is because there are obstacles that are experienced at the stage of paying attention to the teacher about the presentation of the problem, there are several groups that do not pay attention to the direction of the teacher in solving the problem, so some groups of students have difficulty while working on the worksheet. The visible effects of passivity in student learning include students slow in doing or doing assignments, never asking even if they don't understand so often left behind in lessons and less respected by their group friends [38][39].

3.2. Improvement of mathematics learning through the CPA approach

Mathematical learning outcomes experience various improvements in the learning process to achieve maximum results. Comparison between the post-test cycles of learning outcomes can be seen in the following table 2.

| Table 2. Post-test comparison of mathematics learning outcomes between cycles. |
|---------------------------------------------------------------|
| Aspect | Cycle I | | Cycle II | |
| | 1st Meeting | 2nd Meeting | Average | 1st Meeting | 2nd Meeting | Average |
| Completed (%) | 85.71 | 85.71 | 85.71 | 85.71 | 90.47 | 88.09 |
| Not completed (%) | 14.28 | 14.28 | 14.28 | 14.28 | 9.52 | 11.90 |
| Average | 71.71 | 73.80 | 72.75 | 78.57 | 80 | 79.28 |
| Highest score | 100 | 100 | - | 100 | 100 | - |
| Lowest score | 40 | 40 | - | 50 | 50 | - |

Improvement of mathematics learning by applying the CPA approach can be measured by looking at student learning outcomes by providing an evaluation at each meeting. Based on table 2, in the first cycle, it was found that the percentage of students who had finished in the first cycle of meeting 1 was 85.71%, and meeting 2 was 85.71%. The average student who completed the first cycle was 85.71% with an average overall score of 72.75. In cycle II the percentage of students who had finished at meeting 1 was 85.71%, at meeting 2 that was 90.47%. The average student who has completed the second cycle is 88.09%, with an average overall score of 79.28. From the average results obtained it can show that the learning outcomes of mathematics that have been implemented have reached an indicator of success that is 85%.

The results of this research are relevant to the research using the CPA approach can improve the process of understanding mathematical concepts and improving mathematics learning in the classroom [12][13][17]. Other relevant research is research conducted by Yulianto, Putri, and Rahayu which results show that the application of the CPA approach can improve the ability of mathematical connections and learning outcomes in learning in class V Elementary School [18]. The results of this research are also supported by the results of research on the effectiveness of the CPA approach and its effect on the learning process [10][16][22][40].

3.3. Constraints and Solutions in Implementing the CPA Approach

The application of the Concrete Pictorial Abstract approach that was implemented encountered several obstacles encountered, namely: 1) the teacher had not used the media when explaining the measurement of flat shapes in semi-concrete situations, 2) the teacher directly demonstrated the measurement of abstract situations and had not explained the examples of abstract situations first. 3) students are not allowed to ask questions, 4) some students have not been active in groups, 5) some groups of students do not cooperate when working on worksheets, 6) the teacher has not shown a reenactment of abstract situation measurements on all students, 7) there are still some students who are absorbed in playing alone, so they do not pay attention to the teacher's explanation, and 8) students do not pay attention to the direction of the teacher in solving problems about measuring the circumference of a rectangle. In the
research conducted by the researcher this time, it was found that obstacles generally occur because of the many indicators of the stages of the CPA approach steps and students who tend to be passive and less focused when the following learning so that it becomes an obstacle in the implementation of the CPA approach. In fact, according to Cicekci & Sadik [41], the focus and attention of students in learning is something that needs attention because students who research with greater focus will be more resistant to setbacks and forgetfulness. Attention is the basis for seeing the center of the problem, understanding the problem, and generating ideas by thinking creatively and critically. Students who have difficulty focusing their attention will lose interest in learning so it is easy to stop their learning tasks, have problems in following the rules and sometimes interfere with the course of the lesson [42].

These constraints are in line with the results of the research which states that the shortcomings of the CPA approach are each stage of the learning steps that must be implemented and also the reduced focus of students following learning when students consider using manipulative objects in learning as activities that only play to fill time rather than provide opportunities to improve students' understanding of mathematics, the application of the CPA approach in learning provides potential pitfalls for students in developing their mathematical abilities [18]. In line with this opinion, the results of other studies suggest that a constraint that may be present in the CPA approach is the possibility that can occur at the concrete stage [21]. The use of manipulative objects in mathematics learning is important to help students understand the mathematical concepts they learn. But the use of manipulative objects has the potential of traps for students. The potential for this trap occurs when students consider it more a play activity to pass the time rather than providing opportunities to increase students' understanding of mathematical concepts.

The solutions to these constraints are: 1) the teacher uses the media that is already available to explain how the measurement of flat shapes to students, 2) the teacher explains examples of abstract situations to students first then explains how to measure them, 3) the teacher provides opportunities ask and motivate students to be brave to ask questions, 4) teachers increase mastery of classroom management so that students' attention is always focused on the learning process, 5) teachers direct students to work together in solving problems in groups, 6) teachers demonstrate measurements of abstract situations in front of the class so that all students can pay attention, 7) the teacher increases mastery of classroom management, and 8) the teacher directs students to pay attention to any problem-solving instructions.

Some of these solutions are based on the opinion expressed by Fauziah that the teacher must better understand the stages of the CPA approach and be firm in following the planned time allocation so that each stage in the implementation of the CPA approach can be carried out maximally [21]. Another solution is to increase the activeness of students in asking questions; the teacher must provide motivation and provide stimulation through verbal questions or explanations [43]. Furthermore, the importance of teacher skills in managing classes. This is because teachers who have high-class management skills are able to develop caring and supportive relationships between students, organize and implement learning by optimizing student access to learning, encouraging student involvement in working on assignments or group discussion activities, developing social skills and self-regulation students as well as helping students who have behavioral problems [44][45].

4. Conclusions

Based on the presentation of the results of the research and discussion above, it can be concluded: 1) the steps in applying the CPA approach to improve mathematics learning of geometry, namely: a) concrete, b) pictorial, c) abstract; 2) the application of the CPA approach can improve mathematics learning, and 3) the constraints of applying CPA to enhance mathematics learning, namely: a) the teacher has not used the media when explaining the measurement of flat shapes in semi-concrete situations, b) the teacher directly demonstrates the measure of abstract conditions and has not presented the examples of abstract situations first, c) students are not given the opportunity to ask questions, d) there are some students who have not been active in groups, e) some groups of students do not cooperate when working on worksheets, f) the teacher has not shown a reenactment of abstract situation measurements on all students, g) there are still some students who are absorbed in playing by themselves, so they do not pay
attention to the teacher's explanation, h) students do not pay attention to the direction of the teacher in solving problems about measuring the circumference of a rectangle. Solutions to the obstacles that arise are: 1) the teacher uses the media that is already available to explain how the measurement of flat shapes to students, 2) the teacher presents an example of an abstract situation to students first then describes how to measure it, 3) the teacher gives an opportunity ask and motivate students to be brave to ask questions, 4) the teacher increases mastery of classroom management so that students' attention is always focused on the learning process, 5) the teacher directs students to work together in solving problems in groups, 6) the teacher demonstrates the measurement of abstract situations in front of the class so that all students can pay attention, 7) the teacher increases mastery of classroom management, and 8) the teacher directs the student to pay attention to any problem-solving instructions.

Based on the above research conclusions, information can be obtained that this research contributes knowledge about the application of CPA to improve mathematics learning. Therefore, it is recommended that teachers apply the CPA to improve the quality of mathematics learning in elementary schools. The teacher is encouraged to pay more attention to the steps in using the CPA approach, especially in the Abstract effort, and further, enhance the ability to stimulate students to ask questions so that students take an active role in learning activities. Then, for other researchers in the future should make learning activities more innovative in accordance with the development of increasingly advanced science by prioritizing knowledge for students.

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