# Exploring Effectiveness of ACE Cycle of Instruction on Teaching Area and Volume of Cylinder

**Deb Bahadur Chhetri**

Department of Mathematics, Dhawalagiri Multiple Campus, Baglung
Corresponding author: dev.chhetri@dmc.tu.edu.np

Orcid https://orcid.org/0000-0002-1860-1395

**ABSTRACT**

*This article aimed to explore the effectiveness of the application of activities, classroom discussion and exercise (ACE) cycle in mathematics instruction and investigate students' perceptions of the ACE cycle of teaching. The study focused on the area and volume of cylinders and was conducted among 20 students in grade nine selected for the intervention. The study adopted the APOS (Action, Process, and Object Schema) theory as the guiding theory and the ACE teaching cycle for intervention and implemented it over only one week. The study's results revealed that the well-planned three phases of the ACE cycle of instruction were effective in promoting students' activeness, developing their understanding of the area and volume of the cylinder, enhancing their motivation and improving their achievement.*

*Keywords: ACE cycle of instruction, Area and volume of cylinder, participatory action research*

## Introduction

A significant challenge lies in imparting students with clear concepts related to mathematical topics during their school years. A solid mental schema is required to develop a clear concept of mathematics content. However, the need for preparing mental schema for a better understanding of mathematical concept stands behind the failure and becomes a poor mathematics achievement. The student's mental schema on mathematical content can be developed by making mathematics learning easy. How can a teacher make mathematical learning easy and help the students create their mental map of the topic of mathematics is an ongoing research agenda? To answer these queries, different theoretical approaches, like APOS theory, suggest other models and strategies like the ACE teaching cycle for mathematics instruction can be considered. The teaching and learning activities are also responsible for developing mathematical concepts for the students (Yeh et al., 2019). Activity-based mathematics instruction is essential for developing mathematical concepts in this century (Pokhrel, 2018). The problem of teaching the area and volume of a cylinder can be challenging for some students, but several strategies can be employed to help them understand these concepts.

In teaching the area and volume of a different solid object, teacher dominance textbook-based teaching takes place rather than activity-based instruction. The secondary school mathematics course included menstruation, under which the area and volume of the cylinder are one (Government of Nepal, 2078). The secondary mathematics curriculum aims to develop students' thinking skills at a higher level. Besides such an aim, ensuring such capacity in each mathematics c is challenging. Menstruation is one of them. As a teacher, I feel that it is difficult to develop a clear concept of the area and volume of a regular object. There needs to be more than the traditional method to develop clear concept problem-solving skills and higher-level thinking skills (Yuanita et al., 2018; Zlatinka et al., 2022). More than memorizing formulas and applying them to solve the problems posed in the book is required to develop a clear concept and better understand the mathematics taught. In the case of the area and volume of the cylinder, the method of instruction includes showing the figure of the book, demonstrating the model of the problem and solving contributes to learning Mathematics. But more than this type of instructional teaching is required to develop a clear concept of the area and volume of a cylinder.

Visual aids and problem–solving methods are commonly used in the context of Nepal for teaching the area and volume of a cylinder. However, these methods alone may not be sufficient for developing a clear concept of these mathematical concepts. Moreover, it is important to provide ample opportunities for students to practice applying their knowledge of area and volume in various contexts. This could involve solving a real problem, creating their problem, and working collaboratively with peers to deepen their understanding.

APOS theory proposes that teaching and learning mathematics should focus on helping students use their existing mental frameworks while also allowing for developing new, more sophisticated structures for dealing with increasingly advanced mathematical concepts (Arnon et al., 2014). Pedagogical practices derived from APOS theory include the ACE (activities, classroom discussion, and exercise) cycle of instruction given by Brousseau (1984), which enables students to construct novel mathematical structures. The ACE cycle help to make a solid mental schema.

This participatory action research aims to determine the effectiveness of the application of the ACE teaching cycle on students' learning achievement in the area and volume of a cylinder and their perception. Two research questions guided this study:

1. What is the effectiveness of the ACE cycle of instruction in the teaching of the area and volume of a cylinder?
2. How do students perceive the ACE cycle of instruction?

**Theoretical Framework**

Piaget described the steps and phases of mathematical reasoning in the context of acquiring complex mathematical concepts. Piaget's work was the foundation for Dubiky's (1984) APOS theory (Sefik et al., 2021). APOS theory, which stands for Action, Process, Object, and Schema, is a cognitive theory of mathematical learning that explains how students develop mathematical concepts and ideas. The theory posits that mathematical knowledge is constructed in four stages. In the action stage, students identify the underlying processes or procedures involved in the action they performed in the first stage. For example, they might recognize that finding a rectangle's area involves multiplying the length and width (Vahid et al., 2018). In the object phase, students identify the object or concept the process relates to. For example, they might recognize how to find a rectangle's area and apply it to other shapes. Schema is the last phase of mathematical learning in which students integrate their understanding of the action, process and object into a schema, a mental framework for understanding the concept. This allows them to apply their knowledge to new situations and solve problems.

This theory focuses on providing opportunities for students to engage in physical or mental actions related to the mathematical concept and encouraging students to identify the underlying processes or procedures involved in their activities. Additionally, teaching needs to help the students identify the object or concept that the process related to a mathematical concept. APOS theory provides a framework for understanding how students learn mathematical concepts and how instructional strategies can be developed to facilitate this learning.

One of the pedagogical practices of APOS theory is the application of the ACE lesson cycle. This cycle provides opportunities to engage in physical or mental activities through group activities, classroom discussions and exercises that help create a mental map of the content being taught.

**APOS Theory and ACE Teaching Cycle**

Generally, mathematics teaching is concerned with concept development and knowledge creation. Among the constructivist learning theories, APOS is applied in mathematics teaching. ACE cycle of teaching connected to APOS theory. It significantly improves students' learning engagement and achievement (Bill &

Hendra, 2022; Dubinky, 1995). This teaching cycle follows the learning theory of constructivism, which believes that learners' minds construct knowledge and it is beneficial to engage students learning, improving their learning activities and achievement (Bonder & Elmas, 2020; Pazina & Fynny, 2019; Salame et al. 2020). This teaching cycle improves students' learning activities and achievement in mathematics at a higher level, like linear algebra (Boriji & Voskoglou, 2017; Syarifunddin, 2013). This teaching strategy improves the students' habit of learning engagement and participation in questioning and expressing ideas (Kaplan & Kilicoglu, 2019). These studies indicate ACE as a beneficial and effective way of teaching. Thus, this instruction strategy was utilized during the intervention in the teaching area and volume of the cylinder.

ACE teaching cycle is the pedagogical approach of APOS theory that focuses on how students create a mental structure to understand mathematical concepts. The creation of the mental map of the mathematical concept is associated with the construction of knowledge. Thus, a constructive environment is required to design to provide the chance for creating cognitive structure about the mathematical concept. These types of design of learning environments can be managed through the ACE cycle of teaching. A well-designed environment must help the student create the mental structure of a new mathematical concept, genetic decomposition (Trigueros & Possani, 2013).

The constructivist learning environment is designed as a map that enables the students to construct a mental structure of the new mathematical concept. This environment can be developed through the ACE cycle, activities, classroom discussions and exercises included in the ACE teaching cycle (Zavala & Rodriguez, 2013).

### *Action Phase*

The Action-Process-Object-Schema (APOS) theory, which stands for learning theory, emphasizes the mental procedures needed to acquire mathematics. The Action stage of the ACE teaching cycle for teaching mathematics following this theory is the initial stage. The teacher gives students a practical experience connected to the mathematical idea taught during the Action stage. This activity may use manipulative, physical objects or actual issues. Through hands-on learning, this stage aims to assist pupils in creating a mental image of the mathematical concept.

### *Classroom Discussion Phase*

Classroom Discussion comes next in the ACE cycle of teaching mathematics using the APOS theory after the Action stage. The teacher encourages a conversation among the students concerning the mathematical ideas and concepts taught in the

Action stage during the Classroom Discussion stage. Students' understanding can be clarified, links between their personal experiences and the concepts being prepared can be made, and any misunderstandings or problems can be found. The teacher might use open-ended questions during the classroom discussion stage to enable pupils to express their ideas and to aid them in drawing connections between various subjects. The teacher can also offer comments and directions to help pupils deepen their comprehension of the mathematical topics being taught.

In this stage, the teacher can provide comments and directions to help pupils develop their skills and comprehension. The teacher can also use the outcomes of the activities to evaluate the understanding of the class and, if necessary, modify the following lessons. Ultimately, the exercise stage is a crucial aspect of the ACE teaching cycle because it enables students to practice the ideas they have learned in the other stages, apply them, and become fluent and confident users.

### *Exercise Phase*

Exercise is the final phase of the ACE teaching cycle. In the exercise phase, students take part in tasks that allow them to put their newly learned mathematical ideas into practice. These exercises, problems, or other exercises can test students' ability to apply the concepts they have learned in fresh and original ways. The goal of the exercise stage is to assist students in solidifying their comprehension of mathematical ideas and building fluency in employing them. Students can improve their grasp and absorb the concepts by applying and practising the topics. The teacher might offer criticism and direction to pupils throughout the exercise stage to assist them in honing their abilities and comprehension.

## Methodology

Participatory action research is not merely a research method but an entire research approach (Pain, Whitman, Milledge, & Lune Rivers Trust, 2011) that involves a cycle including four steps (Gaffney, 2008), and participants work as partners with the researcher (Boyle, 2012). This study used the participatory action research approach. It emphasizes collaboration and active participation of the people involved. This study was completed in three steps.

In the first step, an instructional module and lesson plan were developed for teaching the area and volume of the cylinder through the ACE activity-based approach. This involved creating a structure and engaging lesson plan focused on interactive learning activities to help students understand the concept of the area and volume of a cylinder. The module was designed to ensure the learning objectives were met while catering to all student's needs and learning styles. The ACE activity-based approach aimed to create a dynamic and practical learning experience that would help students grasp the fundamental concepts of the area and volume of the cylinder.

In the second stage, interventions were carried out, which included three phases:

In the first phase of the intervention, the first phase of the ACE cycle was followed. The students observed and manipulated the physical teaching aids related to the cylinder, focusing on area and volume. During the activities, students were encouraged to explore the developed material hands-on, using their senses to observe its different parts and their relation to each other. For example, they may have been asked to manipulate the material to observe how the height of the cylinder changes as the radius of the base changes or to observe how the shape of the base affects the overall shape of the cylinder. In particular, students were likely asked to focus on the different parts of the cylinder and its plane figure base parts. This may have included observing and manipulating the base, which is the flat surface on which the cylinder rests and which determines the shape of the cylinder, as well as the sides of the cylinder, which curve around the base to form a three-dimensional shape. Overall, the first phase of the intervention aimed to provide students with a hands-on, experiential learning experience that allowed them to explore the characteristics and properties of cylinders in a concrete and tangible way. By focusing on the different parts of the cylinder and its base, students could develop a more nuanced understanding of how these shapes work and how they can be used in real-world applications.

In the second phase of the intervention, classroom discussion strategies were followed. In this phase, students were given short facilitation on the topic, and they were given a developed worksheet and were instructed to work on it in groups of six students. The worksheet was based on a module, and the students were encouraged to engage in collaborative discussions while completing the worksheet. The intervention took three classes, during which the students engaged in individual observation and group discussion. This approach to learning and instruction may have been intended to foster collaboration and peer-to-peer learning and help students better understand the module's content.

In the last phase of the ACE cycle, students were engaged in exercise. In this phase, students were engaged in exercises and problem-solving activities designed to reinforce their understanding of the topic. These exercises are typically provided in a workbook or through other instructional materials. These activities allowed students to apply what they have learned in a practical context and consolidate their knowledge. Furthermore, the students were also instructed to solve the problems at home. This form of homework is intended to help students develop a deeper understanding of the material by applying it outside the classroom. The assignment questions are typically designed to challenge students and encourage them to think critically.

After the completion of the intervention, a test was conducted to assess the impact of the ACE teaching cycle on students' achievement, perception and experience. The questions used in the trial were designed to measure knowledge, understanding, application, and higher ability. The questions were carefully crafted to cover a range of cognitive skills, allowing the evaluation to provide a more comprehensive view of the effectiveness of the learning strategy. By including questions that tested higher ability, such as analysis and evaluation, the evaluation could assess the student's understanding of the material and ability to apply it in different contexts. To ensure the quality of the evaluation process, the questions were validated by expert judgment. Experts in the field reviewed the questions to ensure they accurately measured the intended cognitive skills and were appropriate for the intended grade level. This validation process helped ensure the test results' validity and reliability. After this test, students' perceptions and experiences were surveyed on the teaching strategy. The survey items were self-prepared and judged by the expert. It included four items targeted to measure students' experiences with ACE cycle-based instruction. The single-time interview was also used to explore the students' experience with the teaching method.

Regarding reliability and validity, **r**eflexivity, collaborative design, triangulation, continuous member feedback, co-analysis, external review, transparency, extended portability of engagement, and expert judgment are methods to ensure reliability and validity in participatory action research. The following three techniques were used to ensure reliability and validity. Expert judged the tools for a survey of students' experience. Additionally, a test for student achievement was prepared based on the specification grid provided by CDC Nepal and evaluated by the expert. Colleagues judged the prepared plan and process of intervention. Thus, experts' judgment refined the tools and techniques for reliability and validity. Participatory action research involves a validity method where researchers engage with participants in the field, and their activities contribute to ensuring validity (Wallerstein & Duran, 2006; Minker, 2004). Therefore, the research incorporated activities and observation of the intervention's activities. The researcher stood as a teacher and was engaged in all intervention processes. Describing the process of data collection activities refers thick description. The researchers used the technique of thick description for validity, explained by Patterotto (2006) and Lincon (1985). All the intervention processes, existing situations and changed situations are included to ensure validity.

## Results and Discussions

This study is used a survey, observation, lunching test and interview. It also used triangulation as a method of data analysis. The study utilized three data sources: a survey, observation, and interviews. The results from the survey were presented in the initial stage of the study, likely to provide a general overview of the participants' perceptions of the ACE cycle-based teaching method. The survey results provided quantitative data that could be used to understand the overall level of agreement or disagreement among participants regarding their perception of the teaching method. Following the survey, the study is likely to have employed observation and interview techniques to gather more detailed and qualitative data. Observation involved watching and recording the participants' behaviour during the teaching process to understand how they engaged with the material and the teaching method. Interviews were conducted to gain more insight into the participants' experiences and perceptions of the ACE cycle-based teaching method. Finally, the results from the observation and interviews were combined to provide a more comprehensive and reliable understanding of the effectiveness of the ACE cycle-based teaching method. Combining these results allowed for cross-validation of the findings and provided a more complete picture of the participants' experiences and perceptions of the teaching method.

### Socio-demographic scenario of students

Table 1 presents the socio-demographic information of the students who participated in the study. The majority of the students were male, and female followed male students.

**Table 1**

*Socio-demographic Status of Students*

| Category | | N | Percentage |
|---|---|---|---|
| Gender | | | |
| | Male | 11 | 55 |
| | Female | 9 | 45 |
| Ethnicity | | | |
| | Dalit | 2 | 10 |
| | Janajati | 3 | 15 |
| | Brahmin/Chhetri | 15 | 75 |
| Total | | 20 | 100 |

The students belonged to three different ethnic groups: Dalit, Janajati, and Brahmin/Chhetri. Of these groups, the largest proportion of students (more than three-fourths) was from the Brahmin/Chhetri group, while approximately one-tenth were from the Dalit group and nearly one-tenth were from the Janajati group.

**Application and effectiveness of ACE cycle of instruction**

The better way of applying the ACE cycle of instruction guided by APOS theory is planning. The plan should be detailed and guide the teacher to perform every step of instruction. In the activities phase, the solid materials, charts, and activity guidelines were prepared and the lesson was delivered according to the plan for activities. Students were engaged in observing, doing activities, and discussing with friends to deal with guiding questions for activities provided by the teacher. In the second stage, a discussion was conducted based on a prepared plan which includes our main discussion points on the role of the student and teacher. Students were told the position and the activities. In the exercise phase, students were given tasks for the classroom and at home for practice. Thus, the ACE cycle can be used in three phases with well-planned activities explained by Zavala & Rodriguez (2013). The following set of activities was found to show how we can apply the ACE instruction cycle. The following activities were made, supported by APOS theory and research finding by Sefik et al.( 2021).

***Activities phase:*** Activities are hands-on tasks that can help students build their understanding of a concept through exploration and experimentation. When planning activities, we need to consider the remarkable techniques: (a) align the activity with the learning objective, (b) Provide clear instructions, (c) Create opportunities for collaboration, (d) Incorporate feedback. Classroom discussions: Classroom discussions are a powerful tool for promoting critical thinking, communication, and collaboration skills.

***Discussion phase***: When planning discussions, consider these techniques (a) set clear expectations, (b) prepare through-provoking questions, (c) encourage participation, and (d) summarize vital points.

***Exercise phase:*** The exercise phase is where students practice applying the knowledge and skills they have learned. When planning exercises, we need to consider the idea of (a) creating realistic scenarios, (b) providing guidance, (c) including feedback, and varying the level of difficulty.

**Analysis of Achievement Level**

An achievement test was conducted, and a percentage was computed to describe the level of achievement. The letter grading guidelines published by the government of Nepal, MEST (2079), were used to prepare criteria for interpreting achievement levels. The achievement and its level were as shown in Table 2.

**Table 2**

*Students Achievement Level Comparison*

| Category of Achievement | Level of achievement in area and volume of cylinder after intervention | | Students' Achievement Level in First term examination of Mathematics | |
|---|---|---|---|---|
| | Level | Interpretation | Level | Interpretation |
| Knowledge | 86% | Excellent level | 65.8% | Good |
| Understanding | 75% | Very good | 60.6% | Good |
| Application | 89.37% | Excellent | 68% | Good |
| Higher ability | 52% | Satisfactory | 49.8% | Satisfactory |
| Total average achievement | 75.59% | Very good | 61.05% | Good |

According to these guidelines, the student's achievement levels were either "very good" or "excellent" in knowledge, understanding and application domains. However, in the domain of higher ability, the student's achievement level was at the "satisfactory" level. This means that while students performed exceptionally well in most areas, they could have performed better in the higher-ability domain. The total average achievement level was found to be very good. It's important to note that "satisfactory" does not necessarily mean that the student's performance was poor; instead, it suggests room for improvement. The results could be used to identify areas where students may need extra support and to develop strategies to help them improve their performance in the higher-ability domain. Therefore, the ACE cycle-based instruction is beneficial to increase students' performance in mathematics.

Table 2 provided the comparison of students' achievement levels of the same students. The result showed that students' achievement in all domains of achievement is comparatively good than their total achievement in mathematics based on their secured marks on different domains of achievement. This result shows that ACE cycle-based teaching is beneficial to increase the students' achievement.

### Students' Perception Towards ACE Cycle-Based Teaching

A survey scale was administered after completing the intervention and test to identify the students' perception of the ACE strategy. The perception survey was Likert type where 1= strongly disagree, 2= disagree, 3= Neutral, 4= agree, and 5= strongly agree. To analyze the perception rate, the mean was calculated and categorized into two levels. When the mean was more than equal to 3, it was leveled as a strong level of perception, and less than three showed a weak level of perception about the ACE teaching strategy. The survey result was as shown in Table 3.

**Table 3**

*Students' Perception Toward ACE Cycle-Based Teaching*

| Items | Strong level of perception in % | Weak level of Perception in % |
|---|---|---|
| I feel this method of teaching is more engaging rather than usual methods of teaching | 75 | 25 |
| I feel it easy to learn the presented topic via this method | 80 | 20 |
| I am motivated by this method to learn mathematics | 95 | 5 |
| I feel that this method increased my mark on the test | 100 | 00 |

The achievement test results shown in Table 2 indicate that students improved their knowledge, understanding, and application performance after being taught using the ACE cycle-based instruction. However, the higher-ability achievement level was lower than expected, indicating that further instruction may be needed. Despite this, the overall group's achievement level increased to 74%, significantly improving their previous test achievement. This demonstrates that using ACE cycle-based instruction can be an effective teaching method for improving student learning outcomes. Additionally, the students' reflections during the interview support the test results, as all students reported feeling more confident in their ability to understand and apply the material after being taught using the ACE cycle-based instruction. This indicates that the teaching approach was engaging and effective in helping students learn and apply the concepts they were taught.

In conclusion, using ACE cycle-based instruction can lead to increased learning achievement among students. This teaching approach can help students build on their existing knowledge, develop their understanding, and apply what they have learned to new situations. The test results and students' reflections support the effectiveness of this teaching method in improving their learning outcomes.

Table 3 displays the students' perception of the ACE cycle-based teaching method. The test included four items as shown in Table 3, and for each item, the percentage of students who have a strong level of perception and the percentage of students who have a weak level of perception is presented. The first item in the table is "I feel this method of teaching is more engaging than usual methods of teaching." 75% of the students have a strong level of perception that the ACE cycle-based teaching method is more engaging than usual teaching methods, while 25% have a weak level of perception in this regard. The second item is "I feel it easy to learn the presented topic via this method." Here, 80% of the students have a strong level of perception that they find it easy to learn the presented topic via the ACE cycle-based teaching method, while 20% have a weak level of perception. The third item is "I am motivated by this method to learn mathematics." In this case, a whopping 95% of the students have a strong perception that the ACE cycle-based teaching method motivates them to learn mathematics, while only 5% have a weak level of perception. Finally, the fourth item in the table is "I feel that this method increases my mark on the test." All the students in the study strongly perceive that the ACE cycle-based teaching method has increased their marks on the test, indicating a 100% response rate for the intense level of perception.

In summary, the table shows that most students have a strong level of perception towards the ACE cycle-based teaching method. The method is perceived to be more engaging than usual teaching methods, easy to learn from, and motivating for learning mathematics. Additionally, all students reported that the technique had increased their marks on the test.

**Students' Experience with ACE Cycle-based Teaching**

During the interview, all students expressed their favorable experiences with the teaching and learning activities that they had participated in. They all enjoyed the practical actions that were a part of the learning cycle. Specifically, student A mentioned they had a great time and were attracted to the activities demonstrating the cylinder and its components. In particular, they found the action where the volume of the cylinder was verified using mathematics and water pouring in a measuring cylinder to be very engaging. Student A said, "I enjoy and am attracted to the activities that demonstrated the cylinder and its parts and justified the volume verified by mathematics and the pouring of water into a graduated cylinder."

Students experienced that the activities effectively captured their attention and made the learning experience enjoyable. Using practical exercises to demonstrate concepts is a proven teaching strategy, as it can help students understand the material better and retain the information for a more extended period. By incorporating hands-on activities into the learning process, students can experience the concepts first hand, making the lessons more memorable and impactful, which is supported by. The survey result mentioned in Table 3 supports that students have a strong positive perception towards this way of instruction.

Overall, seeing that the students had positive feedback about their learning experiences is encouraging. This is a testament to the effectiveness of the teaching strategies used and the dedication of the teacher to create engaging and interactive learning activities for their students.

## Concept Clearing Method

The ACE cycle-based instruction is an effective concept-clearing method. This instructional method enables students to understand the teaching topic clearly. Based on the feedback from the students, it is evident that this method of instruction is an excellent way to engage students and help them grasp the reality represented by mathematical formulas. During the interview, student F said, "I request to utilize these methods in other topics; additionally, F said, "I fully grasp how formulas function and what formulas represent the different portions of cylinders." This saying was also supported by the other students' experiences. They expressed their desire to see this method used in other topics. Most students shared their experiences and supported this statement, indicating that this method is beneficial for teaching mathematical concepts.

While most students preferred the ACE cycle-based instruction, it is worth noting that five students compared it with the previous method and viewed the usual method as also helping to learn mathematics. This highlights that there is no one-size-fits-all approach to teaching and that different strategies may work better for other students. Despite this, it is clear that ACE cycle-based instruction is an effective teaching method, particularly in helping students understand mathematical concepts. The use of this method allows students to engage with the material in a more meaningful way, helping them to retain the information better and apply it in practical situations.

Generally, the students' feedback favours using ACE cycle-based instruction to teach mathematical topics. It is a strategy that successfully eradicates misunderstandings and gives students a firm grasp of mathematical concepts and formulas.

## Motivating and enabling students to create knowledge

Based on the students’ experiences, it is clear that ACE cycle-based instruction is a motivating teaching strategy. Specifically, the activities phase of the instruction particularly motivated the students. This is because it allows students to engage in material activities to learn mathematical concepts. During the activities phase, students were observed to be happy and engaged in the activities and were seen to be busy working on the activities and noting down the results. This indicates that the activities effectively motivated students to actively participate in the learning process.

Some students who may have felt uneasy with traditional methods of instruction were observed to be very active in the activities phase of the ACE cycle. For example, student C mentioned that searching for reality and relating it to the formula was very interesting to them and was the most exciting aspect of the instruction from their perspective. Other students shared similar experiences and emphasized the motivating impact of the activities phase on their learning.

Overall, the feedback from the students highlights the importance of the activities phase in motivating students to learn mathematical concepts. By providing opportunities for students to engage in material activities, the ACE cycle-based instruction effectively captures their interest and encourages them to participate in the learning process. This ultimately leads to better outcomes in terms of student understanding and achievement.

The ACE cycle-based instruction is a beneficial approach for creating knowledge among students. During the activities phase of the teaching, students observed formula verification and sought new relations about the mathematical facts they were learning. Student H said, "We can find the diameter of big cylindrical wood by measuring its perimeter. This view showed that this method promotes the students to create mathematical knowledge. During the evaluation in the practical examination, students were able to use their understanding of mathematics to make discoveries, such as finding the diameter of a large cylindrical wood by measuring its perimeter. This example highlights how the ACE cycle-based instruction enables students to seek out new mathematical relationships and apply their learning practically. Thus, the finding shows that the ACE cycle of teaching helps to create new knowledge, solving the problem of factual context, and this finding is supported by the result of Yuanita et al. (2018) and Zlatinka et al. (2022), who found ACE technique increasing the problem-solving ability of the students.

By encouraging students to engage in the learning process actively, the ACE cycle-based instruction creates an environment where students can take ownership of their learning and develop their understanding of mathematical concepts. This approach helps students retain information in the area and volume of the cylinder more effectively and allows them to see the practical applications of the concepts they are learning.

Furthermore, by allowing students to seek new relations between mathematical ideas, the ACE cycle-based instruction promotes creativity and innovation in problem-solving. This is an important skill to develop in students as they prepare for the demands of the modern workforce, which increasingly requires critical thinking and problem-solving skills.

Overall, student feedback suggests that the ACE cycle-based instruction is a practical approach to creating knowledge and promoting creativity in mathematics. By empowering students to take ownership of their learning and seek new relationships between mathematical ideas, this approach can help to foster a deeper understanding of mathematical concepts on the area and volume of cylinders and prepare students for success in the 21st century.

**Increasing Achievement**

The achievement test results indicate that students improved their knowledge, understanding, and application performance after being taught using the ACE cycle-based instruction. However, the higher-ability achievement level was lower than expected, indicating that further instruction may be needed. Despite this, the overall group's achievement level increased to 74%, significantly improving their previous test achievement. This finding is supported by the last theoretical claim and researcher finding (Bill & Hendra, 2022; Dubinky, 1995;). This demonstrates that the use of ACE cycle-based instruction can be an effective teaching method for improving student learning outcomes which are supported by the findings of previous research (Bonder & Elmas, 2020). Additionally, the students' reflections during the interview helped the test results, as all students reported feeling more confident in their ability to understand and apply the material after being taught using the ACE cycle-based instruction. This indicates that the teaching approach was engaging and effective in helping students learn and apply the concepts they were taught.

Therefore, the use of ACE cycle-based instruction can lead to an increase in learning achievement among students. This teaching approach can help students build on their existing knowledge, develop their understanding, and apply what they have learned to new situations. The test results and students' reflections support the effectiveness of this teaching method in improving student learning outcomes.

## Conclusion

The ACE cycle of instruction in teaching area and volume is more beneficial than the traditional method. Utilizing the ACE cycle of education can be particularly advantageous in mathematics teaching as it can enhance student engagement, motivation, and learning outcomes when accompanied by well-planned activities in the three phases. However, implementing this approach can be labor-intensive and necessitates proficiency in designing the instructional role and activities. Despite these limitations, its usage can lead to higher achievement rates.

## Declarations

### Ethical Consent and Consent to Participate

I declare that this research was conducted ethically and take sole responsibility for any plagiarism or misconduct.

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