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Mathematical Conceptual Understanding in Inside-Outside Circle Learning: A Quasi-Experimental Study

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ABSTRACT

Purpose of the study: This study aimed to investigate the effect of the Inside-Outside Circle (IOC) cooperative learning method on students' mathematical conceptual understanding and to determine whether the method provides better learning outcomes than conventional instruction among junior high school students.

Methodology: This study employed a quantitative approach using a quasi-experimental method with a randomized posttest-only control group design. The participants consisted of seventh-grade students of SMP IT Al-Qur'aniyyah. Data were collected using an essay test of mathematical conceptual understanding. Descriptive statistics, normality tests, homogeneity tests, and independent samples t-tests were performed using IBM SPSS Statistics software.

Main Findings: The findings revealed that students taught through the Inside-Outside Circle cooperative learning method achieved higher mathematical conceptual understanding scores than those receiving conventional instruction. Statistical analysis indicated a significant difference between the experimental and control groups, demonstrating that the IOC method effectively improved students' mathematical conceptual understanding and promoted more meaningful mathematics learning experiences.

Novelty/Originality of this study: This study specifically emphasizes mathematical conceptual understanding as the primary outcome variable within the implementation of the Inside-Outside Circle method. Unlike previous studies that mainly focused on learning achievement or communication skills, this research provides empirical evidence from an Islamic junior high school context, thereby enriching current knowledge regarding cooperative learning in mathematics education.

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1. INTRODUCTION

Mathematical conceptual understanding is one of the fundamental competencies that students need to develop logical thinking, systematic reasoning, and problem-solving skills in various learning contexts. This competence enables students not only to memorize procedures but also to understand the meaning and relationships underlying mathematical concepts [1], [2]. In mathematics education, conceptual understanding

serves as the foundation for mastering more advanced topics at higher educational levels. Therefore, fostering students' mathematical conceptual understanding has become one of the primary goals of effective mathematics instruction [3], [4]. Achieving this objective requires the implementation of learning approaches that actively engage students in the learning process.

Despite its importance, several challenges related to students' mathematical conceptual understanding are still encountered in junior high schools. Mathematics instruction is often dominated by teacher-centered approaches that limit students' opportunities to construct knowledge independently [5], [6]. As a result, many students experience difficulties in connecting concepts, explaining mathematical ideas, and applying learned concepts to different situations. These conditions lead students to rely more on procedural memorization than on conceptual comprehension [7], [8]. Consequently, the need for instructional strategies that promote active participation and meaningful learning has become increasingly important.

Previous studies have reported that cooperative learning contributes positively to students' academic achievement and mathematical abilities. Several researchers have found that the Inside-Outside Circle (IOC) method enhances students' learning activities, communication skills, and overall learning outcomes. Other studies have also demonstrated that cooperative interaction provides opportunities for students to exchange ideas and strengthen their understanding of learning materials [9], [10]. However, most of these studies have focused primarily on general learning achievement rather than specifically examining mathematical conceptual understanding as the main outcome variable. Furthermore, empirical evidence regarding the effectiveness of the IOC method in mathematics learning contexts remains relatively limited.

Although studies concerning the Inside-Outside Circle method have been widely conducted, several research gaps still deserve further attention. Existing studies tend to emphasize learning achievement, motivation, or mathematical communication skills rather than conceptual understanding [11]. In addition, only a limited number of studies have employed a quasi-experimental design to investigate the effect of the IOC method on students' mathematical conceptual understanding. Research conducted in Islamic-based educational settings is also relatively scarce compared with studies carried out in general schools [12], [13]. These conditions indicate the need for further investigation to provide a more comprehensive understanding of the effectiveness of the IOC method in mathematics learning.

Investigating the influence of the Inside-Outside Circle method on mathematical conceptual understanding is important for improving the quality of mathematics education. Strong conceptual understanding enables students to develop higher-order thinking skills and solve problems systematically [14], [15]. Moreover, interactive and collaborative learning approaches are highly relevant to the demands of twenty-first-century education, which emphasizes communication and cooperation among learners. The findings of this study are expected to provide teachers with an alternative instructional strategy to enhance both learning processes and learning outcomes in mathematics [16], [17]. Therefore, this study possesses both theoretical and practical significance for mathematics education.

The novelty of this study lies in its specific focus on examining the effect of the Inside-Outside Circle cooperative learning method on students' mathematical conceptual understanding through a quasi-experimental design. Unlike previous studies that mainly emphasized general academic achievement, this study highlights conceptual understanding as an essential component of mathematics learning. In addition, this study was conducted in a junior high school context, which has received relatively limited attention in previous research concerning the IOC method. The research setting provides additional empirical evidence regarding the implementation of cooperative learning in mathematics education. Therefore, the findings of this study are expected to enrich the existing literature and contribute to the development of more effective instructional practices for improving students' mathematical conceptual understanding.

2. RESEARCH METHOD

2.1 Research Design

This study employed a quantitative approach using a quasi-experimental design to investigate the effect of the Inside-Outside Circle (IOC) cooperative learning method on students' mathematical conceptual understanding [18]. Specifically, the study adopted a randomized posttest-only control group design involving an experimental group and a control group. The experimental group received mathematics instruction through the Inside-Outside Circle cooperative learning method, whereas the control group was taught using conventional learning [19]. At the end of the treatment, both groups were administered a posttest to assess students' mathematical conceptual understanding. This design enabled the researchers to determine the effectiveness of the IOC method in mathematics learning.

Table 1. Research Design

Group	Treatment	Posttest
Experimental Group	X	O
Control Group	–	O

Note:
X = Inside-Outside Circle (IOC) learning treatment
O = Posttest

2.2 Participants

The participants of this study were seventh-grade students of SMP IT Al-Qur'aniyyah. Two classes were involved in the study, consisting of one experimental class and one control class. Each class consisted of 25 students, resulting in a total of 50 participants. The experimental group received mathematics instruction using the Inside-Outside Circle cooperative learning method, while the control group was taught using conventional learning. These participants were selected to compare the effectiveness of different instructional approaches in improving students' mathematical conceptual understanding.

2.3 Instrument and Data Analysis

Data were collected using an essay test designed to measure students' mathematical conceptual understanding. Prior to its implementation, the instrument was validated to ensure its appropriateness and content validity. After the completion of the learning treatment, both groups were administered a posttest to obtain the research data. The collected data were analyzed using descriptive statistics, normality tests, homogeneity tests, and an independent samples t-test. These analyses were conducted to determine whether the Inside-Outside Circle cooperative learning method significantly influenced students' mathematical conceptual understanding.

3. RESULTS AND DISCUSSION

3.1 Descriptive Statistics of Students' Mathematical Conceptual Understanding

The results of this study were obtained from the posttest scores of students' mathematical conceptual understanding in both the experimental and control groups. The experimental group received mathematics instruction through the Inside-Outside Circle cooperative learning method, whereas the control group was taught using conventional learning. Descriptive statistical analysis was conducted to identify differences in students' mathematical conceptual understanding between the two groups. The findings revealed that students in the experimental group achieved better results than those in the control group. The descriptive statistics are presented in Table 2.

Table 2. Descriptive Statistics of Mathematical Conceptual Understanding Scores

Statistics	Experimental Group	Control Group
N	25	25
Mean	75.64	67.00
Median	78.00	70.00
Standard Deviation	9.39	12.53
Minimum	45	38
Maximum	90	85

The descriptive statistics indicate that the mean score of the experimental group was higher than that of the control group. Students who learned through the Inside-Outside Circle cooperative learning method obtained an average score of 75.64, whereas students who experienced conventional learning achieved a mean score of 67.00. In addition, the experimental group exhibited lower score variability than the control group, as indicated by the smaller standard deviation. These findings suggest that the implementation of the IOC method contributed positively to students' mathematical conceptual understanding. Therefore, the descriptive results provide preliminary evidence of the effectiveness of the Inside-Outside Circle method in mathematics learning.

3.2 Assumption Testing Results

Before conducting hypothesis testing, prerequisite analyses consisting of normality and homogeneity tests were performed. The normality test was conducted to determine whether the data in both groups were normally distributed. Meanwhile, the homogeneity test was used to examine the equality of variances between the experimental and control groups. The results showed that the data fulfilled the assumptions required for parametric statistical analysis. Therefore, the independent samples t-test was employed to test the research hypothesis.

Table 3. Results of Normality Test

Group	Sig. Value	Conclusion
Experimental	0.177	Normal
Control	0.060	Normal

Table 4. Results of Homogeneity Test

Levene Statistic	Sig. Value	Conclusion
2.163	0.148	Homogeneous

The normality test results indicated that the significance values for both groups were greater than 0.05. In addition, the homogeneity test revealed that the significance value exceeded the significance level of 0.05, indicating homogeneous variances between groups. These findings demonstrate that the assumptions for parametric analysis were satisfied. Consequently, hypothesis testing using the independent samples t-test could be appropriately conducted. Thus, the data were considered suitable for further inferential analysis.

3.3 Hypothesis Testing Results

Hypothesis testing was conducted using the independent samples t-test to determine the effect of the Inside-Outside Circle cooperative learning method on students' mathematical conceptual understanding. The analysis revealed that the significance value obtained from the test was lower than the significance level of 0.05. This finding indicates that there was a statistically significant difference between the experimental and control groups. Therefore, the alternative hypothesis was accepted, suggesting that the Inside-Outside Circle method significantly influenced students' mathematical conceptual understanding. The results of the hypothesis testing are summarized in Table 5.

Table 5. Results of Independent Samples t-Test

Variable	t-value	df	Sig. (2-tailed)	Decision
Mathematical Conceptual Understanding	2.305	48	0.008	Ha Accepted

The hypothesis testing results demonstrated that the significance value was 0.008, which was lower than 0.05. This result indicates that a significant difference existed between the experimental and control groups. Students who learned through the Inside-Outside Circle cooperative learning method achieved better mathematical conceptual understanding than those who received conventional instruction. Therefore, the alternative hypothesis was accepted. These findings suggest that the implementation of the Inside-Outside Circle method was effective in improving students' mathematical conceptual understanding.

Students who participated in the Inside-Outside Circle (IOC) cooperative learning method demonstrated better mathematical conceptual understanding than those who experienced conventional instruction. This difference was evidenced by the higher mean score achieved by the experimental group compared to the control group. Statistical analysis through the independent samples t-test further confirmed the existence of a significant difference between the two groups. Such findings indicate that the IOC method provides a positive contribution to the development of students' conceptual understanding. Consequently, cooperative learning activities can create meaningful learning experiences that support mathematics learning.

Several factors may explain the effectiveness of the IOC method in improving students' mathematical conceptual understanding. During the learning process, students were actively involved in exchanging ideas, discussing mathematical concepts, and providing explanations to their peers [20]. These activities enabled learners to construct knowledge through social interaction and collaborative experiences. Moreover, the rotating discussion pattern characteristic of the IOC strategy encouraged students to participate actively and communicate their mathematical thinking [21], [22]. As a result, students gained deeper conceptual understanding and became more engaged in the learning process.

Consistent with previous studies, the present findings support the view that cooperative learning has a positive influence on students' learning outcomes and conceptual development. Earlier investigations have reported that the Inside-Outside Circle method promotes active participation, communication skills, and collaborative problem-solving among learners [23]. Such characteristics are closely associated with the enhancement of mathematical conceptual understanding because students are encouraged to share and clarify their ideas with peers. Similar evidence has also demonstrated that interactive learning environments contribute to more meaningful mathematics learning experiences [24]. Therefore, the results obtained in this study reinforce the existing literature regarding the effectiveness of the IOC method in mathematics education.

An important contribution of this study lies in its emphasis on mathematical conceptual understanding as the primary outcome variable within the context of Inside-Outside Circle learning. Unlike many previous studies that concentrated on learning achievement, motivation, or communication skills, this research specifically examined conceptual understanding through a quasi-experimental approach [25], [26]. Another distinctive aspect concerns the research setting, which involved students from an Islamic junior high school. Investigations conducted in such educational contexts are still relatively limited in the existing literature [27], [28]. Hence, this study provides additional empirical evidence that enriches current discussions on cooperative learning and mathematics education.

From a practical perspective, the results of this study offer important implications for mathematics teachers and educational practitioners. The positive impact of the IOC method suggests that student-centered and collaborative learning approaches should be integrated into classroom practices. Creating opportunities for interaction and discussion may help students develop higher-order thinking skills and strengthen their conceptual understanding [29], [30]. In addition, the findings highlight the importance of fostering active participation as part of twenty-first-century learning requirements. Therefore, the IOC method can serve as an alternative instructional strategy to improve the quality of mathematics instruction.

Despite providing valuable insights, several limitations should be acknowledged in interpreting the findings of this study. One limitation concerns the relatively small number of participants, which may restrict the generalizability of the results [31]. Another limitation is that the investigation focused exclusively on mathematical conceptual understanding without considering other variables that might affect learning outcomes. Furthermore, the use of a posttest-only quasi-experimental design limited the possibility of examining students' initial abilities in greater detail. Future studies are therefore recommended to involve larger samples, different educational settings, and additional variables to obtain more comprehensive findings.

4. CONCLUSION

This study concludes that the implementation of the Inside-Outside Circle (IOC) cooperative learning method significantly contributes to improving students' mathematical conceptual understanding, as evidenced by the higher achievement of students in the experimental group compared to those who received conventional instruction. These findings are consistent with the research objective presented in the introduction and confirm that interactive and collaborative learning activities facilitate meaningful conceptual development in mathematics learning. In addition, the results highlight the importance of student-centered learning approaches in promoting active participation, communication, and deeper understanding of mathematical concepts. The present study also provides empirical support for the application of cooperative learning strategies in Islamic junior high school settings, thereby enriching the existing literature on mathematics education. From a practical perspective, the findings suggest that the IOC method can serve as an alternative instructional strategy for mathematics teachers seeking to enhance students' conceptual understanding and learning quality. Future research is recommended to involve larger samples, different educational contexts, and additional variables in order to obtain more comprehensive findings and further expand the application of the IOC method in mathematics education.

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