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The Impact of Cooperative Learning Activities using the Team-Assisted Individualization (TAI) Technique Combined with Activity-Based Learning on Problem-Solving Abilities and Mathematical Connections Abilities in the Subject of Congruence

Narintra Mingolo[1]

[1] Faculty of Education and Human Development, Roi Et Rajabhat University, Roi Et, Thailand

Correspondence: Narintra Mingolo, Faculty of Education and Human Development, Roi Et Rajabhat University, Roi Et, Thailand. E-mail: nusharin_m@kkumail.com

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Abstract

This research is a quasi-experimental study with the following objectives: 1) To examine the effectiveness of cooperative learning activities using the TAI technique combined with activity-based learning on the topic of congruence for students at Roi Et Rajabhat University, aiming to achieve the 75/75 efficiency criterion. 2) To compare mathematical problem-solving abilities before and after implementing the learning activities. 3) To compare mathematical connection abilities before and after the learning activities. The sample group consisted of 24 students enrolled in the Number Theory course during the first semester of the academic year 2024, selected through cluster sampling. The research instruments included: 1) Four lesson plans for cooperative learning activities using the TAI technique combined with activity-based learning, 2) A subjective test measuring mathematical problem-solving abilities consisting of five items, and 3) A subjective test measuring mathematical connection abilities consisting of five items. The statistical methods used were mean, percentage, standard deviation, and the Wilcoxon Signed Rank Test. The research findings revealed that: 1) The cooperative learning activities using the TAI technique combined with activity-based learning achieved an efficiency of 80.83/78.85, which was higher than the specified criterion. 2) The students' mathematical problem-solving abilities on the topic of congruence were significantly higher after the learning activities at the .05 level of significance. 3) The students' mathematical connection abilities on the topic of congruence were significantly higher after the learning activities at the .05 level of significance.

Keywords: TAI cooperative learning technique, activity-based learning, mathematical problem-solving ability, mathematical connection ability, congruence

1. Introduction

1.1 Introduce the Problem

Number theory is a branch of mathematics that studies the properties of integers, focusing on key topics such as divisibility, modular arithmetic, and prime factorization. This subject is highly significant as it forms the foundation for analyzing mathematical problems and developing various mathematical formulas. Learning number theory helps students understand the structure of numbers and the relationships between them, which can be applied in various fields such as computer science, cryptography, and mathematical engineering (Shoup, 2005).

Congruence is one of the key topics in number theory, which deals with the equivalence of integers under division. It helps students understand the relationships between numbers when divided by a specified divisor, a concept that is useful in solving problems involving division and remainder calculations. Additionally, congruence plays a vital role in theoretical analysis in fields related to mathematics, such as cryptography and algorithm design.

However, teaching number theory, particularly in the topic of congruence, faces several challenges, especially in developing mathematical problem-solving skills and connecting mathematical concepts. Due to the abstract nature of the content, many students find it difficult to apply their knowledge effectively in problem-solving. Moreover, linking congruence with other mathematical topics remains a significant challenge.

1.2 Explore Importance of the Problem

In traditional teaching methods, rather than using approaches that promote interpretation, reasoning, analysis, and synthesis skills, information is often presented to students in fragmented pieces. This results in students memorizing the information instead of deeply understanding mathematical concepts and applying them logically. In this approach, the role of students is largely passive, with no responsibility for their own learning, while teachers play a dominant role in the teaching process, assuming full responsibility for students' learning outcomes. In this teacher-centered approach, teachers often rely heavily on textbooks and solve common problems as examples on the board. A significant drawback of this method is that a single teacher cannot provide personalized attention or guidance to every student (Ehrenberg et al., 2001).

According to the PISA Thailand assessment presented on pisathailand.ipst.ac.th, Thai students achieved an average score of 394 in mathematics. Compared to PISA 2018, this represents a decline of 25 points. Furthermore, from PISA 2000 to PISA 2022, Thailand's average mathematics scores have shown a downward trend. Problem-solving is a key framework in the PISA mathematics assessment, emphasizing that students must be able to apply their mathematical knowledge to solve real-world problems in challenging contexts.

In the past academic year, teaching in the Number Theory course revealed that students continue to struggle with developing problem-solving skills and connecting mathematical content to relevant theories, particularly in the topic of congruence, which is complex and highly abstract. Most students were unable to link the theory of congruence with its application to real-life mathematical problems, leading to insufficient development of problem-solving and deep analytical skills. Therefore, there is a pressing need to improve teaching approaches and learning activities to foster deeper understanding and more effective application of these concepts.

1.3 Describe Relevant Scholarship

According to the National Council of Teachers of Mathematics (NCTM) (2000), there are five standards in the process of learning mathematics, including problem solving, reasoning and proof, connections, communication, and representation. The ability to solve mathematical problems and make connections in mathematics are essential skills as outlined by the NCTM.

1.3.1 Mathematical Problem-Solving Ability

Mathematical problem-solving ability refers to a person's ability to apply mathematical knowledge and skills to find solutions to given problems. The process of solving mathematical problems involves understanding the question, implementing a solution plan, and evaluating the results (Polya, 1985). Although these phases are not complete, they are intrinsically linked. Students with a poor grasp of the subject often struggle with mathematical problem-solving (Lester, 1994). In recent years, many research studies have explored mathematical problem-solving abilities. In 2022, Yapatang and Polyiem studied the effects of integrating cooperative learning in the Team Assisted Individualization (TAI) model with Polya's problem-solving process. They found that this approach successfully enhanced students' mathematical problem-solving abilities and learning achievement, while also contributing to a more satisfying classroom experience. In 2023, Li *et al*. applied peer tutoring in collaborative learning for mathematical problem-solving in flipped classrooms. This learning management approach helped students improve their mathematical problem-solving skills, while in 2024, Heebkaew & Seehamongkon used cooperative learning with STAD and KWDL techniques to improve grade 6 students' decimal problem-solving skills, leading to enhanced mathematical problem-solving abilities. In the same year, Tinungki *et al.* (2024) evaluated the improvement of self-proficiency, mathematical problem-solving skills, and mathematical communication by applying the Team-Assisted Individualization (TAI) Cooperative Learning Model in the context of Non-Parametric Statistics, a core course in undergraduate statistics programs.

1.3.2 Mathematical Connection Ability

Mathematical connection ability refers to students' ability to link mathematical concepts with other scientific fields and real-world phenomena. Students with strong mathematical connection skills can recognize relationships among mathematical ideas, understand how they interrelate, and apply these concepts beyond the classroom (NCTM, 2000). Developing these abilities is crucial for students as it builds a network of knowledge that allows them to understand and connect different mathematical concepts, processes, and methods. Mathematical connections help students grasp the relationships between concepts quickly, opening opportunities for skill development (Kenedi *et al*., 2019). However, research by Rahmawati, Budiyono, & Saputro (2019) and Siregar & Surya (2017) highlights that secondary students' mathematical connection abilities are often low, particularly in making connections between mathematical concepts, scientific disciplines, and real-life problems. The low ability in mathematical connections is an urgent issue that requires intervention from multiple stakeholders, including teachers and researchers. Teachers should act as facilitators, providing challenging problems that encourage students to develop these connections. In 2020, Maulidawati *et al*. compared students taught through cooperative learning versus scientific learning and found that those who learned through cooperative methods had stronger mathematical connection abilities. In 2022, Son conducted a comparison of students' achievement and improvement in mathematical connection abilities using different learning models. The study found that the Connecting, Organizing, Reflecting, and Extending (CORE) model with Realistic Mathematics Education (RME) was more effective in enhancing students' mathematical connection abilities than the CORE model. Later in 2023, Rafiepour and Faramarzpour conducted a study on students' mathematical connection ability in solving mathematical problems and the correlation between various indicators of this ability. The variables in the study included indicators of mathematical connection ability, such as connections between mathematical concepts, connections between mathematics and other sciences, and connections between mathematics and everyday life. The study found a significant correlation between the indicators of mathematical connection ability.

Although there have been studies on mathematical connection abilities, it has been found that students' abilities in this area remain low, particularly in linking mathematics with science and real-world problems. The development of learning activities that effectively enhance connection skills is still an area requiring further research. Additionally, the connection between mathematics and everyday life is another area where students' abilities are still insufficient, highlighting the need for developing teaching methods that can foster these connections more effectively. Thus, teaching methods designed to develop mathematical problem-solving and connection skills should encourage students to practice solving problems. Cooperative learning is one popular approach that allows students to work in small groups, sharing ideas and collaborating on solutions (Kagan, 1994). Techniques like Team-Assisted Individualization (TAI) enable students of varying abilities to learn together (Posamentier, Smith, & Stepelman, 2010). TAI benefits both the class and individual students, allowing high-ability students to mentor others while lower-ability students can seek help from peers. This approach aligns with the nature of mathematics, which requires guidance from teachers and collaborative learning with peers. On the other hand, Activity-Based Learning engages students actively in the learning process, emphasizing hands-on experiences rather than passive listening. This method includes reading, writing, discussion, real-world activities, problem-solving, analysis, synthesis, and evaluation. Bonwell & Eison (1991) define active learning as strategies that require students to think critically about their actions. Activity-based learning fosters teamwork, builds self-confidence, promotes participatory learning, and encourages creative problem-solving and discovery learning (Festus, 2013).

In conclusion, both cooperative learning with TAI techniques and activity-based learning are effective in enhancing students' mathematical problem-solving and connection abilities. Cooperative learning promotes teamwork and communication, helping students develop both social and mathematical thinking skills. Activity-based learning, meanwhile, emphasizes hands-on experiences, fostering engagement, confidence, and analytical thinking. Both approaches enable students to participate actively in learning and apply mathematical concepts to real-world situations.

1.4 The Purpose of the Study and Research Problems

This study aims to investigate the impact of cooperative learning activities using the TAI technique combined with activity-based learning on problem-solving abilities and mathematical connection abilities in the context of congruence. Accordingly, the sub-problems explored in this study are as follows:

1) Is the implementation of cooperative learning activities using the TAI technique combined with activity-based learning effective in developing the mathematical problem-solving and connection abilities in the topic of congruence among students at Roi Et Rajabhat University?

2) Is there a difference between the mathematical problem-solving and connection abilities before and after learning through the cooperative learning activities using the TAI technique combined with activity-based learning?

2. Methodology

2.1 Research Design

This research employs a quasi-experimental design. The researcher utilized a One Group Pretest-Posttest Design, in which students were given a pretest before instruction, followed by cooperative learning activities using the TAI technique combined with activity-based learning, and then a posttest was conducted after the learning.

2.2 Study Group

The study group for this research consisted of 24 students from Roi Et Rajabhat University, enrolled in the Number Theory course during the first semester of the 2024 academic year. The students were selected through cluster random sampling, with one classroom chosen for the study.

2.3 Instruments

The research instruments included: 1) cooperative learning activity plans using the TAI technique combined with activity-based learning, 2) a mathematical problem-solving ability test, and 3) a mathematical connection ability test. The content focused on the topic of congruence. The learning management consisted of four lesson plans, each lasting 2 hours and 30 minutes, which were evaluated by experts and found to be appropriate for developing students' skills. The mathematical problem-solving ability test on the topic of congruence, consisting of five subjective questions, was reviewed by three experts and achieved an IOC score of 1.00. The test was then trialed with 29 students who were not part of the sample group. The difficulty index and discrimination index were analyzed using the Whitney and Sabers method, with difficulty values ranging from 0.41 to 0.65 and discrimination values ranging from 0.44 to 0.69. The reliability of the entire test was calculated using Cronbach's alpha, with a value of 0.88. The mathematical connection ability test on the topic of congruence, consisting of five subjective questions, was also reviewed by three experts and achieved an IOC score of 1.00. The difficulty values ranged from 0.41 to 0.56, the discrimination values ranged from 0.31 to 0.63, and the reliability of the entire test was 0.81.

2.4 Data Collection

This research was designed as an experimental study. The students took a pretest to assess their knowledge of number theory, specifically on the topic of congruence, before the learning management. The experiment took place during the first semester of the 2024 academic year. After the learning sessions, the students took tests on their mathematical problem-solving ability and mathematical connection ability.

2.5 Data Analysis

Analyze the effectiveness of cooperative learning activities using the TAI technique combined with activity-based learning on students' mathematical problem-solving and connection abilities in the topic of congruence at Roi Et Rajabhat University by calculating the E_1/E_2 ratio. Additionally, the researcher compared the mathematical problem-solving and connection abilities before and after implementing cooperative learning activities using the TAI technique combined with activity-based learning in the topic of congruence, utilizing the Wilcoxon Signed Rank Test. This test was chosen because the researcher found that the distribution of the pre-test (left) and post-test (right) scores of mathematical problem-solving ability and mathematical connection ability was non-normal, as shown in Figures 1 and Figure 2, respectively.

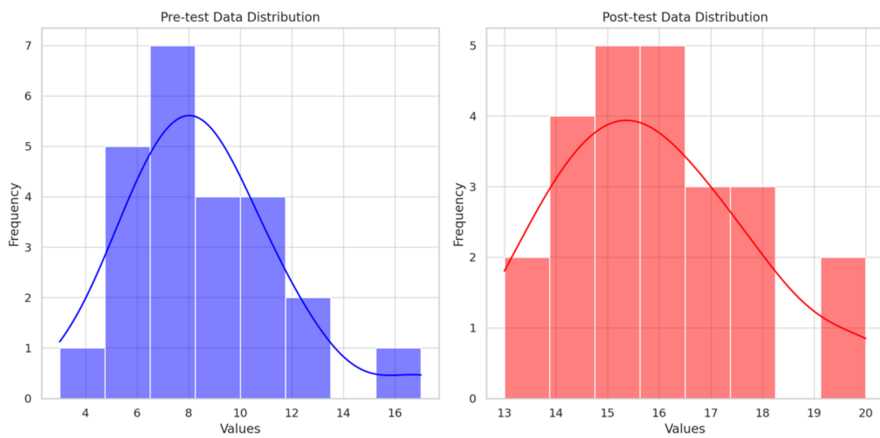

Figure 1. The distribution of the pre-test (left) and post-test (right) scores of mathematical problem-solving ability

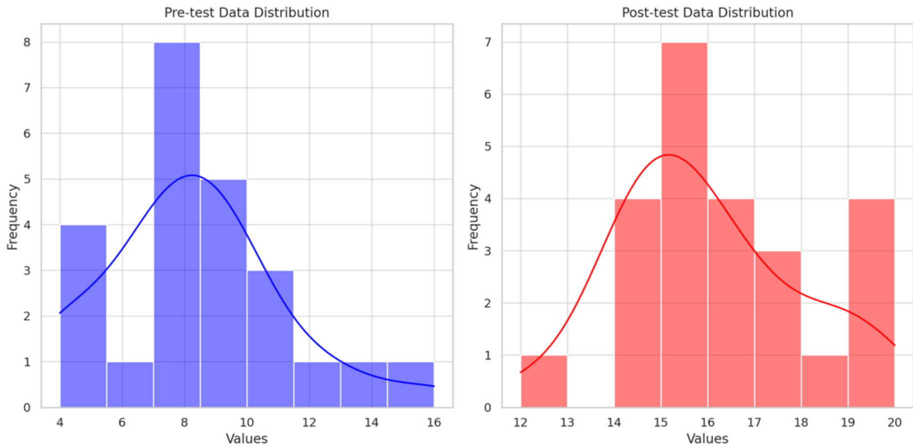

Figure 2. The distribution of the pre-test (left) and post-test (right) scores of mathematical connection ability

2.6 Implementation Process

This study was conducted during the first semester of the 2024 academic year and lasted for 4 weeks. The experimental group was the only group in this research. Before starting the process, students were assessed on their mathematical problem-solving ability and mathematical connection ability through a pretest. The results from this test were used to divide the students into groups of 4-5 members, with each group consisting of students with different abilities to encourage mutual support within the group. After that, each group assigned roles to its members, and roles were rotated for each activity to ensure that every student had the opportunity to participate in the learning process. This made students feel like an integral part of the learning process and helped them develop responsibility for their own learning. The activities conducted during this process are shown in Table 1.

Table 1. The activities carried out in the implementation process

Activities	Week 1	Week 2	Week 3	Week 4
Pre-test	✓			
Cooperative learning activities using the TAI technique combined with activity-based learning	✓	✓	✓	✓
Post-test				✓

Week 1: Students were provided with detailed information about the process and completed a pre-test assessing their mathematical problem-solving ability and mathematical connection ability. After gathering the pre-test data from all students, they were divided into groups of 4-5 based on their pre-test scores to ensure that each group consisted of students with varying abilities. Afterward, each group assigned roles to its members, and roles were rotated for each activity to ensure that every student had the opportunity to participate in the learning process. This made students feel like an integral part of the learning process and helped them develop responsibility for their own learning. After the grouping, the teacher explained the learning objectives on the topic of congruence, including an explanation of the properties of congruence. Following this, each group proceeded with *Activity 1: Properties of Congruence*, while the teacher monitored and checked the progress of each group. Once Activity 1 was completed, the teacher asked each group to present their results and discuss them with the rest of the class.

Week 2: The teacher reviewed the lesson from Week 1 and began by explaining the process of solving linear congruences. The teacher outlined the steps for solving linear congruences and their applications. After that, each group proceeded with *Activity 2: Solving Linear Congruences*. The teacher assigned each group increasingly complex linear congruence problems and monitored their work by walking around and checking the groups. The teacher provided targeted guidance when students or groups encountered doubts or difficulties in solving problems. Once Activity 2 was completed, the teacher and students summarized the week's learning and assigned homework for further practice.

Week 3: The teacher reviewed the principles of solving linear congruences learned in previous weeks and provided additional explanations on using the Chinese Remainder Theorem (CRT). Afterward, each group proceeded with *Activity 3: Solving Systems of Linear Congruences using CRT*. Once Activity 3 was completed, the teacher summarized the learning outcomes with the students and opened the floor for questions and discussions on applying CRT in real-life scenarios.

Week 4: The teacher reviewed the concepts of solving systems of congruences and CRT that were covered in the previous week. After that, the teacher explained Euler's and Fermat's Theorems and their applications in finding remainders in modular arithmetic. Once the explanation was complete, each group proceeded with *Activity 4: Finding Remainders using Euler's and Fermat's Theorems*. The teacher and students then summarized the learning outcomes from all four weeks. Afterward, the students completed a post-test assessing their mathematical problem-solving ability and mathematical connection ability. The process concluded once all responses were collected.

3. Results

This section presents the results of implementing cooperative learning activities using the TAI technique combined with activity-based learning on the mathematical problem-solving and connection abilities in the topic of congruence among students at Roi Et Rajabhat University. The research findings are as follows:

3.1 Findings on the First Sub-Problem

The effectiveness of cooperative learning activities using the TAI technique combined with activity-based learning on mathematical problem-solving and connection abilities in the topic of congruence is rated as highly appropriate overall and meets the 75/75 efficiency criterion, as shown in Table 2.

Table 2. Process effectiveness of cooperative learning activities using the TAI technique combined with activity-based learning on the mathematical problem-solving and connection abilities

Effectiveness	Full mark	$\bar{x}$	S.D.	Percentage
Process effectiveness (E_1)	20	16.17	0.72	80.83
Outcome effectiveness (E_2)	40	31.54	3.82	78.85
The effectiveness index (E_1/E_2) = 80.83/78.85				

According to Table 2, the effectiveness of cooperative learning activities using the TAI technique combined with activity-based learning on the mathematical problem-solving and connection abilities in the topic of congruence among students at Roi Et Rajabhat University has an efficiency value of 80.83/78.85, which is higher than the specified criterion of 75/75.

3.2 *Findings on the Second Sub-Problem*

The comparison of mathematical problem-solving and connection abilities in the topic of congruence among students at Roi Et Rajabhat University, using cooperative learning activities with the TAI technique combined with activity-based learning, before and after learning, was conducted. The researcher analyzed the problem-solving and connection ability scores in the topic of congruence to check the normal distribution of the data. The test results indicated that the scores were not normally distributed. Therefore, the researcher compared the mathematical problem-solving and connection abilities before and after learning using the Wilcoxon Signed Rank Test. It was found that the mathematical problem-solving ability, through cooperative learning activities using the TAI technique combined with activity-based learning in the topic of congruence among students at Roi Et Rajabhat University, was significantly higher after learning than before learning, at the .05 level of statistical significance, as shown in Tables 3 and 4, respectively.

Table 3. Results of the Wilcoxon signed ranks test regarding students' pre-test and post-test scores of the mathematical problem-solving ability test

Posttest-pretest	N	Mean Rank	Sum of Ranks	z	p
Negative Ranks	0	.00	.00	-4.29	.00
Positive Ranks	24	15.42	370.0		
Ties	0				

The analysis results show a significant difference between the pre- and post-test scores of the students participating in the research ($z = -4.29$, $p < .05$). Regarding the mean rank and sum of the ranks, this observed difference favors the post-test. Based on this result, it can be concluded that the TAI cooperative learning technique, combined with activity-based learning, has a significant effect on improving the mathematical problem-solving ability in the topic of congruence among students at Rajabhat Roi Et University.

Table 4. Results of the Wilcoxon signed ranks test regarding students' pre-test and post-test scores of the mathematical connection ability test

Posttest-pretest	N	Mean Rank	Sum of Ranks	z	p
Negative Ranks	0	.00	.00	-2.89	.00
Positive Ranks	24	12.5	300.0		
Ties	0				

The analysis results indicate a significant difference between the pre-test and post-test scores of the students involved in the study ($z = -2.89$, $p < .05$). In terms of the mean rank and the sum of ranks, this difference leans in favor of the post-test scores. These findings suggest that the TAI cooperative learning technique, combined with activity-based learning, has a notable impact on enhancing the mathematical connection ability in the topic of congruence among students at Rajabhat Roi Et University.

4. Discussion

This study investigated the impact of cooperative learning activities using the TAI technique combined with activity-based learning on problem-solving abilities and mathematical connection abilities in the context of congruence. The results of the study lead to the issues discussed below.

4.1 The Effectiveness of Cooperative Learning Activities Using the TAI Technique Combined with Activity-Based Learning Is Effective in Developing the Mathematical Problem-Solving and Connection Abilities

The research results indicate that students were able to improve their mathematical problem-solving abilities after learning through a learning management system designed with cooperative learning activities using the TAI technique and activity-based learning. This result can be further analyzed by interpreting that the use of the TAI technique helps create a learning environment that enables students to engage with more complex problems. Group work encourages students to exchange ideas, practice analytical thinking, and learn from peers with different abilities, which is a key factor in enhancing problem-solving skills. Moreover, activity-based learning provides opportunities for students to actively apply their mathematical knowledge in real-life contexts. This not only deepens their understanding of mathematical concepts but also promotes systematic thinking and sustainable application skills in new situations. These results highlight the positive impact of learning management design that can foster a shift in students' thought processes from solving simple problems to developing deeper cognitive skills, which is essential for tackling more complex challenges in the future. These findings are consistent with the studies of Aljaberi and Gheith (2016), Arrahim, Sugiharti, and Damayanti (2020), Yapatang and Polyiem (2022), Tinungki *et al.* (2022), Küpçü (2012), Altintas and Ozdemir (2012), and Maulidawati *et al. (*2020), which also highlighted the benefits of cooperative learning activities using the TAI technique combined with activity-based learning. These activities enable students to effectively exchange ideas, solve problems, and connect mathematical knowledge. This learning technique helps students apply their mathematical knowledge to real-life situations and develop systematic thinking processes. By engaging in planning and problem-solving through activities, students enhance their understanding of mathematical content and sustainably improve their problem-solving skills.

4.2 The Difference Between Mathematical Problem-Solving Ability Before and After Learning Through Cooperative Learning Activities Using the TAI Technique Combined with Activity-Based Learning

The results of the comparison of mathematical problem-solving abilities in the topic of Congruence, before and after learning through cooperative learning activities using the TAI technique combined with activity-based learning, showed that the post-learning problem-solving scores were significantly higher than the pre-learning scores at the .05 statistical significance level. This result can be interpreted as indicating that cooperative learning activities and activity-based learning not only help improve problem-solving scores but also bring about qualitative changes in students' thinking processes. Cooperative learning provides students with the opportunity to learn through exchanging ideas with their peers, which helps enhance critical thinking skills and the ability to systematically evaluate problems. Participation in these activities requires students to apply a variety of strategies, including problem analysis, solution planning, and outcome evaluation, which are key components of analytical thinking processes. This study aligns with the research by Yapatang and Polyiem (2022), which found that the integration of cooperative learning, especially the Team-Assisted Individualization (TAI) model, leads to success in improving mathematical problem-solving abilities and learning outcomes. Similarly, the study by Tinungki *et al.* (2022) suggested that the TAI cooperative learning model is an effective option for developing mathematical problem-solving skills, communication skills, and self-proficiency. There is a clear correlation between mathematical communication skills and problem-solving abilities. Additionally, this is consistent with the findings of Langcauon and Reston (2018), who found that using activity-based cooperative learning materials in teaching has the potential to develop students' critical thinking and problem-solving skills, as students actively engage in working with real data sets to evaluate, make decisions, or solve various problems.

4.3 The Difference Between Mathematical Connection Ability Before and After Learning Through Cooperative Learning Activities Using the TAI Technique Combined with Activity-Based Learning

The comparison of mathematical connection abilities in the topic of Congruence, before and after learning through cooperative learning activities utilizing the TAI technique combined with activity-based learning, revealed that the post-learning scores in mathematical problem-solving were significantly higher than the pre-learning scores, with a statistical significance level of .05. This result can be interpreted as indicating that learning through cooperative activities and activity-based learning not only helps students understand specific mathematical concepts more deeply, but also enables them to connect these concepts to broader contexts, such as applications in science or everyday life. By participating in activities that encourage them to communicate and discuss mathematical problems with their peers, students enhance their communication skills and their ability to make connections. These connections form a critical foundation that allows students to apply mathematical concepts effectively in complex and unfamiliar situations. Moreover, the increase in post-learning scores reflects the long-term impact of developing systematic skills and mathematical knowledge connections. This will help students handle increasingly complex problems in the future. These effects suggest that cooperative and activity-based learning approaches are highly effective in developing mathematical connection skills, which are crucial in today's rapidly interconnected world. This study aligns with the research by Son (2022), who compared students' achievement and progress in mathematical connection abilities across different learning models. The study concluded that the CORE RME model was effective in enhancing students' mathematical connection abilities. Additionally, it aligns with the research of Maulidawati *et al.* (2020), which compared students taught through cooperative learning and scientific learning. It was found that students who learned through cooperative methods were able to improve their mathematical connection abilities.

5. Conclusion

The research questions of this study can be summarized as follows: 1) The cooperative learning activities using the TAI technique combined with activity-based learning in Number Theory, specifically on the topic of congruence, were effective in developing students' mathematical problem-solving abilities and mathematical connection abilities. 2) Students who participated in the cooperative learning activities using the TAI technique combined with activity-based learning on the topic of congruence showed higher mathematical problem-solving abilities after learning compared to before learning. 3) Students who participated in the cooperative learning activities using the TAI technique combined with activity-based learning on the topic of congruence demonstrated higher mathematical connection abilities after learning compared to before learning. It is evident that the implementation of cooperative learning activities using the TAI technique combined with activity-based learning can lead to success in improving both mathematical problem-solving and connection abilities. Therefore, this approach should be applied in mathematics teaching to further develop students' abilities. Moreover, in future studies, this learning model could be adapted for a wider range of mathematical content to observe its effectiveness in various contexts. Additionally, integrating qualitative research methods would provide deeper insights into the impact of combining these two approaches on students' learning processes. Furthermore, future studies should also explore students' satisfaction with these activities. Since mathematics is a core foundation of education, fostering both mathematical problem-solving and connection abilities is crucial for helping students achieve success in this subject, which will in turn form the foundation for students' educational and life opportunities.

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Authors contributions

The sole author was responsible for all aspects of this research, including the study design, data collection, data analysis, manuscript writing, and revision.

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Data sharing statement

No additional data are available.

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