Utilizing Integrated Think-Pair-Share and SSCS Techniques to Enhance Problem-Solving Skills in Mathematical Set among 10th Grade Students

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Abstract

This study aimed to investigate the impact of integrating Think-Pair-Share (TPS) and Search Solve Create Share (SSCS) techniques on the problem-solving skills of 10th-grade students within the framework of set theory, while also assessing participants' satisfaction with these methods. Conducted using a one-group experimental research design, the study involved 37 10th-grade students selected through cluster random sampling from a public school in Mahasarakham province, Thailand. Ethical considerations were meticulously observed throughout the study. Instruments utilized included a TPS and SSCS learning management plan, a Mathematics Set Problem Solving Ability Test, a Satisfaction Questionnaire, and Rubric Scoring. Data analysis employed percentage, mean score, standard deviation, and a one-sample t-test comparing to a predetermined criterion of 75% of the maximum score for each test. The results demonstrated that the integrated TPS and SSCS techniques were effective in developing students' problem-solving abilities and provided satisfying learning experiences. This underscores the efficacy of collaborative learning techniques, particularly in enhancing problem-solving skills. Additionally, the study highlights the potential of integrating various collaborative methods to achieve favorable outcomes in mathematics education.

Keywords: think-pair share, SSCS, mathematic problem-solving ability, mathematics education

1. Introduction

In mathematics education, the comprehension of mathematical sets serves as a foundational milestone in a student's mathematical journey. Mathematical sets encapsulate a collection of distinct elements, often organized according to specific criteria or properties (Lawvere, 2003). Understanding sets and their operations is crucial for developing higher-order mathematical skills and concepts. Mastery of set theory not only forms the bedrock for advanced mathematical topics but also fosters critical thinking and problem-solving abilities among students (Pinter, 2014). Moreover, proficiency in set theory lays the groundwork for tackling complex mathematical problems in fields such as computer science, statistics, and logic, underscoring its significance beyond the confines of the classroom (Dawkins, 2017).

However, attaining mastery in mathematical sets requires a solid understanding of foundational mathematical concepts and principles. Students must grasp fundamental concepts such as elements, subsets, intersections, unions, and complements to effectively navigate set operations (Stoll, 2012). Additionally, proficiency in logical reasoning and abstract thinking is essential for comprehending the intricate relationships between sets and applying set-theoretic principles to solve mathematical problems (Mayberry, 2000). Without a strong conceptual framework and the requisite skills in place, students may struggle to grasp the complexities of set theory, impeding their ability to engage with and apply these concepts in mathematical problem-solving contexts (Dawkins, 2017). Consequently, targeted instruction and comprehensive support are vital for facilitating students' understanding of mathematical sets and fostering their problem-solving skills within this domain (Tirosh, 2013).

In Thailand, as the focus area of this study, challenges persist in the realm of mathematics education, including the comprehension and application of set theory concepts (OECD, 2022). Thai students often encounter difficulties in mastering these concepts, reflecting broader issues within the educational landscape (Thailand Development

Research Institute, 2023). Criticisms regarding various aspects of the educational context, including instructional practices and teacher shortages, contribute to the challenges faced in teaching mathematical sets effectively (Payadnya et al., 2024; Promwongsai & Poonputta, 2023; Yuenyong, 2019). Addressing these challenges requires innovative pedagogical approaches that cater to students' needs and preferences, fostering an engaging and dynamic learning environment conducive to developing problem-solving skills in mathematical set theory.

Considering the nature of knowledge acquisition of mathematical sets could provide a broadened picture of how the concept can be instructed to the students. For example, in the constructivist approach to learning mathematical sets, students actively construct their understanding through hands-on experiences and collaborative activities, such as sorting objects into groups based on common characteristics and engaging in group discussions to negotiate meanings (Faulkenberry & Faulkenberry, 2006). Teachers scaffold learning by gradually introducing complex concepts and providing support tailored to students' current understanding. Connectivism emphasizes leveraging online resources and networks to explore set theory independently, participate in online communities, and create dynamic learning environments that adapt to learners' needs and interests (Klinger, 2011). Behaviorism involves reinforcing learning through repetitive practice, immediate feedback, and behavior modification strategies, such as drills and exercises, automated quizzes, and positive reinforcement, to shape desired learning behaviors and attitudes towards mathematical sets (Klinger, 2010). These pedagogical theories offer diverse approaches to facilitate the learning of mathematical sets, catering to students' individual learning styles and preferences.

It's clear that mastering the concepts of sets requires logical thinking, knowledge construction, and collaborative learning. Thus, an instructional method fostering active participation, discussion, and experience-sharing is crucial. Enter the Think-Pair-Share method: students first contemplate prompts independently, then discuss them with a partner, and finally share insights with the class (Slavin, 1995, 2008; Tint & Ei Nyunt, 2015). This method promotes active engagement and deeper understanding. However, the complexity of learning mathematics calls for enhancement. Integrating the Search, Solve, Create, Share (SSCS) technique could strengthen the Think-Pair-Share process. SSCS allows learners to search for information, solve problems, collaborate, and share findings (Putriana & Haqiqi, 2023; Yasin et al., 2020). This integration enriches the Think-Pair-Share method: instead of merely thinking of answers, students search for information; the creation stage elevates collaboration by fostering the generation of new knowledge, perhaps through tackling more complex tasks or aiding each other.

Hence, this study integrates the SSCS method with Think-Pair-Share to formulate a comprehensive learning management plan addressing challenges in teaching and learning mathematical sets. The outcomes are poised to significantly impact the field. Firstly, they validate the efficacy of Think-Pair-Share in mathematics education. Secondly, they demonstrate SSCS's potential as an augmentation to Think-Pair-Share in math instruction. Finally, the findings illustrate how learners can enhance their grasp of set theory by thoroughly demonstrating problem-solving techniques after engaging with the integrated Think-Pair-Share and SSCS approach.

2. Literature Review

2.1 Collaborative Learning and Mathematics Education

Collaborative learning in mathematics education underscores the significance of students actively engaging with peers to construct knowledge collectively. Defined as a pedagogical approach where students work together in groups to achieve common learning goals, collaborative learning fosters an environment where students exchange ideas, challenge assumptions, and construct deeper understandings of mathematical concepts (Johnson & Johnson, 1999). Central to collaborative learning is the principle of social interdependence, where individuals perceive that their success is contingent upon the success of their peers, thus promoting cooperation and mutual support within the group (Johnson et al., 2000). By working collaboratively, students not only enhance their conceptual understanding of mathematics but also develop vital communication, problem-solving, and critical thinking skills essential for success in the modern world (Slavin, 1995).

In mathematics education, collaborative learning is applied through various strategies aimed at promoting active student participation and peer interaction. Cooperative problem-solving tasks, group discussions, and peer tutoring sessions are examples of collaborative learning activities commonly employed in mathematics classrooms (Bittinger, 2003). Through these activities, students engage in meaningful mathematical discourse, share multiple problem-solving approaches, and collectively construct solutions to mathematical problems. Furthermore, collaborative learning encourages students to articulate their reasoning, justify their solutions, and critique the reasoning of their peers, fostering a deeper understanding of mathematical concepts and processes (Hiebert et al., 2002).

To effectively apply collaborative learning in mathematics education, educators should create a supportive learning environment where students feel empowered to collaborate, take risks, and learn from their peers (Webb, 2009). Teachers play a crucial role in structuring collaborative learning experiences, establishing clear learning objectives, and providing guidance and feedback throughout the process (Slavin, 2015). Additionally, educators should cultivate a culture of respect, inclusivity, and accountability within the classroom to ensure equitable participation and meaningful collaboration among all students Bittinger, 2003. By embracing collaborative learning principles and practices, mathematics educators can create dynamic learning experiences that foster deep conceptual understanding, promote mathematical discourse, and empower students to become active, self-regulated learners in mathematics and beyond.

2.2 Think-Pair Share

Think-Pair-Share is a collaborative learning strategy that involves students working together in pairs to engage in learning activities, exchange ideas, and arrive at conclusions collectively. The process begins with students individually thinking about a given topic or question, followed by pairing up to discuss their thoughts and findings. Finally, students share their conclusions or answers with the whole class. This approach encourages active participation, critical thinking, and knowledge sharing among students. Lyman (1981) outlined the three key steps of Think-Pair-Share as thinking individually, pairing up for discussion, and sharing findings with the class. The technique has been praised for its ease of implementation, minimal preparation requirements, and ability to foster student engagement and participation at all academic levels. Kaddoura (2013) further noted its applicability in large classrooms, promotion of student interaction, and development of higher-order thinking skills. Therefore, Think-Pair-Share is a versatile and effective method for encouraging collaborative learning and enhancing student understanding of various subjects.

Scholars in the field of mathematics education, as exemplified by Falentina et al. (2022), Istikomah & Juandi (2023), Ningsih (2019), Ningsih et al. (2019), Promwongsai and Poonputta (2023), and Tanujaya & Mumu (2019), have extensively explored the application of the Think-Pair-Share technique across various educational settings and mathematical topics. Their collective research has provided substantial evidence supporting the efficacy of this method in fostering critical thinking skills, deepening conceptual understanding, and improving overall academic performance in mathematics. Additionally, these studies have shed light on the significant role of Think-Pair-Share in cultivating learner autonomy by encouraging active participation, collaborative learning, and the sharing of diverse perspectives among students. Overall, the findings underscore the value of integrating collaborative learning strategies like Think-Pair-Share into mathematics instruction to enhance student engagement and learning outcomes.

2.3 SSCS

The SSCS (Search, Solve, Create, Share) approach to learning management emphasizes an active and collaborative learning environment focused on fostering problem-solving skills and critical thinking among students (Tiara et al., 2024; Yasin et al., 2020). This method prioritizes student engagement and autonomy in the learning process, encouraging them to actively seek information, apply problem-solving techniques, organize their findings, and share their insights with peers. Several principles underpin this approach, including constructivism, which emphasizes that learning is an active process where individuals construct knowledge based on their experiences and interactions with the environment. Connectivism, another principle, highlights the importance of networks and connections in learning, suggesting that learning occurs through social interactions and collaboration. Additionally, the principle of experiential learning supports the SSCS approach by emphasizing the significance of hands-on experiences and reflection in the learning process. By integrating these principles, the SSCS method promotes a dynamic and interactive learning environment conducive to deep understanding and knowledge construction.

Previous research (e.g., Putriana & Haqiqi, 2023; Tiara et al., 2024; Yasin et al., 2020; Zulkarnain et al., 2021) has underscored the efficacy of employing techniques such as SSCS in mathematics classrooms. These methods have been shown to enhance various facets of learning, including academic performance, collaborative abilities, critical thinking, and mathematical reasoning. By engaging students in active problem-solving tasks and collaborative activities, the SSCS approach fosters a deeper understanding of mathematical concepts and encourages students to articulate and justify their reasoning. Additionally, it promotes peer learning and discussion, which further solidifies comprehension and allows students to explore multiple perspectives on problem-solving strategies. Overall, the adoption of SSCS techniques in mathematics education aligns with contemporary pedagogical approaches aimed at cultivating a more participatory and inquiry-driven learning environment.

It can be noted that both Think-Pair-Share (TPS) and SSCS have demonstrated their effectiveness as collaborative learning methods in mathematics education. However, previous studies have identified some gaps in their application. For instance, Falentina et al. (2022) highlighted the need to integrate TPS more comprehensively into the curriculum, advocating for its use across various mathematical concepts. Moreover, existing research has primarily focused on assessing learning outcomes through multiple-choice tests, which may not fully capture students' understanding of mathematical problem-solving processes. Given that TPS combines individual reflection, peer or group discussion, and class summarization, the thinking process is paramount, and providing students with supportive resources, such as access to relevant information in textbooks or online, could enhance their learning experience. Therefore, integrating TPS with SSCS through the development of a comprehensive learning management plan may offer a promising approach to enhancing students' mathematical knowledge. The objectives of this study were to investigate the impact of integrating TPS and SSCS on the problem-solving skills of 10th-grade students in the context of set theory and to assess participants' satisfaction with these methods for developing their mathematical problem-solving abilities.

3. Methodology

3.1 Research Design

The study utilized a one-group experimental research design to investigate the efficacy of a learning management plan designed using the principles of Think-Pair-Share (TPS) and SSCS.

3.2 Participants

The participants consisted of 37 10th-grade students from a public school in Mahasarakham province, situated in northeastern Thailand. They were chosen through cluster random sampling and Ethical considerations regarding human research were carefully observed in their treatment throughout the study.

3.3 Instruments

3.3.1 Think-pair Share and SSCS Learning Management Plan

The learning management plan comprises six sub-lesson plans, each designed to teach specific components of mathematical sets. These include finding the number of members of a finite set, solving problems involving the number of members of finite sets with two sets, and addressing problems with three sets.

The learning management plan underwent evaluation by a panel of three experts comprising scholars in the field of education and experienced professional teachers. The results of the evaluation indicated that the learning management plan received an very high rating for its suitability, with an average score of 4.63.

3.2.2 Mathematics Set Problem Solving Ability Test

The mathematics set Problem solving ability test originally comprised 10 constructed-response items, with 6 of them scored using a rubric. The test was presented to three experts to assess its content validity, revealing that 10 items were content-valid (IOC = 1.00). The test was then administered to 37 students who were not part of the sample group but had the same or similar characteristics to the sample. The test was analyzed for difficulty (P_D) and discrimination (D) using the Whitney and Sabers method (1970), with criteria set between 0.20-0.80 for P_D and 0.20-1.00 for D. The results showed that all 10 items met the criteria, with P_D ranging from 0.65 to 0.78 and D ranging from 0.20 to 0.31. Afterward, six items were selected for further use, and their reliability was assessed using Cronbach's alpha coefficient, yielding a coefficient value of 0.84.

3.2.3 Satisfaction Questionnaire

A satisfaction survey regarding the implementation of the Think-Pair-Share technique combined with the SSCS was conducted. It consisted of 10 Likert-scale questions, rated on a scale of 1 to 5, presented to three experts to evaluate content validity. The results showed that all questions were content-valid, with an index of item congruence (IC) exceeding the standard of 0.50, as compared to specialized vocabulary definitions. All questions obtained an IC value of 1.00, indicating high congruence with the content.

3.3 Data Collection and Data Analysis

The information was gathered in the initial term of the academic year 2023, utilizing a research design involving a pretest-posttest with a single group. Data analysis encompassed the use of percentage, mean score, standard deviation, and a one same t-test comparing to the 75% of the maximum score of each test.

4. Results

4.1 After completing the implementation of the think-pair share and SSCS learning management plan, the participants took a posttest with a maximum score of 30. The analysis reveals that the average posttest score of the participants ($\bar{x}$ = 25.81, S.D = 1.98) significantly exceeded the predetermined criterion of 75% (22.50), with a t-value of 10.15 and p-value of 0.00. (Table 1). The think-pair share and SSCS learning has been shown to improve learning outcomes in grade 10 high school students, with those achieving higher success rates.

Table 1. The Participants' Post-Treatment Mathematic Set Problem Solving Ability

	Full mark	Expected score (μ_0)	$\bar{x}$	%	SD	Mean Difference	t	df	Prob
posttest	30	22.50	25.81	86.04	1.98	3.31	10.15	36	.00*

*Prob <0.5

4.2 Participants' Learning Experiences with the Integrated Think-Pair Share and SSCS Learning Management Plan

The findings indicate that participants strongly agreed with the positive aspects of the learning experience facilitated by the integrated think-pair share and SSCS learning management plan ($\bar{x}$ = 4.55, SD = 0.60). Specifically, they valued the engaging nature of the learning process, its effectiveness in enhancing learning outcomes, its positive impact on peer relationships, its ability to foster systematic thinking, collaborative learning opportunities, and the valuable feedback received from both peers and teachers. (Table 2)

Table 2. The Participants' Satisfaction with the Learning Management Plan

Item	**Statements**	$\bar{x}$	**S.D.**	**Degree of agreement**
1	Working with peers made me feel excited and not bored.	4.65	0.48	Very high
2	Working with peers helped me understand the content better.	4.49	0.51	High
3	Engaging in think-pair-share activities improved my relationship with my peers.	4.73	0.45	Very high
4	Activities with peers stimulated my learning.	4.54	0.61	Very high
5	Engaging in think-pair-share activities along with SCSS prompted me to think systematically.	4.46	0.61	High
6	Engaging in think-pair-share activities along with SCSS allowed me to exchange knowledge with peers.	4.62	0.55	Very high
7	Engaging in think-pair-share activities along with SCSS helped me practice problem-solving together with peers.	4.43	0.61	High
8	Engaging in think-pair-share activities along with SCSS enhanced my understanding of problem-solving.	4.46	0.61	High
9	I appreciated the fair grading by the teacher.	4.57	0.50	Very high
10	I appreciated the feedback provided by the teacher after the presentations.	4.57	0.50	Very high
	Overall	4.55	0.60	Very high

5. Discussion

The findings reveal a significant increase in participants' average scores compared to the predetermined criteria in both learning activities and posttest evaluations. This suggests that the integrated approach of think-pair share and SSCS within the learning management plan effectively facilitated Grade 10 learners in the Thai context to achieve the anticipated outcomes pertaining to mathematical sets. These results contribute additional evidence supporting the efficacy of think-pair share and SSCS as valuable instructional techniques in mathematics education, consistent with previous research findings (e.g., Falentina et al., 2022; Istikomah & Juandi, 2023; Ningsih, 2019; Ningsih et al., 2019; Putriana & Haqiqi, 2023; Tanujaya & Mumu, 2019; Tiara et al., 2024; Yasin et al., 2020; Zulkarnain et al., 2021; Irma et al., 2024).

The findings also suggest that participants thoroughly enjoyed the learning experiences facilitated by think-pair share and SSCS, as they appreciated the engaging nature of these methods. Moreover, they recognized the effectiveness of these approaches in improving learning outcomes, fostering positive peer relationships, encouraging systematic thinking, providing collaborative learning opportunities, and offering valuable feedback from both peers and teachers. These results align with previous research studies (e.g., Istikomah & Juandi, 2023; Tiara et al., 2024; Zulkarnain et al., 2021), which have similarly emphasized the benefits of collaborative learning experiences in mathematics education, highlighting their capacity to enhance overall satisfaction with the learning process.

In this study, collaborative learning refers to the instructional approach where students work together in pairs or small groups to solve mathematical problems and engage in learning activities. Specifically, the integrated use of the think-pair-share (TPS) and Search, Solve, Create, and Share (SSCS) techniques facilitates collaborative learning. In the TPS process, students first individually analyze a problem or concept, then discuss their ideas with a partner, and finally share their thoughts with the whole class. This promotes active participation and peer interaction, allowing students to learn from each other's perspectives and build upon their collective understanding (Slavin, 1995). Similarly, the SSCS approach involves students collaboratively searching for information, solving problems, creating solutions, and sharing their findings with their peers. By engaging in these collaborative learning processes, students not only deepen their understanding of mathematical concepts but also develop essential skills such as communication, critical thinking, and teamwork (Johnson et al., 2000). Thus, collaborative learning in this study involves active student engagement, peer interaction, and cooperative problem-solving to enhance learning outcomes in mathematics. Similarly, in mathematics disciplines enhances students' academic performance, fosters systematic and sequential thinking, elevates learning outcomes, and promotes active engagement in the learning process. (Jose, 2024).

Moreover, the search process within the Search, Solve, Create, and Share (SSCS) method serves as a complementary component that enhances the overall effectiveness of the think-pair-share (TPS) technique. By engaging in the search phase, students are encouraged to explore additional resources and gather more information related to the problem or concept at hand. This extended exploration not only broadens their understanding but also deepens their critical thinking skills. When students have the opportunity to delve into various sources to find relevant information, they are prompted to think more critically and analytically about the subject matter. As a result, they can bring more insightful perspectives and ideas to the subsequent discussion phase of the TPS process. Moreover, the additional knowledge gained through the search process empowers students to contribute more substantively during the sharing phase. Therefore, the integration of the search process within the SSCS method not only enhances the individual thinking process but also enriches the collaborative learning experience fostered by the TPS technique.

Finally, it can be concluded that the integration of both methods has facilitated a profound comprehension of mathematical concepts among learners. This is evidenced by their ability to thoroughly demonstrate problem-solving techniques related to mathematical sets, as evaluated by the test. The successful performance of students across all test criteria in this study underscores the efficacy of collaborative discussion and knowledge transfer among peers in fostering deeper understanding.

6. Conclusion

The study harnesses the advantages of collaborative learning in mathematics classrooms by integrating two principles: think-pair-share and SSCS. These were amalgamated to formulate a comprehensive learning management plan aimed at teaching the concept of sets to 10th graders within the Thai educational framework. The findings demonstrate that the implementation of this learning management plan yielded the anticipated outcomes for the class, along with high levels of satisfaction among the learners. This underscores the efficacy of collaborative learning techniques, particularly in enhancing problem-solving abilities. Moreover, the study highlights the potential of integrating various collaborative methods to achieve favorable outcomes in mathematics education.

Pedagogical implications of this study suggest that educators can effectively employ collaborative learning techniques such as think-pair-share and SSCS to enhance students' problem-solving abilities in mathematics. By integrating these methods into the curriculum, teachers can foster active engagement, peer interaction, and deeper conceptual understanding among students. Furthermore, this study underscores the importance of incorporating diverse instructional strategies to cater to the diverse learning needs of students.

As for the direction for further research, future studies could delve deeper into exploring the specific mechanisms through which collaborative learning methods impact students' mathematical problem-solving skills. Additionally, investigating the long-term effects of integrating these techniques into mathematics education, such as their influence on students' academic achievement and attitudes towards learning, would be beneficial. Moreover, comparative studies examining the effectiveness of different collaborative learning approaches across various educational contexts could provide valuable insights into best practices for mathematics instruction.

Regarding limitations, it is important to acknowledge the absence of qualitative data in this study, which could have provided richer insights into students' experiences and perceptions of collaborative learning. Future research could address this limitation by incorporating qualitative methodologies, such as interviews or focus groups, to capture students' perspectives more comprehensively. Additionally, the small sample size of this study may limit the generalizability of the findings. Conducting similar studies with larger and more diverse participant groups could offer a more robust understanding of the effectiveness of collaborative learning techniques in mathematics education.

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Authors contributions

Supakit Hansuk were responsible for conceptualization, literature review, create a research tool and data collection, Suksawat Jansoda were responsible for editing a research tool, data collection and research design and Associate Professor Dr. Apantee Poonputta were responsible for editing a research tool, analysis, write the manuscript and revising. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Informed consent

Obtained.

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The Publication Ethics Committee of the Sciedu Press.

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.