



Think-Pair-Share as a Tool for Promoting Metacognitive Awareness in Organic Chemistry Education

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Abstract

This study examined the effect of the Think-Pair-Share (TPS) instructional strategy on the development of metacognitive awareness among undergraduate students enrolled in the Organic Chemistry course. Grounded in Flavell's metacognitive theory and Vygotsky's social constructivist framework, the study employed a convergent parallel mixed-methods design. The quantitative component used a quasi-experimental pretest-posttest non-equivalent control group design, while the qualitative strand utilized semi-structured interviews. The study was guided by 2 research questions and 1 null hypothesis. A total of 45 students from two purposively selected colleges participated. The Metacognitive Awareness Inventory (MAI) and an interview guide were used to collect data. Findings showed a statistically significant improvement in the TPS group ($p = 0.001$), confirming TPS's role in enhancing planning, monitoring, and cognitive regulation. Qualitative data revealed gains in reflective thinking and collaborative problem-solving. The study recommends integrating TPS into science instruction with appropriate scaffolding to enhance metacognitive development and promote deeper learning in complex subject areas.

Keywords: Think-Pair-Share, Instructional Strategy, Metacognitive Awareness, Organic Chemistry, Undergraduate Education

Introduction

The ability to reflect on one's thinking is a defining trait of effective learners, particularly within today's cognitively demanding academic environments. This self-regulatory process, known as metacognitive awareness, enables students not only to absorb content but also to monitor, control, and evaluate their learning strategies. Flavell (1979) defines metacognition as the capacity to regulate cognitive activities and skills that are integral to academic success. Its relevance is especially pronounced in disciplines like Organic Chemistry, where students must engage with abstract concepts and solve complex problems. Metacognitive skills promote such independent learning by helping students assess their needs, apply strategies, and improve understanding, crucial for mastering complex scientific concepts. However, cultivating metacognitive awareness remains a challenge in higher education, often hindered by a traditional emphasis on rote memorization rather than active cognitive engagement (Guenther & Abbott, 2024). This underscores the need for innovative pedagogies that not only enhance understanding but also build metacognitive capabilities. One such strategy

is the Think-Pair-Share (TPS) model, introduced by Lyman (1981), which encourages

students to reflect individually, discuss in pairs, and share ideas with the class. By combining reflection and peer interaction, TPS fosters deeper engagement and the development of metacognitive skills, making it particularly valuable in complex subjects like Organic Chemistry.

The TPS instructional strategy engages students in a structured, three-step process: individual reflection, paired discussions, and group sharing. This method encourages students to independently process information, collaborate with peers to refine their understanding, and share insights with the larger group. In doing so, it strengthens cognitive engagement, critical thinking, and metacognitive awareness, skills that are particularly beneficial in disciplines such as Organic Chemistry. By creating opportunities for students to regulate and monitor their cognitive strategies, TPS helps students develop the ability to reflect on their thinking and identify areas of improvement (Guenther & Abbott, 2024; Hizir et.al, 2022). Studies have shown that TPS improves student participation, engagement, and achievement across



disciplines such as mathematics, science, and medical education. It fosters deeper cognitive involvement and metacognitive growth. In Organic Chemistry, where learners face complex topics like molecular structures and reaction mechanisms, TPS offers a structured approach that supports both content mastery and metacognitive awareness. This collaborative and reflective learning environment helps students not only navigate complex material but also develop the self-regulation skills necessary for long-term academic success (Guenther & Abbott, 2024; Niyibizi et al., 2024).

Organic Chemistry is a fundamental subject in fields such as pharmaceuticals, materials science, and medicine. However, it is often perceived as abstract and difficult, posing challenges for students in mastering essential concepts. To overcome these challenges, instructional strategies that promote a deeper conceptual understanding are essential. One effective strategy is the development of metacognitive awareness, which enables students to monitor and regulate their cognitive processes. By cultivating these skills, students can more effectively tackle complex topics, such as reaction mechanisms and stereochemistry, and apply appropriate learning strategies to address gaps in their understanding. Metacognitive awareness not only enhances Organic Chemistry comprehension but also promotes cognitive flexibility and lifelong learning, both of which are critical for success in scientific fields (Dinsmore et al., 2021; Christian, 2025). The TPS model offers a promising solution for enhancing metacognitive awareness in Organic Chemistry. By promoting interactive, reflective, and collaborative learning, TPS helps students engage with the material in a way that fosters deeper cognitive processing and metacognitive development. Research from various fields suggests that TPS improves student participation, critical thinking, and metacognitive awareness. These benefits indicate that TPS can be an effective strategy for helping Organic Chemistry students navigate the complexities of the subject with greater clarity, confidence, and understanding.

Many undergraduate students often perceive Organic Chemistry as abstract and challenging, leading to difficulties in mastering essential concepts such as reaction mechanisms, molecular structures, and stereochemistry. This difficulty is compounded by traditional teaching methods that predominantly emphasize rote memorization rather than fostering deep conceptual understanding. As a result, students struggle

to develop critical thinking and problem-solving skills essential for mastering complex concepts and applying them in real-world contexts. One major concern is the lack of focus on students' metacognitive awareness, their ability to regulate and monitor their cognitive processes during learning. Without this ability, students may be unable to identify gaps in their understanding, adopt effective learning strategies, or engage in meaningful self-assessment. Although pedagogical approaches like TPS have shown potential across various disciplines, there remains limited exploration of how TPS can specifically enhance metacognitive awareness and academic performance in Organic Chemistry.

Despite the growing body of research that supports the effectiveness of the Think-Pair-Share (TPS) strategy in improving student learning outcomes, much of it has focused predominantly on academic performance and interest. For instance, Achufusi et al. (2024) and Usang et al. (2021) demonstrated that TPS enhances performance and interest in Chemistry classrooms. However, these studies did not investigate its potential in cultivating metacognitive awareness, a critical component of self-regulated learning. In spite of the increasing emphasis on active learning strategies in science education, limited attention has been given to how TPS influences students' ability to monitor, regulate, and reflect on their cognitive processes, particularly in Organic Chemistry. This study seeks to fill that gap by examining the effectiveness of TPS in promoting metacognitive awareness among undergraduate students. By integrating collaborative and reflective learning practices, the research aims to contribute to the broader discourse on innovative pedagogies that foster deeper learning and cognitive self-regulation.

Theoretical Framework

The theoretical framework for this study is based on two key theories: metacognitive theory and collaborative learning principles. Metacognitive theory, as outlined by Flavell (1979), focuses on the importance of self-regulation in learning. This involves students' ability to plan, monitor, and evaluate their cognitive processes. Metacognitive awareness plays a critical role in improving academic performance, especially in complex subjects like Organic Chemistry, by helping students become more effective in identifying gaps in understanding and employing appropriate learning strategies. The study also draws on collaborative learning principles, particularly those derived from Lev

Vygotsky's social constructivist theory. Vygotsky (1978) emphasized that learning is a social process and occurs most effectively through interaction with others. In collaborative learning environments, such as the Think-Pair-Share (TPS) model, students engage in reflective dialogue, share ideas, and solve problems together. This interaction not only enhances content mastery but also facilitates the development of metacognitive skills, as students learn to regulate their thinking through peer collaboration and feedback.

Research Questions

The following research questions guided the study:

1. What is the difference between the metacognitive awareness of students taught Organic Chemistry using the Think-Pair-Share instructional strategy and those taught using the lecture method?
2. How does the Think-Pair-Share instructional strategy enhance students' capacity to reflect on and regulate their learning processes in Organic Chemistry?

Hypothesis

The following null hypotheses were formulated to be tested at a significance level of 0.05:

H₀₁: There is no significant difference between the metacognitive awareness of students taught Organic Chemistry using the Think-Pair-Share instructional strategy and those taught using the lecture method.

Methods

This study employed a convergent parallel mixed-methods design to investigate the effectiveness of the Think-Pair-Share (TPS) instructional strategy. The quantitative component used a quasi-experimental pretest-posttest non-equivalent control group design to compare an experimental group taught using TPS with a control group receiving conventional lectures. Simultaneously, the qualitative component utilized semi-structured interviews to explore how TPS influenced students' reflective and regulatory learning processes. The target population consisted of 200-level pre-service Integrated Science students enrolled in Organic Chemistry courses. Two colleges were purposively selected based on their similar academic structure, such as shared curriculum, academic calendar, and assessment format, to ensure

comparability with a sample size of 45 students (30 in the experimental school and 15 in the control school). Intact classes were used to maintain natural classroom settings. A purposive subset of students from the experimental group participated in semi-structured interviews to provide feedback on their experiences. Two instruments were used for data collection: the Metacognitive Awareness Inventory (MAI), which was administered before and after to measure knowledge of cognition and regulation of cognition, and a semi-structured interview guide to explore students' experiences with TPS.

Procedure

The study commenced with the administration of the Metacognitive Awareness Inventory (MAI) to both groups to establish baseline levels of metacognitive awareness. Subsequently, the experimental group was exposed to a structured implementation of the Think-Pair-Share (TPS) instructional strategy, involving a sequence of individual reflection, peer interaction, and whole-class discussion. In contrast, the control group received instruction through conventional lecture-based methods. Upon completion of the instructional intervention, the MAI was re-administered to assess post-intervention changes in students' metacognitive awareness. Additionally, semi-structured interviews were conducted with participants in the experimental group to obtain qualitative insights into their learning processes and the influence of the TPS strategy on their metacognitive regulation. To address Research Question One, descriptive statistics involving mean ranks and mean rank differences were employed, while the corresponding hypothesis was tested using the Mann-Whitney U test. The decision rule was to reject the null hypothesis if $p \leq 0.05$. For Research Question Two, content analysis was utilized to identify recurring themes in students' reflections and to categorize their metacognitive and regulatory behaviors. The study adhered to ethical research standards. Informed consent was obtained from all participants, and measures were taken to ensure confidentiality and anonymity throughout the research process. Permission to conduct the study was obtained through an official letter to the Undergraduate Directors of the selected Colleges of Education before data collection.

Results and Findings

Data from the Metacognitive Awareness Inventory (MAI) and semi-structured interviews were analyzed to address the research questions and test the null hypotheses at a significance level of $P \leq 0.05$. This section outlines the findings related to the research questions and corresponding hypotheses.

Table 1:

Mean rank analysis on the Difference Between Experimental and Control Groups on Metacognitive Awareness

Group	N	Mean Rank	Sum of Ranks	Mean Rank Difference
Experimental	30	29.85	895.50	10.55
Control	15	19.30	139.50	

Table 1 shows that there is a difference in the Metacognitive Awareness of undergraduate students taught Organic Chemistry using the Think-Pair-Share Instructional Strategy compared to those taught with the lecture Method. The Experimental Group, taught with Think-Pair-Share, had a higher Mean Rank of 29.85, while the Control Group recorded a lower Mean Rank

of **19.30**. The Mean Rank difference of 10.55 indicates that students in the Experimental Group demonstrated greater metacognitive awareness. To determine the statistical significance of this observed difference, the associated hypothesis was tested using the Mann-Whitney U test at the 0.05 level of significance in Table 2.

Table 2:

Mann-Whitney statistical analysis on the difference between the Metacognitive-Awareness of Experimental and Control Groups

Variable	Groups	N	Mean Rank	Sum of Ranks	Mann-Whitney U	P-value	R
Metacognitive-Awareness	Experimental	30	29.85	895.50	19.50	0.001*	S
	Control	15	19.30	139.50			

***Significant at $p \leq 0.05$**

Table 2 reveals a statistically significant difference in metacognitive awareness between the two instructional groups, as indicated by a p-value of 0.001, which is less than the 0.05 significance level. This result confirms that the Think-Pair-Share strategy had a significant impact on students' metacognitive awareness compared to the lecture method. Consequently, the null hypothesis was rejected, affirming the effectiveness of the Think-Pair-Share

strategy in enhancing metacognitive awareness among undergraduate students.

The interview was a focus group; six groups were interviewed, with five participants in each group. Making a total of 30 participants, but only the responses of 3 participants from each group were documented. Content analysis of the interview is presented in Table 3.

Table 3:

Components	Metacognitive Statement	Non-metacognitive Statement
Awareness of Personal Learning Process	16 (88.8%)	2 (11.2%)
Reflective thinking and application of previous knowledge	15 (83.3%)	3 (16.7%)
Collaborative problem-solving ability	17 (94.4%)	1 (5.6%)
Discourse feature	14 (77.8%)	4 (22.8%)

The Think-Pair-Share (TPS) instructional strategy significantly enhanced students' capacity to reflect on and regulate their learning processes in Organic Chemistry, as evidenced by findings from a focus group interview with 18 participants. Content analysis revealed four key themes: awareness of personal learning processes, reflective thinking through the application of prior knowledge, collaborative problem-solving, and engagement in discourse. TPS encouraged students to consciously plan, monitor, and evaluate their learning, thereby fostering metacognitive awareness. It also boosted confidence, as participants reported increased willingness to share ideas, engage in peer discussions, and contribute meaningfully to group tasks. These metacognitive gains translated into improved academic performance, validating the effectiveness of TPS in promoting deeper learning and self-regulation in complex scientific contexts.

Discussion of Results

The findings of this study provide compelling evidence for the transformative potential of the Think-Pair-Share (TPS) instructional strategy in enhancing metacognitive awareness among undergraduate students in Organic Chemistry. In alignment with Flavell's (1979) metacognitive theory, students exposed to TPS demonstrated statistically and qualitatively significant improvements in their ability to monitor, regulate, and evaluate their cognitive processes, core components of effective learning. This improvement may be attributed to the structured nature of TPS, which actively engages students in reflection, discussion, and feedback processes that enhance self-awareness and metacognitive development. The statistically significant difference in metacognitive awareness between the experimental and control groups ($p = 0.001$) substantiates prior assertions by Guenther and Abbott (2024), who observed that conventional lecture-based instruction frequently lacks the interactive and reflective elements needed to foster deep cognitive engagement. The structured TPS model, comprising individual reflection, peer interaction, and group

dialogue, appears to provide a conducive environment for promoting such engagement, thereby facilitating the development of metacognitive skills.

The qualitative data reinforce these findings, echoing the work of Hizir et al. (2022), who documented the positive impact of collaborative learning strategies on student engagement and self-awareness. In the present study, over 88% of students demonstrated explicit awareness of their learning processes, while more than 94% exhibited enhanced collaborative problem-solving abilities. These findings further validate the theoretical underpinnings of social constructivism, particularly Vygotsky's (1978) emphasis on the value of socially mediated learning and reflective discourse in developing higher-order thinking. Thematic insights from focus group interviews also showed that TPS increased student confidence and conceptual understanding, especially in complex areas like reaction mechanisms and stereochemistry. These outcomes align with Niyibizi et al. (2024) and Dinsmore et al. (2021), who emphasized the role of metacognitive strategies in tackling abstract content. Christian (2023) similarly highlighted that metacognitive development promotes lifelong learning. Students in this study reported increased autonomy, suggesting TPS supports sustainable, self-regulated learning beyond a single course.

While the study affirms the effectiveness of the Think-Pair-Share (TPS) strategy in enhancing metacognitive awareness, caution is warranted in generalizing its impact. Critics argue that peer collaboration may not always yield productive learning, particularly in unstructured settings or for novice learners lacking foundational knowledge. Scholars such as Topping et al. (2017) and Kirschner et al. (2006) emphasize the need for instructor guidance and scaffolding to avoid reinforcing misconceptions and cognitive overload. Others, including Ozdem-Yilmaz & Bilican (2025) and Rohrer & Pashler (2012), question whether increased engagement translates into long-term knowledge retention. These concerns highlight three key considerations: the context-dependent nature of

TPS, the necessity of scaffolded support, and the uncertain durability of its effects. Therefore, TPS should be implemented thoughtfully, with further research needed to explore its long-term impact and optimal instructional conditions in science education.

Conclusion

This study demonstrates that the Think-Pair-Share (TPS) instructional strategy significantly enhances metacognitive awareness among undergraduate students studying Organic Chemistry. By fostering individual reflection, peer collaboration, and group discourse, TPS supports students in monitoring and regulating their learning processes, key elements of academic success in complex scientific subjects. Quantitative and qualitative findings confirm that TPS promotes deeper cognitive engagement and reflective thinking compared to traditional lecture methods. However, its effectiveness depends on factors such as instructional design, student preparedness, and continuous support. TPS should therefore be implemented with structured guidance. Future studies are encouraged to examine the long-term impact of TPS and optimize its use in science education.

Recommendation

Based on the findings of this study, it is recommended that the Think-Pair-Share (TPS) instructional strategy be integrated into science instruction with appropriate scaffolding to enhance metacognitive development and promote deeper learning in complex subject areas such as organic chemistry. Educators should be trained to implement TPS effectively, ensuring that students are guided through structured, reflective, and collaborative activities. Additionally, curriculum developers should consider integrating metacognitive skill-building activities into science education programs to promote self-regulated learning.

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