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Effectiveness of Team Assisted Individualization as a Teaching Approach

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Abstract

This study aimed to determine the effectiveness of using Team Assisted Individualization (TAI) as cooperative learning teaching approach to improve students' mathematical cognition. A quantitative research design via experimental design using one group pretest and post-test was employed. This only concentrated on specific students' processing speed and working memory and included 67 grade 9 students from a public school in the Philippines. The findings showed that the components of TAI were moderately effective under the placement test, effective under the teams, teaching group, student creative, team study, fact test and team score than whole class and highly effective under team recognition, Furthermore, there is a significant difference between the pre-test and post-test scores in each completed stage, and TAI approach is an effective strategy in improving the mathematical cognition of students. This study argues that TAI approach may be utilized in mathematics classrooms to improve the mathematical cognition of students. The gravity of the lessons or topics may be put into consideration to balance the learning and performances of students.

Keywords: *team-assisted individualization, mathematical cognition, teaching approach, cooperative learning, TAI*

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1. Introduction

Several studies in the Philippines had cited the concerning mathematics proficiency of secondary school students (i.e. Alcantara & Abanador, 2018; Pascual & San Pedro, 2018; Galigao, 2021; Ha, 2011; Magayon & Tan, 2016; Garinganao & Bearneza, 2021; Cabuquin & Abocejo, 2023; Flores, 2019; Santos et al., 2022; Guinocor et al., 2020; Pagaran et al., 2022; Igarashi & Suryadarma, 2023; Balanquit & Ballado, 2023; Lapinid et al., 2022; Callaman & Itaas, 2020; Pecjo, 2023; Cabrella & Junsay, 2019; Valderama, 2022). In fact, Bernardo (2020) also cited the Netherlands-based research that Filipinos fared worst among fifty-eight countries in an assessment for Grade 4 students. Similarly, the International Association for the Evaluation of Educational Achievement (IEA) reported that the Philippines scored 297 in math in the Trends in International Mathematics and Science Study (TIMSS) 2019, even lower than the 358 country's performance in 2003. According to Bernardo (2020), only 1 percent of Filipino students reached the high benchmark in mathematics, six percent in the intermediate benchmark and nineteen percent on the low benchmarks, which means they only have basic mathematical knowledge. While majority of the studies argue the engagement, motivation and capabilities of the students (Bacolod-Iglesia et al., 2021; Ha, 2011; Naungayan, 2022; Galabo et al., 2018; Abalde & Oco, 2023; Cordova & Tan, 2018; Anabo, 2023; Macaso & Dagohoy, 2022; Vergara, 2021; Magsino, 2021), several studies highlighted issues on the educational system (Aksan, 2021; Peteros et al., 2022; Launio, 2015), facilities and support system, and applicability of teaching methodologies (Gamit, 2023; Duzon, 2021; Estonanto et al., 2017; Ha, 2011; Cordova & Tan, 2018; Faustino, 2022; Booc et al., 2023; Delosa & Ong, 2021; de Vera et al., 2022).

According to Acharya (2017), students, teachers, and parents all play crucial roles in fostering a supportive environment conducive to improving mathematics pass rates. One of the key factors affecting mathematics learning highlighted by Muhamad et al. (2016) is the teachers' ability to connect new concepts to previously acquired knowledge. This has been intensified by the studies of Dong et al. (2020), Hailikari et al. (2008), and Alreshidi (2023) that teachers need to scaffold on students' prior learning. Teachers who always rely on traditional learning procedures encourage pupils to be lazy when it comes to mathematics learning. In this pedagogy, students are passive and just comprehend the concept; they do not understand the content and simply follow the procedures to solve the example questions supplied by the teacher to work on comparable practice questions with sample questions. In remaining the primary point of learning, students' capacity to grasp and portray mathematical concepts are being hampered (Smith & Smith, 2014).

Several authors suggest different teaching methodologies from individual, differentiated and contextualized approach (Oliva, 2023; Bal, 2023; Ahdhianto et al., 2020; Prast et al., 2018; Ngunjiri, 2022; Hidayati, 2020; Root et al., 2020; Fabian et al., 2018; Cannon, 2017; Lawson, 2018; Re et al., 2020; Dinglasan et al., 2023; Saguin et al., 2020; Strogilos et al., 2023; Bobis et al., 2021; Jackaria et al., 2019; Picat & Natividad, 2023; Aguhayon et al., 2023; Hackenberg et al., 2021) to group and collaborative (Hofmann & Mercer, 2016; Pons et al., 2014; Algani, 2021; Schwarz et al., 2021; Haftamu, 2017; Rico-Bautista et al., 2019; Sofroniou & Poutos, 2016; Golden, 2020;) and cooperative learning (Cortez et al., 2023; Entonado & García, 2003; Suryatin, 2020; Ningsih, 2019; Catarino et al., 2019; Jones, 2018; Furner, 2022; Chan & Idris, 2017; Klang et al., 2021; Kwame & Samuel, 2020; Anderson, 2003). These studies showed more positive outcomes using cooperative learning methodologies due to the shared tasks among students.

Cooperative learning is one approach to strengthening mathematical problem-solving and communication skills. This method teaches pupils to listen to and take conclusions from the viewpoints of others (Suherman, 2003). It also gives pupils from various backgrounds the opportunity to work collaboratively to complete shared projects and to gain mutual respect. This learning strategy improves cooperation and collaboration skills in addition to social skills (Thungki, 2015). According to Suprihatiningrum (2013), this sort of cooperative learning model stresses that individuals who do not grasp the content are the responsibility of other group members, so those who already understand must aid group members who do not. The cooperative learning technique will force students to collaborate to accomplish organized activities and discuss with one another, resulting in good learning exchanges.

One of the most effective cooperative learning strategy is the team-assisted individualization (TAI) that combines individualized instruction with cooperative learning elements to promote mathematics achievement in students. Majority of the studies that applied TAI in mathematics classroom showed improved student performance (i.e. Al Arsat et al., 2022; Tinungki et al., 2022; Tinungki, 2017; Sari et al., 2022). However, there is very limited studies on the effectiveness of TAI in the Philippine setting. Hence, this study addresses the literature gap in this area. This study aimed to determine the effectiveness of integrating a cooperative learning TAI in improving mathematical cognition of the Filipino junior high school students.

2. Literature review

2.1. Cooperative learning TAI

TAI is a pedagogical symphony where teamwork and individual learning harmonize in perfect cadence. Within this collaborative ecosystem, students embark on a journey of mutual support, guided by shared goals and the unwavering belief in the power of collective minds. Sencibaugh and Sencibaugh (2016) describe TAI the synergy between personal responsibility and collective achievement because it reveals the transformative potential of individual accountability within cooperative learning frameworks. On the other hand, Nievecela and Ortega-Auquilla (2019) emphasize the power of communicative language methods in fostering engagement and motivation of students.

As applied in mathematics, Pappas et al. (2018) stress the crucial role of translating mathematical problems into equations while Sophian (2017) accentuates the intricate interplay between working memory and numerical skills. These underscore the multifaceted nature of mathematical understanding, highlighting the cognitive underpinnings of problem-solving prowess. As the pursuit of academic excellence intensifies, the importance of effective pedagogical strategies cannot be overstated. Habibullah et al. (2020) emphasized the role of teachers in cultivating a learning environment that nurtures mathematical growth, empowering students to reach their full potential. Hence, cooperative learning is recommended in multiple studies.

The study of Kamal (2017) revealed the positive impact of TAI on social studies instruction while Arrahim et al. (2020) demonstrated its efficacy in enhancing arithmetic problem-solving abilities. These studies underscored the versatility of TAI, highlighting its potential to enrich diverse learning domains. On the other hand, Gumrowi (2016) explored the effectiveness of TAI, demonstrating its ability to deepen students' understanding of dynamic electricity. As applied in various disciplines, Riswanto (2016) concluded the positive influence of TAI on student interest and motivation.

In the field of mathematics, several notable studies proved the effectiveness of TAI. For example, Kusuma (2017) revealed superior performance of STAD cooperative learning TAI in mathematics instruction while Qomariyah and Isnani (2019) emphasized the increased performance in problem-solving skills, improved learner engagement, and achievement of mathematical learning outcomes. TAI was also found effective in promoting high-quality communication and reasoning (Lestari et al., 2019), and impacting students' self-confidence (Utami & Kusmayadi, 2017). However, Peng et al. (2018) pointed to the need for a deeper understanding of the cognitive underpinnings of Mathematical Difficulties (MD), suggesting the possibility of multiple subtypes and age-related variations. Similarly, these findings are not reflective of the nature and capabilities of the Filipino learners.

2.2. Theoretical framework

Two theories provided firm footing for this investigation: (a) the Zone of Proximal Development hypothesis; and (b) the notion of social interdependence.

Lev Vygotsky's theory of learning and development centered on the Zone of Proximal Development (ZPD). It is defined as the difference between a student's independent performance and their performance under the guidance of an adult or in collaboration with their peers. Vygotsky advocated for the cultivation of complex cognitive abilities in the classroom. Students' cognitive processes are tested, and new knowledge is acquired when scenarios are designed to challenge their critical thinking abilities. Everyone's actions are grounded in the knowledge they have acquired over time. Conversely, cooperative learning is grounded in the social interdependence idea. When people work together toward a common objective and are affected by the choices made by others, they are socially interdependent (Deutsch, 1962; Johnson & Johnson, 1989). Social interdependence can have both beneficial (cooperation) and negative (competition) outcomes (Deutsch, 1949).

When constructively interdependent people believe that their own success depends on the success of those with whom they are interdependent, there is positive interdependence. As a result, they work together, encouraging one another along the way. In contrast, negative interdependence occurs when people who are competitively linked believe that they can only succeed in their endeavors if the other people with whom they are related also fail. To combat this, educators should adopt a pedagogical approach that promotes student engagement (Irvin et al., 2020).

3. Methodology

A quantitative research was employed in this study through an experimental design via one group pretest and post-test. This research only concentrated on specific students' mathematical cognition, namely their processing speed and working memory with the topics under the third quarter based on the Most Essential Learning Competencies (MELC) in grade 9 mathematics as set by the Department of Education (DepEd) and the specific objectives of the lesson. The sample include 67 grade 9 students from ten (10) sections of classes selected through purposive sampling technique.

The study had two (2) phases. The first phase was the application of treatments on TAI, and the second phase was the conduct of survey where students rated the application of TAI. During the application of TAI, the teacher first conducted the pre-tests (placement exams), which the student answered and completed independently. After marking the pretests, the teacher determined the strengths and weaknesses of the students by examining their scores. After which, the class was divided into six (6) groups. The teacher briefly reviewed the topic, and then a worksheet was distributed to each group, with each member collaborating to answer the worksheet allotted to each group (teaching group). Instructions were given to each group, such as collaborating their ideas and assisting each member so that they could complete the tasks assigned to them, both individually and as a group (student creative). During the activities, both the teacher and the group members gave assistance and shared techniques or ideas on how to solve the problems (team study). Then, mid-tests (fact test) were given to the students individually. The groups who got highest scores were honored (team score rather than team recognition). Finally, following each lecture, post-test (whole class) was administered.

There are two sets of instruments used in this study: 1) pretests and posttests; and 2) survey questionnaire. The tests for working memory are composed of four (4) components, namely: reasoning, memory, problem-solving, and thinking skills. Each component included an eight-item test. On the other hand, the processing speed test has three (3) components, namely: completion time, accuracy, and efficiency. Evaluation sheets of pretests and posttests used adopted rubrics to determine the level of students' mathematical cognition in terms of working memory and processing speed. On the other hand, the survey questionnaire includes the eight (8) components of TAI, namely: placement test, teams, teaching group, student creative, team study, fact test, team score than team recognition, and whole class units. For each TAI component, three (3) questions on students' perceptions were asked that used a rating scale with 5 as strongly agree and 1 as strongly disagree.

Data in the form of test results (particularly in working memory) and in the form of an observation sheet (particularly for the test in processing speed) were subjected to statistical tests, specifically normality tests and correlation tests, to determine whether or not students' mathematical cognition abilities have improved. The percentage technique was used to determine observed student activities during the learning process. Meanwhile, to determine whether there are differences in the score's performance of each group, t-tests were used.

4. Findings and Discussion

Table 1 displays the performance of students on the assessment given in terms of working memory. The table presents the number of students and their corresponding percentages in each performance category for the working memory components such as reasoning, memory, problem-solving, and thinking skills. The performance categories are as follows: advanced, scored 7-8 (pre-test) and 28 or above (post-test); proficient, scored 5-6 (pre-test) and 20 or above (post-test); approaching, scored 3-4 (pre-test) and 15 or above (post-test); novice, scored 0-2 (pre-test) and 6 or above (post-test).

In Week 5, the performance of the students as to working memory under the advanced category shows that from 11 (16.4 %) students it rose to 28 (41.8 %) in reasoning, from 27 (16.4 %) down to 26 (38.8 %) students in memory, 26 ((38.8 %) students remain at 26 (38.8 %) in problem-solving, and from zero to three (4.5 %) students in thinking skills. Meanwhile, the performance of the student in the working memory components showed improvement from the pre-test to the post-test. A higher number of students demonstrated advanced and proficient working memory skills in the posttest, indicating an enhancement in their ability to process and retain information. Additionally, a decrease in the number of students classified as approaching and novice suggests progress in developing and refining their working memory capabilities. This improvement in working memory skills is a positive outcome and highlights the effectiveness of TAI in enhancing students' cognitive abilities. This merely supports the idea that the intervention was helpful in improving the mathematical cognition in terms of working memory.

Table 1

Level of performance of the students as to working memory

Score	Reasoning				Memory				Problem Solving				Thinking Skills				Interpretation
	Pretest		Posttest		Pretest		Posttest		Pretest		Posttest		Pretest		Posttest		
	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%	
	Proportion and Fundamental Theorems of Proportionality to Solve Problems Involving Proportions (Week 5)																
7-8	11	16.4	28	41.8	27	40.3	26	38.8	26	38.8	26	38.8	-	-	3	4.5	Advanced
5-6	19	28.4	32	47.8	17	25.4	28	41.8	20	29.9	20	29.9	10	14.9	28	41.8	Proficient
3-4	27	40.3	6	9	13	19.4	12	17.9	15	22.4	18	26.9	34	50.7	18	26.9	Approaching
0-2	10	14.9	1	1.5	10	14.9	1	1.5	6	9	3	4.5	23	34.3	18	26.9	Novice
	Similarity and Triangle Similarity Theorems (Weeks 6-7)																
7-8	9	13.4	28	42	7	10.4	26	38.8	2	3	26	38.8	8	11.9	3	4.5	Advanced
5-6	28	41.8	32	48	35	52.2	28	41.8	14	20.9	20	29.9	21	31.3	28	41.8	Proficient
3-4	23	34.3	6	9	22	32.8	12	17.9	30	44.8	18	26.9	25	37.3	18	26.9	Approaching
0-2	7	10.4	1	1	3	4.5	1	1.5	21	31.3	3	4.5	13	19.4	18	26.9	Novice
	Right Triangle Similarity Theorem and Pythagorean Theorem and Triangle Inequality Theorem (Week 8)																
7-8	30	44.8	9	13.4	3	4.5	19	28.4	-	-	-	-	-	-	-	-	Advanced
5-6	16	23.9	20	29.9	8	11.9	27	40.3	3	4.5	8	11.9	3	4.5	6	9	Proficient
3-4	12	17.9	28	41.8	19	28.4	16	23.9	17	25.4	22	32.8	25	37.3	29	43.3	Approaching
0-2	9	13.4	10	14.9	37	55.2	5	7.5	47	70.1	37	55.2	39	58.2	32	47.8	Novice

Legend:

above 80 %	Advanced Understanding
66-80%	Proficient
50-65	Approaching
Below 50 %	Novice

In Weeks 6-7, the performance of the students as to working memory under the advanced category shows that 9 (13.4 %) students rose to 28 (42 %) in reasoning, seven (10.4 %) to 26 (38.8 %) students in memory, 2 (3.0 %) to 26 (38.8 %) students in problem-solving, and eight (11.9) down to three (4.5 %) students in thinking skills. In addition, their performance on the working memory part of the test got better from the pretest to the posttest. The number of students with advanced working memory skills went up, while the number of approaching and approaching students went down. This shows that the students' ability to process and remember knowledge in their working memory got better as the intervention went on. The fact that the students did better on the test shows that TAI helped them improve their working memory skills.

In Week 8, there were 30 students (44.8 %) in the pretest and 9 (13.4 %) students in the posttest of reasoning while three (10.4 %) students in the pretest to 19 (28.4 %) students in the posttest of memory. No students reached advanced level in problem-solving, and in thinking skills. The students' responses to the working memory parts in week 8 showed a mixed pattern of results. While the number of advanced students went down, which shows that their working memory skills were getting worse, the number of competent and approaching students went up. This means that some students were able to keep or improve their working memory, while others' skills got worse. The number of students who are called "novices" stayed the same. The gravity of the lesson could have influenced the performance outcomes. However, the data suggest that there is variability in the working memory performance of the students, highlighting the need for targeted interventions and instructional approaches to enhance their working memory skills. Similarly, the results suggest further investigation on the factors that might have contributed to the students’ performance.

Table 2 displays the performance of students in processing speed. The table presents the number of students and their corresponding percentages in each performance category for the processing speed components such as completion time, accuracy, and efficiency. The performance categories are as follows: advanced, scored 4 with a completion time of 6 or below, accuracy of 18 or above, and efficiency of 17 or above; proficient, scored 3 with a completion time of 47 or above, accuracy of 22 or above, and efficiency of 38 or above; approaching, scored 2 with a completion time of 14 or above, accuracy of 18 or above, and efficiency of 12 or above; novice, scored 1 with a completion time of 9 or above.

Table 2

Students' performance in processing speed

Score	Completion Time		Accuracy		Efficiency		Interpretation
	f	%	F	%	F	%	
Proportion and Fundamental Theorems of Proportionality to Solve Problems Involving Proportions (Week 5)							
4	6	9	18	26.9	17	25.4	Advanced
3	47	70.1	22	32.8	38	56.7	Proficient
2	14	20.9	18	26.9	12	17.9	Approaching
1	-	-	9	13.4	-	-	Novice
Similarity and Triangle Similarity Theorems (Weeks 6-7)							
4	6	9	18	26.9	17	25.4	Advanced
3	47	70.1	22	32.8	38	56.7	Proficient
2	14	20.9	18	26.9	12	17.9	Approaching
1	-	-	9	13.4	-	-	Novice
Right Triangle Similarity Theorem and Pythagorean Theorem and Triangle Inequality Theorem (Week 8)							
4	45	67.2	-	-	9	13.4	Advanced
3	19	28.4	15	22.4	49	73.1	Proficient
2	3	4.5	27	40.3	9	13.4	Approaching
1	-	-	25	37.3	-	-	Novice

In week 5, there were six (9.0 %) students in the completion time, 18 (26.9 %) in the accuracy, and 17 (27.4 %) that were categorized under the advanced level. In addition, majority (47 or 70.1%) of the students achieved proficient level in the completion time, 22 (32.8%) students achieved proficient level in accuracy, and 38 (56.7 %) students achieved proficient performance in the efficiency. A significant number of students (20.9%) also demonstrated approaching performance in this component. No students were classified as novices in processing speed, indicating that all students were able to achieve at least a basic level of performance in this skill. The students' performance in the processing speed component in Week 5 was generally positive, with a large proportion of students achieving proficient performance and having no or less under the novice level. The data suggest that the students were able to complete the tasks within a reasonable time frame and with a satisfactory level of accuracy and efficiency. This indicates that they possess adequate processing speed skills to perform tasks that require quick and accurate mental processing.

In weeks 6-7, there were six (9.0 %) students in the completion time, 18 students (26.9 %) in the accuracy, and 17 students (27.4 %) in the efficiency that were categorized under the advanced level. In addition, 47 students achieved proficient level of performance in the completion time, 22 students in accuracy, and 38 in the efficiency. A significant number of students (20.9%) also demonstrated approaching performance in this component. No students were classified as novices in processing speed, indicating that all students were able to achieve at least a basic level of performance in this skill. Furthermore, the performance of the students in the working memory component showed improvement from the pretest to the posttest. The number of students demonstrating advanced working memory skills increased, while the number of students classified as approaching and novices decreased. This suggests that the students' ability to process and retain information in working memory improved over the course of the intervention. The TAI appears to have had a positive impact on the students' working memory skills, as evidenced by the improvement in their performance on the assessment. However, having no information on the performance of students in the novice category, it is challenging to draw a comprehensive conclusion regarding the overall performance level of all students in processing speed.

In week 8, there were 45 (67.2 %) students in the completion time, no students (0%) in the accuracy, and nine students (13.4 %) in the efficiency that were categorized under the advanced level. In addition, majority of the students achieved advanced level of performance in the completion time, 27 students achieved approaching level in accuracy, and 49 students achieved proficient level in the efficiency. Majority of students performed at an advanced level in processing speed during Week 8. This suggests that they were able to complete the tasks with a high level of efficiency. Additionally, a significant portion of students performed at a proficient level, indicating satisfactory accuracy and efficiency. However, there is a small proportion of students who were classified as approaching, indicating a need for improvement in processing speed skills. Overall, the data suggest that TAI has positively influenced students' processing speed abilities, with a majority reaching an advanced level in Week 8.

The majority of students exhibited advanced processing speed by week 8, implying they could execute tasks with exceptional efficiency. This remarkable improvement can be attributed to the implementation of cooperative learning strategies, which foster a dynamic learning environment where students collaborate to solve problems and enhance their understanding. Overall, the data gathered from the study strongly suggests that the cooperative learning approach employed has a positive influence on students' processing speed abilities.

Table 3

Test of difference between the pretest and posttest scores in working memory

Working Memory	Test	Mean	SD	t	df	Sig.	Interpretation
Proportion and Fundamental Theorems of Proportionality to Solve Problems Involving Proportions (Week 5)							
Reasoning	Pre-test	4.33	1.8	6.65	66	0.000	Significant
	Post-test	6.18	1.55				
Memory	Pre-test	5.37	2.22	2.104	66	0.039	Significant
	Post-test	5.93	1.6				
Problem Solving	Pre-test	5.52	2.01	0.261	66	0.795	Not Significant
	Post-test	5.6	1.88				
Thinking Skills	Pre-test	3.1	1.4	3.477	66	0.001	Significant
	Post-test	4.09	1.83				
Similarity and Triangle Similarity Theorems (Weeks 6-7)							
Reasoning	Pre-test	4.61	1.66	5.583	66	0.000	Significant
	Post-test	6.18	1.55				
Memory	Pre-test	4.88	1.44	4.131	66	0.000	Significant
	Post-test	5.93	1.6				
Problem Solving	Pre-test	3.34	1.7	8.12	66	0.000	Significant
	Post-test	5.6	1.88				
Thinking Skills	Pre-test	4.18	1.83	-0.287	66	0.775	Not Significant
	Post-test	4.09	1.83				
Right Triangle Similarity Theorem and Pythagorean Theorem and Triangle Inequality Theorem (Week 8)							
Reasoning	Pre-test	5.52	2.22	-3.956	66	0.000	Significant
	Post-test	4.31	1.84				
Memory	Pre-test	2.82	1.76	7.966	66	0.000	Significant
	Post-test	5.36	1.88				
Problem Solving	Pre-test	1.87	1.35	2.915	66	0.005	Significant
	Post-test	2.54	1.45				
Thinking Skills	Pre-test	2.16	1.31	2.195	66	0.032	Significant
	Post-test	2.66	1.31				

Level of significance: $p<0.05$ (significant)

Table 3 displays the test of difference between the performances of students in the three weeks. The data provided the comparisons between pretest and posttest scores in each completed stage of the working memory. It presents the mean, standard deviation (SD), t-value, degrees of freedom (df), and significance (Sig.) for each completed stage.

In week 5, the table clearly shows that there is a significant difference in the reasoning performances of students with a p-value of 0.000. This means that among the four components of working memory, reasoning skills of students was greatly enhanced by TAI approach.

Additionally, there were also significant differences in the memory skills with a p-value of 0.039 and thinking skills with a p-value of 0.001. However, there is no significant difference in problem-solving skills between the two assessments. These results were congruent with the study of Psycharis and Kalilia (2017) that the thinking skills of students who had the TAI intervention are much better.

In weeks 6 and 7, with a p-value of 0.000, there is a significant difference in how well students do with thinking. This means that of the four parts of working memory, students' thinking skills were most affected by the TAI. Similarly, there were significant changes in memory skills (p-value = 0.039) and thinking skills (p-value = 0.001) between the two groups. But there is no big difference between the two tests in how well they can solve problems.

In week 8, having both the p-value of 0.000, there is a significant difference in the reasoning performances of students and their memory skills. The p-value of 0.005 for problem-solving skills and a p-value of 0.032 in thinking skills signify that there are significant differences in the performances of students for both components of working memory. This justifies that longer exposure to TAI approach contributes to improving the mathematical cognition of students as to working memory. This is exactly the explanation of Navalinda et al. (2020) that longer exposure to TAI could improve how much people talk to each other, and how well people learn in cognitive ways.

The results of the test of significant difference uphold the previous studies on the positive effects of TAI in mathematics performance of the students (i.e. Al Arsat et al., 2022; Tinungki et al., 2022; Tinungki, 2017; Sari et al., 2022).

Table 4 shows the students’ evaluation of the TAI. It shows that among the components of TAI, team score than team recognition was highly effective with the highest mean of 4.54 and a standard deviation of 0.53. It was followed by team study which was effective and got a mean score of 4.39 and a standard deviation of 0.67. On the other hand, the placement test was moderately effective that was last in rank and got the lowest mean of 2.56 and a standard deviation of 0.27.

The results signify that students perceived that receiving score for group’s work and compliments or words of appreciation reward if their group can accomplish the tasks well for instance, being recognized as the best group or the outstanding group, was highly effective in improving their mathematical cognition. Meanwhile, the results also support the idea that collaboration in doing tasks in the mathematical classroom plays an important role in achieving learning.

Table 4

Students' evaluation of the TAI

TAI Components	Mean	SD	VI
Placement Test	2.56	0.27	Moderately Effective
Teams	4.23	0.53	Effective
Teaching Group	4.36	0.59	Effective
Student Creative	4.33	0.65	Effective
Team Study	4.39	0.67	Effective
Fact Test	3.54	0.50	Effective
Team scores than Team Recognition	4.54	0.53	Highly Effective
Whole Class Units	4.25	0.53	Effective
TAI Approach	**4.025**	**0.534**	**Effective**

Legend: 4.50-5.00 Highly Effective; 3.50-4.49 Effective; 2.50-3.49 Moderately Effective; 1.50-2.49 Slightly Effective; 1.00-1.49 Ineffective

The high perceived effectiveness of team score suggests that students value was being assessed and rewarded for their group's collective efforts. This aligns with the notion that cooperative learning can enhance motivation and engagement, as students feel a sense of shared responsibility for their team's success. Similarly, the high perceived effectiveness of team recognition highlights the importance of acknowledging and celebrating group achievements. Positive reinforcement through compliments and words of appreciation can boost students' morale and reinforce the value of collaboration in the learning process.

The relatively lower perceived effectiveness of the placement test suggests that students may not fully appreciate the role of individual assessment in the TAI approach. While individual assessments are important for tracking progress and identifying areas for improvement, they may not provide the same level of motivation and engagement as team-based assessment and recognition strategies. Overall, the implications of these findings underscore the importance of incorporating both team-based assessment and recognition strategies into cooperative learning approaches. These strategies can effectively foster collaboration, enhance motivation, and improve students' overall mathematical cognition. As Seemiller and Grace (2017) mentioned that while accustomed to independent learning, Generation Z students recognize the value of peer collaboration and actively seek opportunities to work with others, often after encountering difficulties on their own.

5. Conclusion

This study found a significant difference between the pretest and posttest scores for each completed stage of the three weeks of application of the intervention. Hence, the TAI approach is an effective strategy for improving students' mathematical cognition. As such, the TAI approach can be used in mathematics classrooms to improve the mathematical cognition of students. However, the difficulty level of the lessons or topics should be considered to ensure a balance between student learning and performance.

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