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Development of Learning Achievement and Motivation in Learning Mathematics of Grade 10 Students by Cooperative Learning

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Abstract

This research developed academic achievements to attain a pass rate of 70% and assessed student motivation in studying mathematics. The target group consisted of 40 Grade 10 students during the second term of the 2023 academic year at Sarakham Pittayakhom School under the Mahasarakham Secondary Educational Service Area Office. The tools used in this research included (1) a plan for organising 12 cooperative learning activities, (2) a mathematical achievement test on the topic of logarithmic functions, (3) a measure of mathematical learning motivation and (4) a diary record. Statistical data included percentages, means and standard deviations. Content analysis was employed as qualitative data and the action research model was divided into three cycles as Cycle 1 organized cooperative learning activities using the TAI technique with 40 students. Thirteen students (32.50%) passed the 70% criterion, while 27 (67.50%) did not. The average motivation score was 3.46, indicating moderate motivation among all the students. Cycle 2 implemented the STAD technique with the same group. Twenty two students (55%) passed the 70% criterion, while 18 (45%) did not. The average motivation score increased to 4.24, showing high motivation levels. Cycle 3 utilised the Think-Pair-Share. Thirty nine students (97.50%) passed the 70% criterion, with only one (2.50%) failing. The motivation score further increased to 4.46, suggesting very high motivation levels. After completing the operating circuits, almost all the students met the required academic achievement criterion in mathematics and exhibited high levels of study motivation.

Keywords: cooperative learning, TAI technique, STAD technique, Think Pair Share technique, mathematical achievement, motivation in learning mathematics

1. Introduction

Mathematical education in the Basic Education Curriculum 2008 (revised 2017) focuses on developing the skills necessary for learning in the 21st century. Emphasis is placed on understanding the application of key mathematical concepts, principles and theories to promote a positive attitude towards mathematics and an awareness of its value and importance (Institute for the Promotion of Teaching Science and Technology, 2017). Thus, learning management in the 21st century extends beyond merely educating students and also prepares them to be well-rounded individuals. This involves cultivating essential life skills alongside academic knowledge (Direk, 2017). The mathematical achievement test results for the 1st and 2nd terms of the 2022 academic year for Grade 10 students at Sarakham Pittayakhom School averaged 60.48% and 61.97% respectively and were below the specified 70% threshold (Sarakham Pittayakhom School, 2022). The assessment results indicated that the effectiveness of teaching was suboptimal. Students showed little interest in learning and had a low knowledge base. One potential cause of this issue was a lack of motivation to study. Therefore, teaching methods must be identified that enhance students' understanding of the lessons, increase their motivation to study and improve their academic achievements (Tisana, 2015). Motivation is a critical factor in learning and academic success. Even for students with high ability, lack of motivation can result in low achievement. Thus, motivation is an essential component of effective teaching (Surang, 2022). The researcher studied appropriate learning activity formats that increased students' learning motivation in mathematics and determined cooperative learning as an appropriate method. This allows students with different abilities to work together in groups with a mix of genders and abilities. The group members assign activities and rotate the duties among themselves. This helps to instill good morals and develop work and social skills (Pimpan, 2011). Organising cooperative learning activities involves utilising various techniques appropriate to the mathematical content to enhance academic achievements and increase students'

motivation to study mathematics. Cooperative learning allows students to collaborate in small groups with diverse abilities, fostering an environment where they can help and support each other. This interaction stimulates group learning, making students enthusiastic and happy to learn mathematics. Learning activities should be designed to encourage students to use various skills in problem-solving within groups. Cooperative learning activities effectively develop mathematical learning achievements and promote student motivation.

2. Literature Review

This research developed mathematical learning achievements to meet or exceed the 70% threshold and studied the motivation in learning mathematics among Grade 10 students by implementing cooperative learning activities.

2.1 Cooperative Learning

Johnson and Johnson (1991) defined cooperative learning as an educational approach that emphasises collaborative and supportive learning by organising students into small groups with diverse abilities, working together to achieve a common goal. Each group member shares responsibility both individually and collectively, using collaborative skills. The group's success depends on the participation of each member and promotes mutual success. Lakkhana (2014) explained that cooperative learning encourages students to work in small groups, typically consisting of 2–5 members with different abilities, to achieve the group's objectives. This research utilised the steps for organising cooperative learning activities outlined by Johnson and Johnson (1991) and Wattanaporn (1999) following the TAI, STAD and Think-Pair-Share techniques. These follow a similar five step process for organising learning activities as follows:

1) In the preparation stage, the teacher provides guidance on student roles. For TAI and STAD techniques, learning is divided into groups of five individuals with varying abilities (skilled, average, weak). For the Think-Pair-Share technique, high-ability students are paired with low-ability students, while middle-ability students are paired together. Activities are then assigned; the students are informed of the learning objectives for each lesson and practice the basic skills necessary for group activities.

2) Teaching stage: The teacher conducts teaching activities, starting with introducing the lesson content and recommending resources. The students in each group are assigned tasks to practice responsibility in sharing work among group members.

3) Group activity: Each student is assigned a role to fulfil within the group activity. The students collaborate and assist one another, exchanging opinions to ensure the completion of the assigned tasks. This fosters mutual reinforcement, support, encouragement and reliance among the group members.

4) Work inspection and testing: This stage involves checking whether the students have completely fulfilled their assigned duties. Emphasis is placed on examining both group and individual performance. Subsequently, an individual test is administered without help from peers to assess the students' understanding and performance. The results are then calculated to determine the average score of the group, which is also considered as the score of each student in the group.

5) Summary of the lesson and evaluation of group work: The teacher and students collaborate to summarise the lesson. If there are aspects that the students still do not understand, the teacher provides further explanation. Group work is also evaluated to identify the strengths and weaknesses as areas for improvement.

Cooperative learning entails students coming together in small groups of 2 to 5 where consideration is given to varying abilities. This promotes participatory learning and the development of group work skills, ensuring that each member and the group as a whole can succeed in achieving the set goals.

2.2 Cooperative Learning Following the TAI (Team Assisted Individualisation) Technique

Sawai (2001) used the TAI technique to foster cooperative learning. This approach provides students with the opportunity to engage in self-study activities tailored to their individual abilities, integrating collaborative learning with individualised instruction. Tisana (2007) further advocated the use of the TAI technique to review or explain lesson content. This involves facilitating discussions between the teacher and the students to enhance comprehension. Subsequently, the teacher assigns tasks or exercises for the students to complete, followed by a review session where the students address any areas of confusion. During testing, the teacher evaluates each student individually and combines the group scores to determine the average. The group achieving the highest score is rewarded accordingly.

2.3 Cooperative Learning Following the STAD (Student Teams-Achievement Division) Technique

Slavin (1995) posited that cooperative learning employing the STAD technique underscores the significance of collaborative group learning and mutual assistance by serving as a platform for social skills training, thereby

enabling students to recognise the value of cooperation through practical examples. Kulisara (2020) suggested that group members cooperate and exchange knowledge without engaging in competitive behaviours. Individual knowledge tests are administered and the scores are aggregated to form group scores. This approach facilitates the presentation of new content using various media formats. Students are grouped into teams of 4 to 5 with diverse abilities. Each group collectively studies the material presented by the teacher, followed by individual assessments. The scores of all group members are then combined to determine the group score, with the highest-scoring group being rewarded.

2.4 Cooperative Learning Following the Think-Pair-Share Technique

Tisana (2007) explained that cooperative learning using techniques such as Think-Pair-Share. This technique involves the teacher asking questions or setting problems for students, which can be presented as a worksheet or an exercise. Each student first thinks of their own answer and then pairs with a classmate to discuss their answers. Suwit and Orathai (2002) explained further that this form of teaching and learning activity allows students to work in groups. It starts with matching ideas, which are then discussed within the group to develop collective thinking. This activity focuses on students developing social behaviour along with gaining knowledge and understanding of the subject studied.

2.5 Mathematical Achievements

Wilson (1971) posited that academic achievement pertains to the intellectual aptitude for learning mathematics. He delineated four levels of desirable cognitive behaviour at the secondary school level as 1) knowledge, memory and calculation, 2) understanding, 3) application and 4) analysis. Good (1973) supplemented this by defining academic achievement as the acquisition of knowledge and the development of academic skills within the school environment. This can be assessed and quantified through standardised tests, teacher-created tests, or a combination of both methods. Considering these perspectives, academic achievement encompasses the knowledge and abilities of students that are enhanced through teaching, skills training and experiential learning. Evaluation can be conducted through standardised tests, teacher-administered tests, or a blend of both, encompassing various behavioural abilities such as memory and computation, understanding, application and analysis.

2.6 Motivation in Learning Mathematics

McClelland (1961) elucidated that motivation in learning denotes the inclination to work effectively, considering it a pivotal motivator for individuals. He posited that the motivation to study is a trait that can be cultivated and nurtured. Lakkhana (2011) also emphasised that motivation in learning manifests as a state arising from a student's eagerness to acquire knowledge, evidenced through behavioural engagement in various activities and leading to the development of academic and professional skills. In essence, motivation in studying represents the impetus that propels an individual's eagerness and readiness to engage in the process of acquiring knowledge, skills or understanding. It serves as the driving force for students' learning endeavours and its intensity may vary among individuals. Motivation to learn can be influenced by an array of factors including personal objectives, curiosity, interest in specific subjects and anticipation of rewards or recognition. It also entails the resilience to persevere through obstacles or setbacks encountered along the learning journey.

2.7 Action Research

The methodology of conducting action research was first outlined by Kemmis and McTaggart (1988). They utilised action research to enhance and refine the actual conditions of teaching and learning within educational settings, involving the following stages:

1) Planning: This initial stage involves identifying critical issues through discussions among the teachers, students, parents, or administrators. The aim is to thoroughly understand the problem by delineating its nature, determining whose problem it is and brainstorming potential solutions.

2) Action: This stage commences once a plan has been collaboratively prepared and the operational steps are set in motion. Stage 2 involves analysing problems and addressing unforeseen obstacles as they arise, necessitating a flexible plan that can be adapted by the researcher based on judicious decision-making. The focus remains on enacting changes as per the pre-defined procedures.

3) Observation: As the research activities unfold, it is crucial to monitor the process closely, noting any friction, obstacles, or disruptions that occur. Observations should be meticulously recorded, capturing changes and challenges in real-time conditions.

4) Reflection: The final stage involves a critical evaluation of the process, identifying problems or constraints that impede progress. The researcher and all stakeholders involved must scrutinise these issues, considering social and

environmental factors within the school. Discussions at this stage serve as a foundation for further improvement and future planning, ensuring that the action research contributes to meaningful developments in educational practice.

3. Method

This action research utilised the ideas of Kemmis and McTaggart (1988) to achieve two main objectives as developing mathematical achievement to meet the 70% criterion and studying the motivation in learning mathematics among 40 grade 10 students through the organisation of cooperative learning activities. The tools employed in the research comprised cooperative learning activity plans on logarithmic functions, totaling 12 plans over 13 hours, with each cycle being utilised to conduct four plans. The specifics of these cycles are outlined in Table 1.

Table 1. The learning activity plan

Cycle	Plan No.	Learning Content	Learning Activities	Time (hour)
1	1	Meaning of logarithm	TAI	1
	2	Graph of a logarithmic function	TAI	1
	3	Logarithm calculator	TAI	2
	4	Common logarithm	TAI	1
2	5	Antilogarithm	STAD	1
	6	Logarithm change of base	STAD	1
	7	Logarithmic equations	STAD	1
	8	Logarithmic inequality	STAD	1
3	9	Application of the logarithmic function (the amount of radioactive material decaying)	Think Pair Share	1
	10	Applications of logarithmic functions (growth in population)	Think Pair Share	1
	11	Application of the logarithmic function (volume)	Think Pair Share	1
	12	Applications of logarithmic functions (level of acidity–the baseness of the solution)	Think Pair Share	1

The mathematical achievement test on logarithmic functions consisted of three tests, each comprising 10 multiple choice questions (five options) that were administered after each of the three operational cycles. A test comprising 30 comprehensive multiple choice questions was also given to students on completion of the three operational cycles. The mathematical learning motivation measure involved 20 questions using a 5-level rating scale and a diary record was also used. The action research was structured in four steps as:

Step 1 Planning: The researcher identified and surveyed issues related to motivation and mathematical achievement among the grade 10 students. This included analysing the causes of problems, reviewing the relevant literature and developing research tools which comprised a cooperative learning activity plan, mathematical achievement tests, motivation measures for learning mathematics and a journal record. All the tools were quality-checked and evaluated by five experts.

Step 2 Action: The researcher collected data from the mathematical achievement tests and the motivation measure, which were then analysed quantitatively, while qualitative data gathered from journal entries were analysed using content analysis techniques.

Step 3 Observation: During the cooperative learning activities, the researcher observed student behaviour and group interactions. At the conclusion of each activity, the students were required to write in their journals hourly to reflect on their experiences. The effectiveness of the activities was assessed at the end of each cycle when students undertook the mathematical achievement tests for logarithmic functions, corresponding to sets 1, 2 and 3.

Step 4 Reflection: Utilising the data from the previous steps, the researcher refined and enhanced the learning activities to increase efficiency. Subsequently, all the collected data were discussed, analysed and summarised to synthesise the research findings and develop strategies for the next operational cycle.

4. Data Collection

The research data were collected through four steps:

Step 1: Preparing for learning activities before the learning activities commenced. The researcher briefed the students and reached an agreement on the organisation of cooperative learning activities using the TAI, STAD and Think-Pair-Share techniques.

Step 2: Implementing the learning management plan. The learning management plan was implemented in the second term of the 2023 academic year and included 12 plans divided into three action cycles. The first action cycle involved a cooperative learning plan using TAI (maps 1–4), the second used STAD (maps 5–8) and the third employed Think-Pair-Share (maps 9–12).

Step 3: Evaluation of learning activities At the end of each learning activity the students were required to write an hourly diary. At the conclusion of each operational cycle, students undertook a mathematical achievement test on logarithmic functions. The tests, sets 1–3, were multiple-choice with 5 options, each containing 10 questions. After completing the operational cycles, a comprehensive multiple-choice test with 30 questions was administered. A 20-question motivation test for learning mathematics was also conducted after each cycle. This step collected information to reflect on the outcomes of the activities and enhance teaching and learning in the subsequent cycles.

Step 4: Data analysis and reflection. The quantitative data obtained from the mathematical achievement tests and the motivation measure for learning mathematics were analysed, with qualitative data from the diary entries also examined to understand the experiences of the student target group. All the collected data were then discussed and analysed and conclusions were drawn to inform future teaching and learning strategies. This structure organised the information systematically, emphasising the specific actions of each step and the purpose of the research process.

5. Data Analysis

Data analysis was divided into two types 1) Quantitative data analysis involved using a mathematical achievement test and a measure of motivation in learning mathematics administered to students after completing each learning activity in each of the three operational cycles. Subsequently, at the conclusion of all three cycles, the researcher used a mathematical achievement test to measure the overall results. The scores were then analysed and compared to the predefined criterion of not less than 70%. 2) Qualitative data analysis utilised the information obtained from students' reflections on the results, recorded in journal forms during the organisation of mathematical learning activities, with data collected from diary entries analysed, interpreted and summarised into lecture formats at each operational cycle.

6. Results and Discussion

Twelve learning activities were divided into three action cycles and synthesised based on the examination of real issues observed in mathematics classrooms.

6.1 Mathematical Academic Achievement

The analysis of mathematical achievement among grade 10 students, facilitated by cooperative learning activities, was conducted at various stages including after each operational cycle and after completing all the cycles, with results detailed in Table 2.

Table 2. Mean scores of mathematical achievement across the three operational cycles and after completing each operating cycle

Comparison list	Cycle 1	Cycle 2	Cycle 3	After completing each operating cycle
Percentage of average score	55.50	63.00	73.00	73.83
Standard deviation	1.87	1.20	0.72	1.41
Number of students who passed the criterion	13	22	39	39
Percentage of students who passed the criterion	32.50	55.00	97.50	97.50

The data presented in Table 2 show that in Cycle 1 the average mathematical achievement score was 55.50%, with standard deviation of 1.87. Out of 40 students, 13 (32.50%) met the criterion. Cycle 2 showed improvement, with average mathematical achievement score of 63.00% and standard deviation of 1.20, with 22 students (55.00%) passing the criterion. Cycle 3 maintained this upward trend, with the students recording an average mathematical achievement score of 73.00% with standard deviation of 0.72. Remarkably, 39 students (97.50%) met the criterion. The average mathematical achievement score across all the cycles was 73.83% with standard deviation of 1.41. Despite this overall improvement in academic achievement, one student failed to meet the criterion, with this result attributed to observed behaviours such as late submission of work and poor engagement with teaching and learning activities. Implementation of the cooperative learning activities led to a significant improvement in mathematical learning achievements among the 40 Grade 10 students across each operational cycle, highlighting the effectiveness of action research and structured learning activities. This result underscored the importance of

employing reliable and systematic approaches to address specific challenges faced by students, as emphasised by Prasat (2013). The evaluation processes should also incorporate various assessment tools and direct observation to accurately gauge student performance in real-life contexts, as advocated by Eggen and Kauchak (2001).

6.2 Motivation in Learning Mathematics

The motivation in learning mathematics among grade 10 students was facilitated by the organisation of cooperative learning activities in each operational cycle. The assessment encompassed six aspects of motivation in learning mathematics, measured through a set of 20 questions administered after the completion of learning activities in each operational cycle. The study spanned three operational cycles, denoted as Cycle 1, Cycle 2 and Cycle 3 each comprising 20 questions, with the findings listed in Table 3.

Table 3. Motivation results in learning mathematics across the three operational cycles.

Topic	Motivation in learning mathematics								
	Cycle 1			Cycle 2			Cycle 3		
	$\bar{x}$	S. D.	Level	$\bar{x}$	S. D.	Level	$\bar{x}$	S. D.	Level
Courage	2.93	0.33	Average	3.95	0.06	High	4.23	0.03	High
Commitment	3.96	0.18	High	4.70	0.08	High*est*	4.90	0.08	High*est*
In terms of self-confidence	3.20	0.68	Average	4.14	0.46	High	4.32	0.47	High
In terms of knowledge to make a decision	3.79	0.19	High	4.31	0.14	High	4.54	0.21	High*est*
Anticipation skill	3.42	0.33	Average	4.13	0.15	High	4.35	0.16	High
Job selection skill	3.48	0.31	Average	4.22	0.12	High	4.44	0.05	High
Total	3.46	0.11	Average	4.24	0.08	High	4.46	0.12	High

Cycle 1 yielded a mean motivation in learning mathematics of 3.46, with standard deviation of 0.11 indicating a moderate level of motivation. In Cycle 2, the mean motivation in learning mathematics significantly increased to 4.24, with standard deviation of 0.08, reflecting a high level of motivation compared to Cycle 1. Continuing this positive trend, Cycle 3 recorded a mean motivation in learning mathematics of 4.46, with standard deviation of 0.12, signifying a further increase in motivation from the second cycle. The outcomes of organising learning activities in each operational cycle revealed that students actively engaged in collaborative work by supporting and assisting one another. They demonstrated effective interaction and assumed responsibility both individually and as a group, fostering a conducive and enjoyable learning environment. Students exhibited heightened enthusiasm, confidence and willingness to participate in various activities, ultimately achieving the predefined learning objectives. These findings aligned with Brier (2006), who emphasised the importance of activities that showcased the outcomes and significance of success in motivating students to exert effort and complete tasks. Such activities enhanced learning and performance skills and also instilled a sense of enjoyment and confidence in students, encouraging them to express their opinions openly and engage in active listening. These observations also resonated with the reference by Surang (2007) to Skinner's reinforcement theory, emphasising the pivotal role of reinforcement in stimulating students' intentions and efforts to seek knowledge.

7. Conclusions

To enhance academic achievement and motivation in learning mathematics among grade 10 students, cooperative learning activities were organised across three operational cycles. In the initial cycle, cooperative learning employing TAI was implemented, yielding unsatisfactory outcomes, with only 13 students (13.50%) meeting the criterion. Factors contributing to this outcome included dissatisfaction among students with group assignments and incomplete comprehension of the subject matter. To address the limitations identified in the first cycle, improvements were made in the organisation of learning activities. The second cycle utilised the STAD technique and the groups were reorganised to include a mix of abilities, fostering healthy competition within each group. Consequently, the number of students meeting the criterion increased to 22 (55%). This approach encouraged greater student engagement and motivation, driving participation in learning. Building upon the progress made in the second cycle, the third cycle addressed previous challenges by employing cooperative learning using the Think Pair Share technique. This further augmented student success, with 39 students (97.50%) meeting the criterion. Through peer support and collaboration, students gained confidence and actively contributed to each other's learning, with only one student failing to meet the criterion. Observations revealed instances of tardy assignment submissions and partial engagement in learning activities among students. However, overall, these interventions fostered an improved learning environment conducive to holistic learning experiences. By integrating enjoyable

and experiential learning approaches, classrooms became spaces where learning flourished, thereby benefitting all the students.

8. Recommendations

When implementing cooperative learning activities, opportunities for independent learning among students should be incorporated within designated steps. Clearly defining the time allocated for each activity segment, while allowing for some flexibility, optimised engagement and participation, while employing a variety of reinforcement strategies enhanced student enthusiasm and fostered a sense of pride, both individually and within the group.

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Authors' contributions

Chinanan Polklang was responsible for the study design, data collection, and drafting of the manuscript. Associate Professor Dr Yannapat Seehamongkon reviewed the research and provided advice to ensure its successful completion. Associate Professor Dr Prasart Nuangchalerm offered suggestions for publication.

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No additional data are available.

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