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TRAINING STUDENTS' COLLABORATIVE PROBLEM-SOLVING SKILLS: A CASE STUDY THROUGH 12TH GRADE MATH TEACHING AND LEARNING AT LAO PEOPLE'S DEMOCRATIC REPUBLIC

Speciality: THEORY AND METHODOLOGY OF MATHEMATICS TEACHING
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1. Vongsy Phommanichan, Tran Viet Cuong: Training student's collaborative problem-solving skills: A case study through 12th grade math teaching and learning at Lao People's Democratic Republic. Eur. Chem. Bull.2023,12 *(special Issue 1)* ISSN 2063-5346, tr 899-914.

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INTRODUCTION

1. Research rationale

1.1. Under the leadership of the Lao People's Revolutionary Party, the Lao People's Democratic Republic (LPDR) has rapidly emerged from underdevelopment and has significantly improved the living standards of its people.

1.2. In the teaching of Mathematics in LPDR, the 12th-grade Mathematics textbook curriculum is quite extensive relative to the available time, which impacts the teaching and problem-solving activities due to insufficient time.

1.3. Currently, the issue of research on cooperation and problem-solving (PS) has received the interest of many educational researchers and teachers, yielding specific research results. For instance:

- The work "Cooperation in Teaching Mathematics" by Hoàng Lê Minh in 2006.
- The doctoral dissertation "Developing Cooperative Teaching Skills for Secondary School Teachers" by Nguyễn Thành Kỉnh in 2010.
- The doctoral dissertation "Teaching Aimed at Developing Cooperative Learning Skills for Pedagogical University Students" by Nguyên Thị Thanh in 2013.
- The doctoral dissertation "Enhancing the Ability to Detect and Solve Problems for High School Students in Geometry Teaching" by Từ Đức Thảo in 2011.
- The doctoral dissertation "Assessing the Problem-Solving Ability of Students in 11th-grade Mathematics Teaching" by Phan Anh Tài in 2014.

However, until now, there has been no studies on training problem-solving cooperation skills for students in teaching 12th-grade Algebra and Calculus. Therefore, we have chosen the research topic of this dissertation: "Training Problem-Solving Cooperation Skills for Students in the Teaching Program of 12th-grade Algebra and Calculus in the Lao People's Democratic Republic."

2. Research Purpose

Based on the theoretical study of cooperative problem-solving skills and the practical application of these skills among 12th-grade students in the Lao People's Democratic Republic (LPDR), this research proposes several pedagogical measures to train cooperative problem-solving skills through the teaching of 12th-grade Algebra and Calculus in LPDR.

3. Research Aim and Objective

- Research Aim:

The cooperative problem-solving skills of students and the methods for training these skills through the teaching of 12th-grade Algebra and Calculus in LPDR.

- Research Objective:

The process of teaching 12th-grade Algebra and Calculus in LPDR.

4. Scientific Hypothesis

If the cooperative problem-solving skills are clearly defined and the proposed pedagogical measures are implemented reasonably, it is possible to train 12th-grade students in LPDR in these skills. This would contribute to improving the quality of 12th-grade Mathematics teaching in particular, and the overall quality of Mathematics education in LPDR.

5. Research Tasks

- Study cooperative skills, cooperative problem-solving skills, and the training of these skills through the teaching of Algebra and Calculus by examining related works from international authors, authors from the Socialist Republic of VieEXam, and LPDR that are closely related to the dissertation content.

- Investigate the current state of 12th-grade Mathematics teaching in LPDR, specifically focusing on the training of cooperative problem-solving skills through the teaching of 12th-grade Algebra and Calculus.

- Propose several pedagogical measures to train cooperative problem-solving skills through the teaching of 12th-grade Algebra and Calculus in LPDR.

- Conduct pedagogical experiments to verify the effectiveness and feasibility of the proposed pedagogical measures.

6. Research Methods

6.1. Theoretical Research Methods
6.2. Practical Research Methods
6.3. Pedagogical Experiment Methods
6.4. Expert Methods
6.5. Case Study Methods
6.6. Mathematical Statistics Methods

7. New Contributions of the Dissertation

- Theoretical Contributions:

+ Clarifying the concept of cooperative problem-solving skills, the components of these skills, and their manifestations in the teaching of 12th-grade Mathematics in the Lao People's Democratic Republic (LPDR).

+ Elucidating several components of cooperative problem-solving skills that are necessary and feasible to train in students during the teaching of 12th-grade Algebra and Calculus in LPDR.

- Practical Contributions:

Proposing several pedagogical measures to contribute to the training of cooperative problem-solving skills for students in the teaching of 12th-grade Algebra and Calculus in LPDR.

8. Arguments for Defense

- Cooperative problem-solving skills are crucial and need to be trained in students.

- Currently, many teachers in high schools in LPDR either do not focus on or face many difficulties in teaching 12th-grade Mathematics with the aim of training students in cooperative problem-solving skills.

- The feasibility and effectiveness of the proposed pedagogical measures for training cooperative problem-solving skills in students through the teaching of 12th-grade Algebra and Calculus in LPDR.

9. Layout of the Dissertation

In addition to the Introduction, Conclusion, and References, the dissertation consists of three chapters:

- Chapter 1: Theoretical and Practical Foundations.

- Chapter 2: Pedagogical Measures to Train Cooperative Problem-Solving Skills for Students in Teaching 12th-Grade Algebra and Calculus in LPDR.

- Chapter 3: Pedagogical Experiment.

CHAPTER 1: THEORETICAL AND PRACTICAL FOUNDATIONS

1.1. Overview of Research Related to the Topic

1.1.1. International Studies

1.1.2. Studies in Laos

1.1.3. General Assessment

From the above studies, it can be seen that cooperative problem-solving (CPS) is an essential skill for the 21st century. CPS has garnered significant attention from educational researchers worldwide. The research indicates that the structure of CPS is based on two components: cooperation and problem-solving. In VieEXam, CPS has initially attracted some educational researchers' attention. However, no author has yet studied CPS in the context of mathematics teaching. In the Lao People's Democratic Republic (LPDR), no research has addressed the issue of CPS

in general, or in mathematics teaching in particular. Therefore, the author's research results will contribute to the theoretical system of mathematics teaching in VieEXam and Laos, thereby aiding in the development of the educational system in LPDR.

1.2. Issues Regarding Cooperative Problem-Solving Skills

1.2.1. Concept of Skills

We agree with the definition provided by Đặng Thành Hưng: A skill is a form of action performed consciously based on knowledge about the task, motor abilities, and other psychological and biological conditions of the individual (the subject possessing the skill), such as needs, emotions, will, and personal positivity, to achieve results according to predetermined goals or criteria, or the level of success according to standards or regulations【30】.

1.2.2. Concept of Cooperative Problem-Solving

We define CPS as the coordinated actions and mutual assistance among group members to collectively solve problems posed to the entire group.

1.2.3. Concept of Cooperative Problem-Solving Skills

In this dissertation, we define CPS skills as the ability of an individual to effectively engage in a group's coordinated actions to jointly solve a common problem by sharing understanding and synthesizing the necessary knowledge and skills to arrive at an appropriate solution.

1.2.5. Criteria for Assessing Cooperative Problem-Solving Skills

In addition to selecting developmental levels, this study constructs evaluation metrics for cooperative problem-solving skills by integrating components of the CPS skills structure. The proposed evaluation criteria form a two-dimensional table. The first dimension represents four main criteria (collaborative problem identification, collaborative problem-solving planning, collaborative problem-solving execution, and collaborative evaluation and adjustment) with 10 measurement indices. The second dimension represents five developmental levels of the skills, arranged from low to high.

1.3. Cognitive Characteristics of 12th-Grade Students in the Lao People's Democratic Republic

1.4. Objectives and Requirements of Teaching 12th-Grade Mathematics in the Lao People's Democratic Republic

1.5. Opportunities and Methods for Training CPS Skills in the 12th-Grade Algebra and Calculus Curriculum in the Lao People's Democratic Republic

1.5.1. CPS Skill Components with Training Opportunities in the 12th-Grade Algebra and Calculus Curriculum in the Lao People's Democratic Republic

1.5.2. Several Directions for Training CPS Skills

1.5.3. Illustrative Examples

1.6. Survey on the Current State of CPS Skill Training through Teaching 12th-Grade Mathematics to Students in the Lao People's Democratic Republic

1.6.1. Survey Objectives

1.6.2. Survey Subjects and Content

1.6.2.1. Survey Subjects

1.6.2.2. Survey Content

1.6.3. Survey Methods and Result Processing

1.6.3.1. Survey Methods

1.6.3.2. Result Processing

1.6.4. Survey Results

1.6.4.1. For Teachers

1.6.4.2. For Students

1.6.4.3. Noted Results

a) For Teachers

- Teachers have a certain understanding of cooperative teaching, recognize the importance of cooperative teaching, and see the necessity of training CPS skills in the Mathematics teaching process.

- In practice, teachers pay little attention to training cooperative skills for students. They often use whole-class teaching methods and rarely employ group learning methods. Teachers typically focus on imparting knowledge, giving students few opportunities to solve problems independently or collaboratively.

- Teachers often teach quickly, require students to take extensive notes, provide unclear guidance, and are hesitant to innovate teaching methods. They rarely create opportunities for students to collaborate in learning and problem-solving, which negatively affects students' performance and interest in Mathematics.

- Most teachers in Laos have not been exposed to or practiced cooperative teaching methods, problem-solving teaching, or project-based teaching. They lack necessary understanding of students' CPS skills.

b) For Students

- Students are not frequently engaged in group work during Mathematics lessons. After learning new knowledge, they are not proficient in applying it to solve exercises or specific problems in daily

life, identifying errors in solutions or answers, or providing correct answers when solving problems with peers. They are not proficient in CPS with classmates when addressing problems posed by the teacher, despite recognizing the necessity of CPS skills in Mathematics learning.

- During Mathematics lessons, teachers often guide students through review of old material and highlight important content to remember. They show quick methods to solve problems, providing few opportunities for students to collaborate and develop problem-solving habits. Teachers typically lecture to the entire class, with students listening and taking notes, offering limited pair work opportunities.

- Additionally, factors such as study materials, class sizes, students' participation awareness, and study habits also impact learning. Students lack problem-solving skills and CPS skills.

CHAPTER 2: SOME MEASURES TO TRAIN COOPERATIVE PROBLEM-SOLVING SKILLS FOR STUDENTS IN TEACHING 12TH-GRADE ALGEBRA AND CALCULUS IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

2.1. Orientation for Developing Measures to Train Cooperative Problem-Solving Skills for Students in Teaching 12th-Grade Algebra and Calculus

Orientation 1: The measures must align with the comprehensive and fundamental educational reforms currently underway in the Lao People's Democratic Republic. This means the measures should clearly demonstrate cooperative skills to contribute to the formation and development of problem-solving abilities in students. They must align with the shift from merely imparting knowledge and skills to fostering the comprehensive development of the learner's qualities and competencies.

Orientation 2: The pedagogical measures must significantly help students effectively acquire mathematical knowledge and skills and complete their academic tasks. The measures should clearly convey the idea of CPS skills for students while enhancing their understanding of the application of mathematics in high school teaching.

Orientation 3: The CPS skill measures must be based on the content of high school Algebra and Calculus as outlined in the current textbooks and knowledge and skills standards. Specifically, the relevant Algebra and Calculus content must be identified to provide opportunities for developing CPS skills in students.

Orientation 4: The measures must target each component of the CPS skills for students. They should address the difficulties and obstacles students face during the teaching and learning process of Algebra and Calculus.

Orientation 5: The measures must be feasible, effective, easy to implement, and suitable for the practical conditions of teaching mathematics.

2.2. Some Measures to Train Cooperative Problem-Solving Skills for Students in Teaching 12th-Grade Algebra and Calculus in the Lao People's Democratic Republic

2.2.1. Measure 1: Exploiting Practical Situations in 12th-Grade Algebra and Calculus Teaching Activities to Train Cooperative Problem-Solving Skills for Students

a) Purpose of the Measure

The aim is to create a conducive environment that activates and promotes problem-solving activities in practical situations for students. This initial step helps form and develop the four component skills of cooperative problem-solving (CPS) for students:

1. Group identification of the problem.
2. Proposal of a common problem-solving plan by the group.
3. Joint implementation of the problem-solving plan within the group.
4. Group evaluation and adjustment.

b) Implementation of the Measure

To implement this measure, teachers should:

1. Integrate practical situations relevant to the students' lives into the teaching of Algebra and Calculus.
2. Design group activities that require students to collaboratively identify problems, propose solutions, execute plans, and evaluate outcomes.
3. Facilitate and guide group interactions to ensure effective cooperation and problem-solving.
4. Use formative assessments to monitor and provide feedback on students' cooperative and problem-solving skills.

c) Example: (Initial Formation and Development of the Four Component CPS Skills for Students)

Illustrative Example 1:

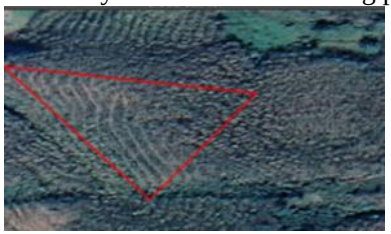
After teaching Lesson 4: Sequences, the teacher presents a problem for students to solve together. This activity trains students in group work, information searching, comparison, reading, and listening skills. It fosters analytical and creative thinking, agility, and the ability to recall information and confidently express personal knowledge. Additionally, it

helps students practice expressing real-world problems using mathematical language.

Problem 1:

Mr. Kham Pheng wants to buy a right-angled triangular plot of land. The owner mentions that he planted 2 rubber trees in the first row, more trees in the subsequent rows in the order of one additional tree per row. He planted 50 rows in total.

Can you determine how many trees Mr. Kham Pheng planted in total?



Step 1:

- The teacher divides the class into 6 groups by counting from 1 to 6, where students with the same number gather to form a group.
- Students begin counting sequentially and organize into groups, arranging desks and chairs, planning their work (reading materials, exchanging ideas, group discussions), assigning group tasks (group leader and members develop a plan and ensure everyone in the group knows and follows the deadlines, the secretary facilitates discussions and takes notes, sending them back to each group member, each member reads the material, solves group tasks according to their own ideas before collectively arranging the results, presenting their work for discussion within the group, each person listens to others without interrupting, takes notes on group discussions, and prepares to report when called upon by the teacher).
- The teacher guides students on group work by asking them to carefully read the problem-solving methods in the textbook.
- Students read the 12th-grade math textbook and watch the YouTube clip: ຄະນິດສາດ ມ7 [ບົດທີ 6 ການນຳໃຊ້ອັນດັບຈຳນວນ] ແກ້ບົດຝຶກຫັດ, ຄະນິດສາດ ມ7 [ບົດທີ 6 ການນຳໃຊ້ອັນດັບຈຳນວນ], then work together to complete the task within 30 minutes.

Desired Answer:

Problem 1:

Given $a_1 = 2$; $d = 1$; find S_{50} =?

Using the formula $S_n = \frac{n}{2}[2a_1 + (n-1)d] => S_{50} = \frac{50}{2}[2.2 +$

$(50-1)1] = 1325$

Mr. Kham Pheng planted a total of 1325 trees.

Step 2:

- The group secretary documents the group's discussion and solution (with teacher support if needed) on A4 paper.

- Each student in the group takes notes on the group's discussion and prepares to present in front of the class. The teacher may select 2-3 groups to report their results as the solutions and steps are similar.

- Groups with different approaches may also present.

- Other groups present their discussions, fostering CPS skills beyond their own group.

Step 3:

- The teacher and students review the class discussion, evaluating which group performed well (students identify effective activities and those needing improvement). This helps students determine what needs to continue or change, especially when using the formula $S_n = \frac{n}{2}[2a_1 + (n-1)d]$. This phase helps students practice listening skills, self-evaluation, and systematic knowledge consolidation, boosting their confidence.

- The teacher might ask additional questions such as, "If you want to verify whether the solution is correct, what should you check?" or "Who would like to explain this to the class?" At this point, some students might volunteer to explain.

This approach allows students to engage in practical problem-solving, enhances their cooperative skills, and prepares them for more complex challenges.

2.2.2. Approach 2: Applying cooperative teaching methods, problem-solving teaching, and project-based teaching to enhance the development of collaborative problem-solving skills for 12th-grade students in Algebra and Calculus classes.

a) Purpose of the approach:

The aim is to contribute to the development of the four components of collaborative problem-solving skills: (1) Group problem identification; (2) Proposal of a group problem-solving strategy; (3) Implementation of the problem-solving strategy within the group; (4) Evaluation and adjustment of the group's performance.

b) Implementation method:

c) Illustrative example:

Illustrative Example 3:

This activity is designed to review, consolidate, and deepen students' knowledge of complex numbers while enhancing their teamwork skills and information processing abilities, simultaneously developing their capacity for individual presentations in front of an audience.

- At the beginning of the class for the lesson on Chapter 4, new complex numbers, the teacher first stabilizes the class organization, checks the number of students, and may ask the class monitor to report for 5 minutes.

- Then, the teacher asks the students if anyone remembers how we solve the equation $ax^2 + bx + c = 0$? Can we find the roots of the equation in three possible cases? What are those cases? Today, we will learn how to find the roots in one of the three cases. You can review the quadratic formula in the math formulas book and we will learn and understand how to find the roots of the remaining case, which is called complex numbers, within 5 minutes.

- The teacher divides the students into 5 groups within 5 minutes: The teacher instructs them to start from the numbered tickets provided by the teacher, with students with the same number forming a group. Then, they arrange the desks and chairs together as guided by the teacher.

- Each group of students receives 3 study sheets, and within the group, students need to read carefully and understand the content. If there are any questions, they should ask the teacher immediately. Students must complete the tasks within 90 minutes.

- The teacher assigns group tasks, selecting a group leader, a secretary, and a presenter to report the group's work in front of the class. The group leader and members develop a group plan, establish group work rules, and allocate tasks to each member.

- Students listen carefully, take notes of the teacher's instructions, and form groups of 5 as directed by the teacher, then arrange the desks and chairs accordingly.

- Each group of students receives the study sheets (3 sheets).

Then, group members concentrate on discussing and improving the tasks within the study sheets for 40 minutes. Finally, the secretary of the group takes 20 minutes to record the group discussion for preparation before presenting it to the class.

At the end of the time allotted, the teacher organizes the students to present their work. The length of the presentation for each group should be reasonable, depending on the predicted length of the task, which will be written on the board.

Additionally, after each group presentation, if any group has a different opinion from the group that has presented, the teacher allows that group to present and exchange ideas in different places. Other groups can also present from different perspectives (10 minutes).

Then, the teacher and the groups summarize the discussions for each group that has presented. The teacher evaluates whether the students have followed and implemented the teamwork skills requirements provided by the teacher and whether they have understood the problem-solving methods before allowing the next group to present (20 minutes).

Table showing training experience

Numerical Order	Content	Method	training experience
1	Solution 2 Teaching cooperatively in small groups Example 3:	Work in small groups	- Propose solutions to solve common group problems - Solve problems together in groups

2.2.3. Approach 3: Developing collaborative problem-solving skills for students in online classes.

a) Purpose of the approach:

The purpose of this approach is to cultivate four essential skills for students during theoretical and exercise-based learning in online classes (students collaborate under conditions where they are not physically present face-to-face, meaning they are at a distance from each other).

b) Implementation method:

c) Illustrative example:

(Regarding the cultivation of the 4 collaborative problem-solving skills as a component for students in conditions where they are not physically present face-to-face, meaning they are at a distance from each other).

Illustrative Example 10:

Below, we present a problem assigned to a group for solving, as found in the 12th-grade math textbook, exercise 11, page 124, designed for group resolution. For example: A company wants to produce two types of products, A and B, with quantities x_1 and x_2 respectively, as follows: Product A takes 5 hours to produce each component, 3 hours to assemble, and 4 hours to pack. Product B takes 2 hours to produce each component, 12 hours to assemble, and 8 hours to pack. The company has only 40 hours to produce each component, 60 hours to assemble, and 48 hours to pack. The profit from each product A is 7000 kip, and from each product B is 21000 kip. Find the values of x_1 and x_2 to maximize the profit and

determine the maximum profit. To complete the task, students will be trained in the following two main parts:

Step 1:

- In class, the teacher divides students into 5 groups by counting sequentially from 1 to 5, with students with the same number forming a group.
- Students form their groups: Choosing a group leader, a secretary, assigning tasks, etc.
- The teacher creates 5 WhatsApp groups according to the student groups formed.
- Each group's secretary provides the teacher with their group's WhatsApp.
- Students are given 2 days to complete the group tasks at home, with the teacher guiding the class on how to work together in groups when physically apart.
- The group leader creates a separate WhatsApp group for their group.
- Each member of the group provides their WhatsApp to the group leader.
- The teacher gives each group study sheets and guides them on how to solve the problem using G. Polya's methods.
- Students receive their tasks and clearly note the teacher's instructions.
- The group leader, along with group members, plans the group's tasks and reports: everyone studies the problem at home, reads and studies the textbook, watches YouTube clips, solves the problem, writes it on A4 paper, takes a picture (or records a video) of the solution, and sends it to the group. In the afternoon, all group members gather online.

Step 2:

The teacher monitors group discussions. Through the group secretary, images are sent to the teacher's WhatsApp group, and the teacher sends them back to individual group members for note-taking. (At this stage, students practice the skill of applying knowledge internally within the subject of Mathematics, skills in mathematical knowledge, distinguishing, selecting, summarizing, understanding the relationships in the problem, and solving problems by formulating equations and inequalities).

Step 3:

- The teacher provides feedback and group discussions. If there are differences, the teacher may present the various approaches again.
- The teacher sends the group the answer to the problem.

Table showing training experience

Numerical Order	Content	Method	Training experience
1	Solution 3 Example 10:	Work in group	- The group identifies the problem - Propose methods to solve common group problems - Evaluate and adjust the whole group

2.2.4. Approach 4: Teaching 12th-grade Algebra and Calculus with an integrated approach to develop collaborative problem-solving skills for students.

a) Purpose of the approach:

The purpose of this approach is to help students actively engage in developing the four collaborative problem-solving skills, enabling them to understand and exchange ideas, motivate each other, manage tasks, resolve conflicts, and handle situations to implement the teaching plan effectively.

b) Implementation method:

The cultivation of collaborative problem-solving skills in teaching must proceed through the following steps:

Step 1: After organizing the class, the teacher selects students to represent groups in reporting the results of group work in turn according to the study sheet for the new lesson given by the teacher for students to study at home.

Step 2: The teacher begins teaching the new lesson clearly according to the textbook.

Step 3: At the end of the class, the teacher organizes new groups, provides guidance, and assigns study sheets for students to research at home.

Step 4: Students work on group assignments at home and send the research results to the teacher.

c) Illustrative example:

(regarding the development of the 4 collaborative problem-solving skills for students).

Illustrative Example 13: Developing students' collaborative problem-solving skills through teaching lesson 14 on reference statistics (12th-grade Mathematics textbook in Laos):

Step 1: Organize student reports; the teacher selects students to represent groups in presenting reports in sequence (study sheet 6), with desired answers as follows:

- A student representing the group presents:

+ The sample mean $\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$ is a detailed coefficient of the average population μ, where $\sum_{i=1}^{n} x_i$ is the total of n populations, and n is the population.

+ The sample variance $s^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}$, is an estimate detailed about the value transformation of the population variance σ^2.

+ The sample proportion $\hat{p} = \frac{x}{n}$ is a detailed tool for evaluating the population proportion p.

+ The population mean at the (1-α)100% confidence level is:

$$\bar{x} - \left|z_{\propto/2}\right| \frac{\sigma}{\sqrt{n}} < \mu < \bar{x} + \left|z_{\propto/2}\right| \frac{\sigma}{\sqrt{n}}$$

μ is the population mean

$\bar{x}$ is the sample mean

σ is the population standard deviation

σ^2 is the population variance

n is the sample size

$z_{\propto/2}$ is the z statistic value found in the table.

+ The population mean at the (1-α)100% confidence level is:

$$\bar{x} - t_{\propto/2}(n-1) \frac{s}{\sqrt{n}} < \mu < \bar{x} + t_{\propto/2}(n-1) \frac{s}{\sqrt{n}}$$

μ is the population mean

$\bar{x}$ is the sample mean

s is the sample standard deviation

s^2 is the sample variance

n is the sample size

$t_{\propto/2}$ is the t statistic value found in the table.

+ The population mean at the (1-α)100% confidence level is:

$$\bar{x} - \left|z_{\propto/2}\right| \frac{s}{\sqrt{n}} < \mu < \bar{x} + \left|z_{\propto/2}\right| \frac{s}{\sqrt{n}}$$

In this phase, students will develop reading skills, search and distinguish skills; share information, discussion skills, and summarize lessons, then the student groups can clearly understand the symbols, formulas, and apply them to solve specific problems as follows:

- A student representing the group presents:

Problem 1: According to the survey of 120 students, it is known that: There are people using SAMSUNG phones 90 people. Please predict the percentage of people who have used this type of phone?

Problem 2: The lifespan of a light bulb from a brand of goods, has a normal distribution with a standard deviation of 40. From 30 examples with an average usage time of 780 hours. Estimate the average lifespan of this light bulb brand, with a confidence level of 90%.

Problem 3: According to information provided, the weight of students at a school follows a normal distribution with a standard deviation of 4.5 kg. From a sample of 23 students showing that the average weight of students

is 65.5 kg. Estimate the average weight of students with a confidence level of 90%.

In this stage, students will be trained in reading skills, problem differentiation skills, and problem-solving skills simultaneously.

Step 2: The teacher begins to teach a new lesson.

Step 3: Organize a new group.

These stages allow students to be trained in group work skills.

Students study and solve problems at home according to the guidance of the teacher in class: Read the lesson content, watch clips to find the formulas and solve the problems the teacher has given and send them to their own group.

The secretary discusses, records the research results of the group, and sends them to the teacher and members of the group to prepare for presentation in front of the class.

Table showing training experience

Numerical Order	Content	Method	Training experience
1	Solution Example 13:	Group work and teacher-centered teaching	- Practice the skills of proposing common problem solving solutions for the group - Carry out problem solving together in the group - Evaluate and adjust the whole group

Chapter 3. PEDAGOGICAL EXPERIMENTATION

3.1. Purpose of the Experiment

3.2. Tasks of the Experiment

3.3. Organization of the Experiment

3.3.1. Subjects and Duration of the Experiment

3.3.2. Procedure of Conducting the Experiment

3.3.3. Content of Pedagogical Experimentation

3.3.4. Method of Evaluating the Results of Pedagogical Experimentation

3.4. Results of the Experiment

3.4.1. Evaluation in Terms of Qualitative Aspects

Table 3.1. Observational Results of Teacher's Performance Before and After the Experiment

Numerical Order	Content	Tools and activities	Number and percentage of teachers who used or did			
			Before		After	
			EX	CT	EX	CT
			N=3	N=3	N=3	N=3
1	Teachers prepare content	There are teaching plans and related documents	3 100%	3 100%	3 100%	3 100%
		There are attractive teaching	1	1	3	1

	and teaching materials	materials and uses for each activity.	33.33%	33.33%	100%	33.33%
		There are homework and answers	3	3	3	3
			100%	100%	100%	100%
2	Teaching methods and techniques	Presentation	3	3	3	3
			100%	100%	100%	100%
		Teaching raises problems	0	0	2	0
			0%	0%	66.66%	0%
		Q&A	0	0	0	0
			0%	0%	0%	0%
		Work in groups	0	0	3	0
			0%	0%	100%	0%
		Role play	0	0	1	0
			0%	0%	33.33%	0%
		Teaching discovery and problem solving	0	0	2	0
			0%	0%	66.66%	0%
		Apply situation theory	0	0	0	0
			0%	0%	0%	0%
		Teaching programming	0	0	3	0
			0%	0%	100%	0%
		Differentiated teaching	0	0	0	0
			0%	0%	0%	0%
		Tablecloth technique	0	0	0	0
			0%	0%	0%	0%
3	Use teaching aids	Audiovisual media	3	3	3	3
			100%	100%	100%	100%
		Programming means	0	0	0	0
			0%	0%	0%	0%
		Work with textbooks	3	3	3	3
			100%	100%	100%	100%
		Work with wall panels	0	0	0	0
			0%	0%	0%	0%
		Use information and communication technology as teaching tools	0	0	3	0
			0%	0%	100%	0%
4	Activities	Introduce the lesson objectives and results	0	0	0	0
			0%	0%	0%	0%
		Organize group teaching, instruct groups to cooperate and solve problems	0	0	3	0
			0%	0%	100%	0%
		Assign tasks to students appropriately	0	0	3	0
			0%	0%	100%	0%
		Remind students to identify, propose plans, make plans, and how to implement plans; Evaluate and adjust problem outcomes	0	0	3	0
			0%	0%	100%	0%
		Monitor, guide and support students	0	0	3	0
			0%	0%	100%	0%
		Organize appropriate group results reporting	0	0	3	0
			0%	0%	100%	0%
		Observe, evaluate, and adjust students' collaborative problem-solving behaviors	0	0	3	0
			0%	0%	100%	0%

From the results, it is observed that the topic preparation and teaching materials prepared by teachers for both the experimental (EX) and control groups (CT) were equivalent before the experiment. However, after the experiment, the experimental group teachers were able to use them with 100% attractiveness, while the control group teachers could only use them with 33.33% attractiveness.

Table 3.2. Observation Results of Student Group Regarding Collaborative Problem-Solving Skills and Attitudes in Learning Activities Before and After the Experiment

Numerical Order	Collaborative problem solving skills and attitudes	Level	Percentage of level			
			Before EX		After EX	
			EX	CT	EX	CT
1	The group identifies mathematical problems through exchanging opinions, sharing identification and analysis, and can agree on how to identify mathematical problems.	Unable to perform	70%	70%	60%	70%
		Performed Minimally	10%	10%	15%	10%
		Performed	15%	14%	17%	15%
		Performed well	5%	6%	8%	5%
		Performed proficiently	0%	0%	0%	0%
2	Propose solutions to solve common group problems: Know how to exchange opinions, learn, analyze information, connect with members, and at the same time know how to discuss to describe, analyze, and agree on options. Choose and evaluate solutions to mathematical problems.	Unable To Perform	70%	70%	40%	70%
		Performed Minimally	10%	13%	13%	13%
		Performed	10%	10%	15%	10%
		Performed Well	10%	7%	12%	7%
		Proficient	0%	0%	0%	0%
3	Solve problems together in the group: Discuss, share, unify members, assign and deploy plans, design solutions, know how to manage work, resolve conflicts and handle situations to solve problems. implement the plan.	Unable To Perform	60%	60%	45%	60%
		Performed Minimally	15%	17%	15%	15%
		Performed	15%	13%	20%	15%
		Performed Well	10%	10%	15%	10%
		Proficient	0%	0%	5%	0%
4	Evaluate and adjust the whole group: Know how to discuss, analyze, monitor progress, know how to evaluate the results of problem solving and cooperate to solve problems of group members, know how to discuss, analyze to give suggestions and Agree to adjust the results of problem solving	Unable To Perform	60%	62%	50%	62%
		Performed Minimally	15%	18%	20%	16%
		Performed	15%	10%	15%	12%
		Performed Well	10%	10%	15%	10%
		Proficient	0%	0%	0%	0%

5	Each person in the group participates fully and has high responsibility for group work	Unable To Perform	80%	80%	0%	80%
		Performed Minimally	10%	10%	50%	10%
		Performed	5%	5%	25%	5%
		Performed Well	5%	5%	15%	5%
		Proficient	0%	0%	10%	0%
6	Each member knows how to listen attentively when other members exchange ideas and help each other work as a team	Unable To Perform	55%	50%	40%	50%
		Performed Minimally	15%	15%	20%	20%
		Performed	15%	20%	20%	15%
		Performed Well	15%	15%	20%	15%
		Proficient	0%	0%	0%	0%
7	Members work together in unison, actively, and contribute to working proactively to achieve the group's common goals	Unable To Perform	70%	75%	40%	70%
		Performed Minimally	10%	10%	15%	10%
		Performed	10%	10%	20%	15%
		Performed Well	10%	5%	20%	5%
		Proficient	0%	0%	5%	0%
8	Members work together in unity, actively, and contribute to working proactively to achieve the group's common goals	Unable To Perform	70%	75%	45%	65%
		Performed Minimally	15%	15%	20%	20%
		Performed	10%	5%	20%	10%
		Performed Well	5%	5%	10%	5%
		Proficient	0%	0%	5%	0%

Based on the above results, it can be observed that the topic identification group before the experiment, both in the experimental and control groups, had an equivalent level of proficiency. However, after the experiment, the experimental group showed a more advanced level of proficiency in every aspect compared to the control group. This suggests that students in the experimental group have improved their skills in problem identification through the experiment.

Similarly, regarding the proposed problem-solving strategies by the math group before the experiment, both the experimental and control groups had similar levels of proficiency. However, after the experiment, it was evident that the experimental group made more suggestions compared to the control group. This indicates that students in the

experimental group were able to propose problem-solving strategies more effectively.

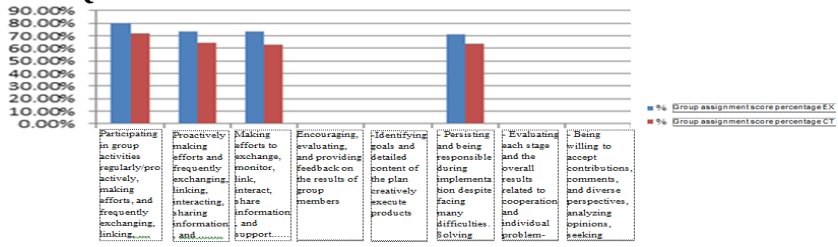
Furthermore, in terms of implementing problem-solving strategies within the math group before the experiment, both the experimental and control groups had comparable proficiency levels. However, after the experiment, it was observed that the experimental group had a higher percentage of students who knew how to implement and practice the skills compared to the control group.

Moreover, in evaluating and adjusting group performance before the experiment, both the experimental and control groups had relatively similar levels of proficiency. However, after the experiment, it was evident that the experimental group had a higher percentage of students who were trained in evaluating and adjusting group performance compared to the control group.

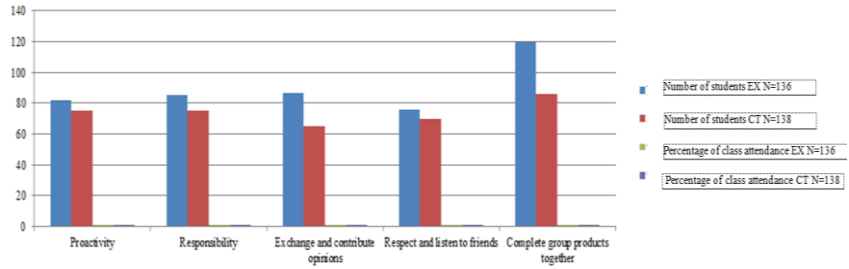
Regarding active listening and teamwork, it was observed that before the experiment, over 50% of students in both the experimental and control groups did not demonstrate active listening skills. However, after the experiment, the percentage of students in the experimental group who demonstrated active listening skills increased to over 60%, while the control group remained at 50%.

Additionally, in terms of encouraging and exchanging information with peers, before the experiment, over 70% of students in both the experimental and control groups showed similar levels of proficiency. However, after the experiment, it was evident that the experimental group had a higher percentage of students who actively encouraged and exchanged information with their peers compared to the control group.

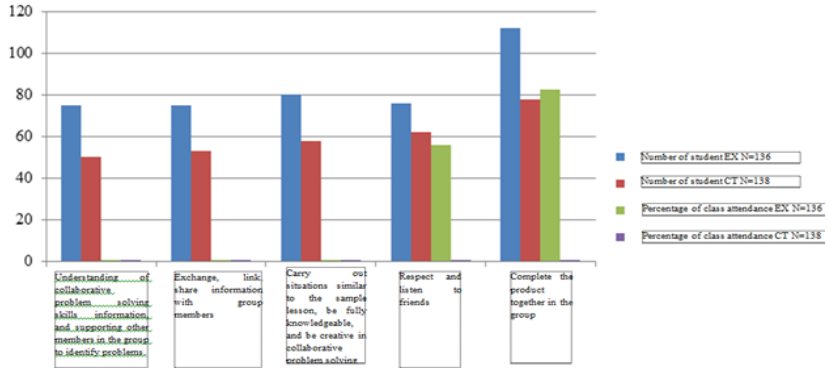
3.4.2. Quantitative Evaluation



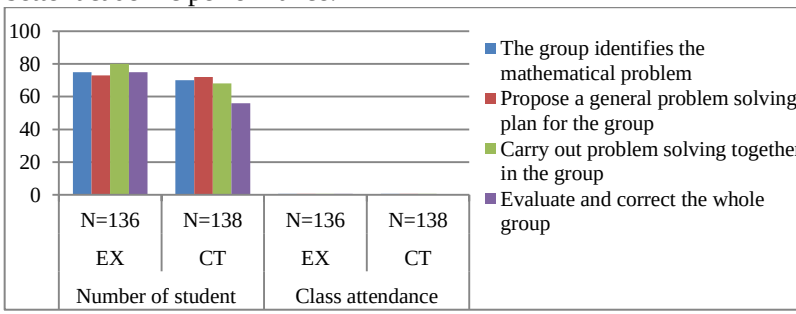
From the above, it is evident that when organizing group work, the student groups in the experimental class exhibited superior performance compared to those in the control class, indicating that the teaching methodology employed in the experimental class effectively engaged and yielded better results among students than in the control class.



Based on the results, it can be concluded that students in the experimental class demonstrated a significantly better understanding of teamwork activities compared to students in the control class.

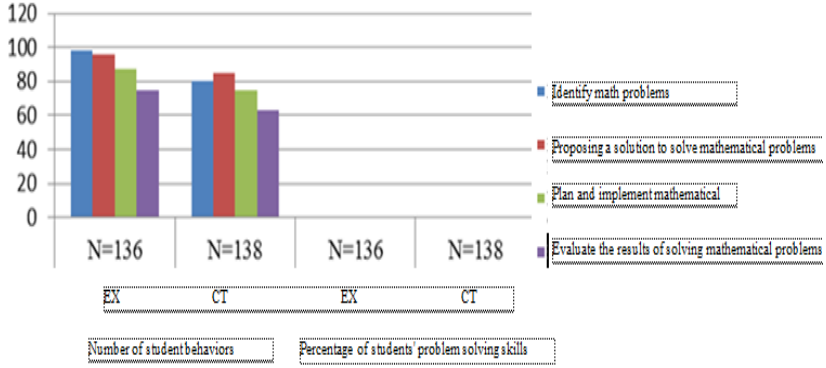


The findings suggest that students in the experimental class displayed more pronounced manifestations of collaborative skills than those in the control class through various group activities, thereby contributing to better academic performance.

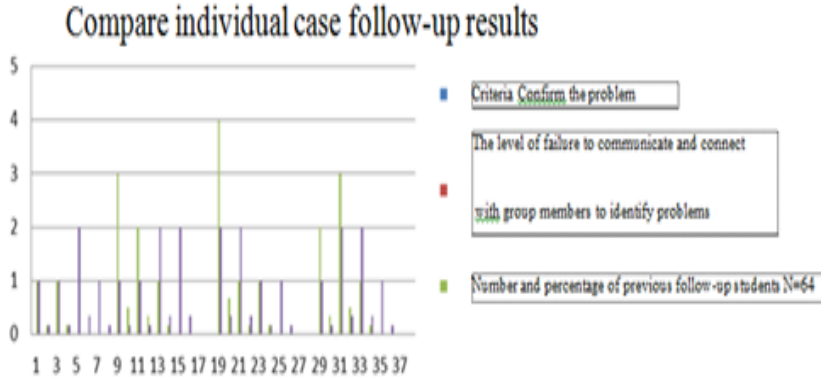


The results also indicate that students in the experimental class were trained in all four aspects of collaborative skills to a greater extent than

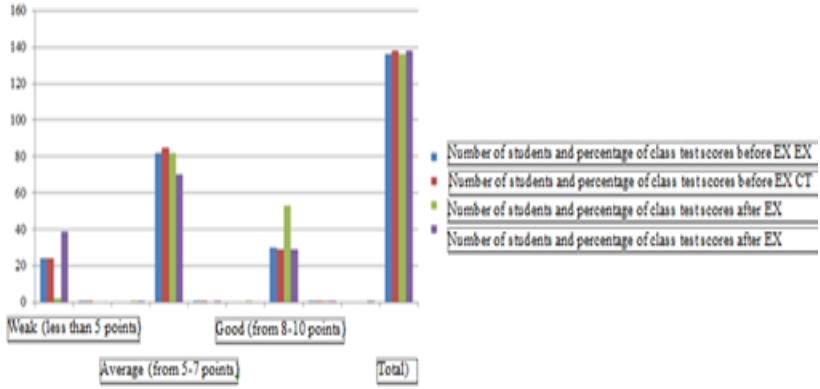
those in the control class, who did not receive the same level of training in collaborative skills.



The behaviors of students in terms of collaborative skills when solving problems together resulted in better problem-solving outcomes in the experimental class compared to the control class, regardless of their physical proximity during the activities.



The data reveals that the teamwork criterion of problem identification in mathematics showed a higher proportion of students in the experimental class reaching various proficiency levels post-intervention compared to pre-intervention, suggesting that students in the experimental class exposed to the new methodology proposed gained more knowledge and experience.



Analysis of the examination results indicates that the proportion of students achieving different proficiency levels pre-intervention in both the experimental and control classes was similar. However, post-intervention, the difference in the proportion of students achieving different proficiency levels between the two classes was significant, with a higher proportion of students in the experimental class achieving higher proficiency levels. Moreover, comparing pre- and post-intervention data, it is evident that the number of students classified as weak or average decreased in both classes, while the number of proficient students increased. Although the difference in the proportion of proficient students between the two classes was not substantial, it can be affirmed that the effectiveness of the method in fostering collaborative skills has the potential to enhance students' learning outcomes compared to traditional teaching methods.

3.4.3. Results of the Survey on the Effectiveness, Rationality, and Feasibility of Measures

Table 3.10. Results of the Evaluation of the Necessity of Measures

Evaluation criteria	Amount /Percentage	Level				Medium score
		Very necessary	Necessary	Barely Necessary	Unnecessary	
BP1	Amount	5	10	2	0	3.17
	Percentage	29.41%	58.82%	11.76%	0%	
BP2	Amount	4	11	1	1	3.05
	Percentage	23.52%	64.70%	5.88%	5.88%	
BP3	Amount	5	11	1	0	3.23
	Percentage	29.41%	64.70%	5.88%	0%	
BP4	Amount	5	9	2	1	3.05
	Percentage	29.41%	52.94%	11.76%	5.88%	

Table 3.11. Opinion results evaluate the reasonableness of the measures

Evaluation criteria	Amount /Percentage	Level				Medium score
		Very Reasonable	Reasonable	Barely Reasonable	Unreasonable	
BP1	Amount	3	13	0	1	3.05
	Percentage	17.64%	76.47%	0%	5.88%	
BP2	Amount	5	9	2	1	3.05
	Percentage	29.41%	52.94%	11.76%	5.88%	
BP3	Amount	3	11	2	1	2.94
	Percentage	17.64%	64.70%	11.76%	5.88%	
BP4	Amount	2	11	2	2	2.76
	Percentage	11.76%	64.70%	11.76%	11.76%	

Table 3.12. Opinion results evaluate the feasibility of the measures

Evaluation criteria	Amount /Percentage	Level				Medium score
		Very Feasible	Feasible	Barely Feasible	Not Feasible	
BP1	Amount	7	8	1	1	3.23
	Percentage	41.17%	47.05%	5.88%	5.88%	
BP2	Amount	5	10	2	0	3.17
	Percentage	29.41%	58.82%	%	0%	
BP3	Amount	5	11	0	1	3.17
	Percentage	29.41%	64.70%	%	5.88%	
BP4	Amount	4	10	1	2	2.94
	Percentage	23.52%	58.82%	5.88%	11.76%	

Based on the statistical data presented in Tables 3.10, 3.11, and 3.12, it can be observed that the average scores falling within the range of $2.60 \leq \overline{x} \leq 3.39$ indicate that the proposed measures in the dissertation are necessary/rational/feasible for teaching and fostering cooperative problem-solving skills in mathematics in secondary schools in the Lao PDR.

CONCLUSION

During the research process of this dissertation, the author has obtained the following main results:

Regarding theoretical aspects:

- Contributed to affirming that Cooperative Problem-Solving Skills (CPSS) is an important skill that needs to be cultivated for students.

- Clarified the concepts of skills and cooperative problem-solving. From there, proposed the concept of CPSS, determined the structure of CPSS consisting of 4 components and the manifestations of students' CPSS, designed a system of criteria to evaluate these components.

- Determined the structure of CPSS consisting of 4 components: Group problem identification; Proposal of a common problem-solving strategy by the group; Cooperative problem-solving within the group; Evaluation and adjustment of the entire group. And the manifestations of CPSS of students in teaching mathematics to 12th-grade students in the Lao PDR.

Regarding practical aspects:

- Proposed 4 measures to train cooperative problem-solving skills for students through teaching Algebra and Analysis for 12th graders: Measure 1 aimed to create a favorable environment to activate and promote CPSS activities in real situations for students, initially forming and developing 4 CPSS components for students; Measure 2 aimed to contribute to training the 4 components of CPSS; Measure 3 aimed to contribute to training students in 4 component skills in the process of teaching both theory and exercises in online classes (students cooperate in conditions where they are not face-to-face, meaning they are distant from each other); Measure 4 aimed to help students actively practice training the 4 CPSS components, helping students understand and exchange links, encourage, manage work, resolve conflicts, handle situations to implement teaching plans.

- Organized experimental teaching to illustrate the feasibility and effectiveness of the proposed pedagogical measures.

Based on the achieved results, it can be affirmed that the research objectives have been achieved, the research tasks have been completed, and the scientific hypothesis is acceptable. The research of the dissertation has affirmed that the measures for training cooperative problem-solving skills for students through teaching Algebra and Analysis for 12th graders are effective and feasible, improving the quality of mathematics learning for students. This is an initial research direction contributing to the integration of education worldwide.