Developing Collaborative Skills for High School Students in Lao People's Democratic Republic in Solving Mathematical Problems

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Abstracts: The research article aims to develop collaborative problem-solving skills in high school mathematics education within the Lao People's Democratic Republic. It introduces five methods that enhance collaboration in solving mathematical problems, offering comprehensive descriptions and implementation strategies. The research equips teachers with effective strategies and creates opportunities for students to engage in collaborative problem-solving. However, the study is limited by its narrow focus on the specific context of the Lao People's Democratic Republic. Future research should explore the adaptability of these methods in diverse cultural and educational settings. To further advance collaborative problem-solving in mathematics education, future research should investigate the effectiveness of these methods across various grade levels and cultural contexts.

Keywords: Cooperation skills, Problem solving, Group activities, Teaching mathematics.

1. INTRODUCTION

The article discusses the significance of promoting collaborative learning among high school students in Laos to enhance their problem-solving abilities in mathematics. The authors contend that traditional teaching methods tend to prioritize individual performance over collaborative work and fail to foster students' capacities to work together and communicate effectively. Consequently, students may struggle to apply mathematical concepts to real-world problems and miss out on opportunities for social and intellectual development.

To substantiate their assertions, the authors draw upon a range of research in the field of education, including Vygotsky's sociocultural theory of learning and various studies on the advantages of collaborative learning in mathematics education. For instance, the authors cite Johnson and Johnson's (1994) argument that collaborative learning can lead to better problem-solving skills, increased engagement, and greater persistence in students. Similarly, the authors reference Hertz-Lazarowitz and Miller's (1992) findings that students who engaged in collaborative problem-solving demonstrated higher levels of critical thinking and creativity.

Overall, the article underscores the need for educators to integrate collaborative learning approaches into their mathematics curricula to better equip students for success in both academic and real-world settings. By emphasizing collaborative skills, educators can help students develop not only their mathematical abilities but also their interpersonal skills, including communication, teamwork, and leadership.

The purpose of the research is to highlight the significance of promoting collaborative learning among high school students in Laos and to develop strategies that enhance their problem-solving abilities in mathematics through collaborative approaches. Additionally, the study aims to demonstrate the advantages of collaborative learning over traditional teaching methods and to encourage educators to integrate collaborative learning into their mathematics curricula to better equip students for academic and real-world success.

1.1. The importance of the study

Collaboration is an essential skill in today's interconnected and interdependent world. Developing collaborative skills in students can not only enhance their problem-solving abilities but also prepare them for success in their future careers. In particular, mathematics is a subject that requires strong collaborative skills, as problem-solving often involves working in teams.

The study "Developing collaborative skills for Lao high school students in solving mathematical problems" is of significant importance as it focuses on enhancing collaboration skills specifically in the context of mathematics education for Lao high school students. The study explores the effectiveness of a collaborative learning approach in improving students' mathematical problem-solving abilities and their attitudes towards mathematics.

The findings of the study suggest that collaborative learning can be an effective approach to improving students' mathematical abilities and attitudes towards the subject. By working together in groups, students were able to share their ideas and perspectives, identify and correct their mistakes, and develop a deeper understanding of mathematical concepts.

The implications of this study are far-reaching, as it highlights the importance of incorporating collaborative learning into mathematics education in Lao high schools. By promoting collaboration, teachers can help students develop important skills that will benefit them not only in mathematics but also in other areas of their lives.

In conclusion, the study "Developing collaborative skills for Lao high school students in solving mathematical problems" emphasizes the importance of collaboration in mathematics education and provides valuable insights into how collaboration can be effectively integrated into the curriculum. This research can be used as a basis for developing strategies to enhance collaboration skills in students and improve their overall academic performance.

2. RESEARCH METHODOLOGY

The article describes a study that implemented a collaborative learning approach in teaching mathematics to high school students in Laos. The research methodology involved the following:

Defining the research objectives: The research team first identifies the main objective of the study, which is to develop collaborative skills for Lao high school students in solving mathematical problems. This objective serves as the core to determine the research methodology and process.

Literature review and previous research: The research team conducts a literature review on theories related to the development of collaborative skills and problem-solving in mathematics. They examine previous studies related to this issue and explore the methods and techniques applied to cultivate collaborative skills in mathematics education.

Constructing a theoretical framework: Based on the gathered knowledge, the research team develops a theoretical framework for developing collaborative skills in solving mathematical problems for Lao high school students. This framework includes crucial factors such as creating opportunities for group work, encouraging exchange of ideas and strategies, promoting knowledge and resource sharing, and fostering a supportive and cohesive spirit.

Applying teaching examples: The research team utilizes teaching examples to illustrate the application of the theoretical framework in actual teaching scenarios. These examples are designed to require students to work collaboratively in solving mathematical problems. The research team observes and records the students' interactions and collaborations during problem-solving, and subsequently analyzes the results and draws important insights and lessons.

Evaluation and result analysis: Lastly, the research team evaluates and analyzes the outcomes obtained from applying the collaborative skills development methodology in solving mathematical problems for Lao high school students. They assess the effectiveness of the methodology and propose improvements and recommendations for enhancing collaborative skills in mathematics education for Lao students.

Overall, this research methodology provides a theoretical foundation and research process for developing collaborative skills in solving mathematical problems for Lao high school students, contributing to the improvement of the quality of mathematics education in Laos.

Conducted a survey with 38 teachers and 372 students. The survey took place during the academic year 2021-2022

3. THEORETICAL FRAMEWORK

3.1. Collaboration in Education

Cooperation in education is a widely recognized concept that plays a significant role in enhancing learning outcomes and improving educational quality. At its core, cooperation refers to individuals or groups working together towards a common goal, with the aim of achieving better outcomes than they could if they were working alone.

According to Johnson and Johnson (1994), cooperation in education is based on the social interdependence theory, which emphasizes the idea that people's behavior and performance are shaped by their social context. This theory suggests that positive interdependence, where individuals perceive that they need to cooperate with each other to achieve a common goal, leads to greater cooperation and more positive outcomes.

In the context of education, cooperation can take many forms, including collaborative learning, cooperative teaching, and cooperative assessment. Collaborative learning involves students working together to complete a task or solve a problem, while cooperative teaching refers to teachers working together to plan, implement and evaluate a lesson or curriculum. Cooperative assessment involves students working together to assess their own and each other's learning progress.

Research has shown that cooperation in education has numerous benefits, including improving academic achievement, enhancing social skills and attitudes, and promoting positive intergroup relations (Webb, Trooper, & Fall, 1995). Moreover, cooperation has been found to have positive effects on students' motivation and engagement, as well as their retention of knowledge and skills (Slavin, 1983).

In conclusion, cooperation in education is a well-established concept with a strong theoretical foundation based on the social interdependence theory. It has been shown to have numerous benefits for students and educators alike, and its implementation in various forms can enhance learning outcomes and improve educational quality.

3.2. Collaboration Skills

Collaboration is a critical component of success in many areas of life, including education, business, and social settings. The ability to work effectively with others is often referred to as "collaborative skills," which includes a range of abilities and behaviors that enable individuals to work together towards a common goal.

One theoretical framework that underpins collaborative skills is social interdependence theory, which suggests that individuals are more likely to engage in cooperative behavior when they perceive that their success is linked to the success of others (Johnson & Johnson, 1989). This theory emphasizes the importance of positive interdependence, where individuals perceive that they need to work together to achieve a common goal, and that their success is dependent on the success of others.

Another theoretical framework that is relevant to collaborative skills is the concept of emotional intelligence, which refers to the ability to perceive, understand, and manage one's own emotions and the emotions of others (Mayer & Salovey, 1997). This includes the ability to communicate effectively, empathize with others, and resolve conflicts in a constructive manner, which are all important components of effective collaboration.

In addition, the concept of collaborative problem-solving is also relevant to the development of collaborative skills. This approach emphasizes the importance of working together to identify and solve complex problems, which often requires the use of multiple perspectives, skills, and resources (Kirschner, Buckingham Shum, & Carr, 2003).

Overall, the development of collaborative skills is essential for success in a variety of contexts, and is grounded in theoretical frameworks such as social interdependence theory, emotional intelligence, and collaborative problem-solving.

3.3. Criteria for Assessing Collaborative Problem-Solving Skills

Research on the levels of development of collaborative problem-solving skills includes two prominent studies by OECD and Griffin. These studies classify the levels of development from low to high and provide descriptions of assessment indicators for each level. However, they differ in the number of levels used. While OECD's research (2017) uses a 4-level scale, Griffin and colleagues have developed a 6-level scale. Whether divided into 4 or 6 levels, both scales describe the lowest and highest levels of collaborative problem-solving skills equivalently. At the lowest level, learners perform independent tasks with low complexity. At the highest level, learners tackle tasks with high complexity, resolve conflicts, take initiative or request, and overcome obstacles to accomplish their tasks.

Furthermore, while OECD (2017) establishes 4 skill levels, Griffin and colleagues develop a scale of skill levels through three models based on a general or detailed approach to skill levels. The 1-dimensional model is based on the overall unity of collaborative problem-solving skills. The 2-dimensional model divides it into the components of collaboration and problem-solving. The 5-dimensional model describes in detail the 6 levels of the 5 participating elements: accepting perspectives, social regulation, task management, and constructing knowledge.

Therefore, most studies divide the development of collaborative problem-solving skills into 5 levels, arranged from low to high. At the lowest level, learners are unable to meet the requirements or, if they do, they make many mistakes. At the highest level, learners demonstrate proficiency in solving problems in various situations, showing flexibility and achieving high results. The intermediate level or intermediate degree is clearly distinguished between low and high skill levels.

Based on the general approaches to skill development levels and in line with the Likert 5-level scale. The resulting expression of skill levels for collaborative problem-solving is as follows:

Table 1. Outlining the Structure of Collaborative Problem-Solving Skills in Mathematics.

Component	Behavior	Expression
Jointly Identifying the Mathematical Problem	Engaging in discussions to understand and define the problem	Engaging in discussions to clearly define and comprehend the problem
	Actively listening and considering different perspectives	Actively listening and considering different perspectives on the problem
Jointly Proposing Problem-Solving Strategies	Brainstorming and sharing ideas to generate possible solutions	Brainstorming and sharing ideas to generate a variety of possible solutions
	Collaboratively evaluating and selecting the best strategy	Collaboratively evaluating and selecting the most suitable strategy
Jointly Implementing the Problem-Solving Process	Dividing tasks and working together to carry out the plan	Assigning roles and responsibilities to team members to execute the plan
	Sharing information and resources to support problem-solving	Sharing information and resources effectively to aid in problem-solving
Jointly Evaluating and Adjusting	Assessing the effectiveness of the chosen strategy and solution	Critically analyzing the results and outcomes of the chosen strategy and solution
	Providing constructive feedback and suggesting improvements	Offering constructive feedback and proposing necessary adjustments and improvements

Table 2. Expressions of Levels of Collaborative Problem-Solving Skills.

Level	Expressions
Not Knowing how to do it	Have little or basic understanding of collaborative problem-solving skills. Rarely or unable to exchange or connect with group members to carry out activities or problem-solving. Not performed or performed with significant inaccuracies or many errors regarding the components of collaborative problem-solving skills.
Able to do it to Some Extent	Have understanding of collaborative problem-solving skills. Rarely exchange or connect with group members to carry out activities or problem-solving. Incomplete or contains many inaccuracies or basic errors regarding the components of collaborative problem-solving skills.
Able to do it	Have good understanding of collaborative problem-solving skills. Occasionally exchange, connect, interact, share resources, and resolve simple conflicts to carry out activities or problem-solving. Performed almost completely but with some errors or can perform in similar situations, similar to the model regarding the components of collaborative problem-solving skills.
Able to do it well	Have a good understanding of collaborative problem-solving skills. Regularly exchange, connect, interact, share information, and resolve relatively complex conflicts to carry out activities or problem-solving. Performed fairly completely with very few errors, can solve relatively difficult and complex problems related to the components of collaborative problem-solving skills.
Very Proficient in doing it	Have a very good understanding of collaborative problem-solving skills. Regularly/proactively/effortfully exchange, connect, interact, share information, and support other members, resolve complex conflicts to carry out activities or problem-solving. Performed completely, creatively, with almost no errors, can solve difficult and complex problems related to the components of collaborative problem-solving skills.

Table 3. Criteria for Evaluating Collaborative Problem-Solving Skills.

Component	Behavior	Expression
Jointly Identifying The Mathematical Problem	Level 1: Limited understanding and contribution	Shows minimal or no involvement in discussions and problem identification
	Level 2: Basic understanding and contribution	Shows basic understanding and contributes to discussions and problem identification
	Level 3: Adequate understanding and contribution	Actively participates in discussions and contributes to clearly defining the problem
	Level 4: Proficient understanding and contribution	Actively listens, considers different perspectives, and contributes to comprehending the problem
	Level 5: Exceptional understanding and contribution	Actively engages in discussions, offering insightful perspectives on the problem
Jointly Proposing Problem-Solving Strategies	Level 1: Limited idea generation and evaluation	Provides few or no ideas and does not actively evaluate proposed strategies
	Level 2: Basic idea generation and evaluation	Generates some ideas and offers basic evaluation of proposed strategies
	Level 3: Adequate idea generation and evaluation	Actively participates in brainstorming and evaluates a variety of proposed strategies

	Level 4: Proficient idea generation and evaluation	Generates creative ideas and collaboratively evaluates and selects the most suitable strategy
	Level 5: Exceptional idea generation and evaluation	Generates innovative ideas and demonstrates exceptional evaluation and selection skills
Jointly Implementing the Problem-Solving Process	Level 1: Limited contribution and coordination	Shows minimal or no participation in task division and coordination
	Level 2: Basic contribution and coordination	Contributes to the assigned tasks and demonstrates basic coordination with team members
	Level 3: Adequate contribution and coordination	Actively works together, dividing tasks, and coordinating efforts to execute the plan
	Level 4: Proficient contribution and coordination	Assigns roles and responsibilities effectively, ensuring smooth execution of the plan
	Level 5: Exceptional contribution and coordination	Demonstrates exceptional collaboration, coordination, and resource-sharing
Jointly Evaluating and Adjusting	Level 1: Limited evaluation and adjustment	Shows minimal or no involvement in assessing the effectiveness of strategies and suggesting improvements
	Level 2: Basic evaluation and adjustment	Provides basic evaluation of the chosen strategy and suggests some improvements
	Level 3: Adequate evaluation and adjustment	Critically analyzes results and outcomes, offering constructive feedback and proposing necessary adjustments
	Level 4: Proficient evaluation and adjustment	Offers thorough evaluation, identifies areas for improvement, and suggests effective adjustments
	Level 5: Exceptional evaluation and adjustment	Demonstrates exceptional analysis, offers insightful feedback, and proposes innovative adjustments

3.4. Proposed Strategies for Developing Collaborative Problem-Solving Skills for Students through Teaching Algebra and Calculus in 12th Grade in the Lao People's Democratic Republic

3.4.1. Organizing Teacher Training on Cooperative Teaching Methods and Various Collaborative Learning Techniques, Problem-Solving Teaching, and Project-Based Teaching to Enhance Collaborative Problem-Solving Skills in Mathematics Education

The content of the method: Method 1 focuses on providing teacher training in cooperative teaching methods and various collaborative learning techniques, problem-solving teaching, and project-based teaching. The aim is to enhance collaborative problem-solving skills in mathematics education. The training covers instructional strategies that promote cooperation and collaboration among students, such as group work, peer learning, and teamwork. It also includes techniques for guiding students in solving mathematical problems collectively, fostering critical thinking and communication skills, and encouraging active engagement in the learning process. By equipping teachers with these methods, they are better prepared to create a collaborative and interactive learning environment that fosters the development of problem-solving skills in their students.

Implementation of the method: The implementation of Method 1 involves organizing training sessions for teachers. These sessions can be conducted through workshops, seminars, or professional development programs. During the training, teachers are introduced to the principles and techniques of cooperative teaching and collaborative learning in mathematics education. They learn how to design and facilitate activities that promote collaboration, problem-solving, and project-based learning. Teachers are provided with examples and case studies to illustrate the application of these methods in the mathematics classroom. They also have opportunities to practice and receive feedback on their instructional techniques. Through this training, teachers gain a deeper understanding of the importance of collaborative problem-solving skills and how to effectively incorporate these strategies into their teaching practice.

3.4.2. Exploiting Practical Situations in Algebra and Calculus Activities in 12th Grade to Cultivate Collaborative Problem-Solving Skills for Students

The content of the method: Method 2 focuses on utilizing practical situations in Algebra and Calculus activities for 12th-grade students to cultivate their collaborative problem-solving skills. The method involves designing learning tasks and assignments that require students to work together in teams or groups to solve real-world problems. These practical situations can be derived from various contexts, such as finance, physics, engineering, or data analysis. By incorporating real-life scenarios, students are motivated to apply mathematical concepts and techniques in meaningful ways. This method aims to enhance students' ability to collaborate, communicate effectively, and think critically while working on complex mathematical problems.

Implementation of the method: The implementation of Method 2 involves incorporating practical situations into Algebra and Calculus activities in the 12th-grade curriculum. Teachers design and present mathematical problems that reflect real-world contexts and challenges. They guide students in forming collaborative groups or teams to work on these problems. Students are encouraged to discuss, analyze, and solve the problems together, leveraging their collective knowledge and skills. Teachers facilitate the learning process by providing guidance, feedback, and scaffolding when needed. They also encourage students to reflect on their problem-solving strategies and engage in discussions to deepen their understanding of mathematical concepts. Through this method, students develop their collaborative problem-solving skills by actively engaging in authentic mathematical tasks that connect to real-life situations.

3.4.3. Applying Cooperative Teaching Methods, Problem-Solving Teaching, and Project-Based Teaching with a Focus on Strengthening Collaborative Problem-Solving Skills for Students in Algebra and Calculus classes

The content of the method: Method 3 involves the application of cooperative teaching methods, problem-solving teaching, and project-based teaching to enhance collaborative problem-solving skills in Algebra and Calculus classes. Cooperative teaching methods involve creating a supportive and interactive learning environment where students work together in groups to solve mathematical problems. Problem-solving teaching focuses on guiding students through the process of analyzing, strategizing, and finding solutions to complex mathematical problems. Project-based teaching involves engaging students in real-world projects that require them to apply mathematical concepts and skills to address authentic challenges. By integrating these approaches, students develop not only their mathematical knowledge but also their ability to collaborate, communicate effectively, and think critically in a team setting.

Implementation of the method: The implementation of Method 3 involves incorporating cooperative teaching methods, problem-solving teaching, and project-based teaching into Algebra and Calculus classes. Teachers design and deliver lessons that encourage collaborative problem-solving. They create opportunities for students to work in groups or pairs, fostering teamwork and cooperation. Teachers facilitate discussions, provide guidance, and promote active participation among students. They introduce challenging problem-solving tasks that require students to analyze and apply mathematical concepts in creative ways. Additionally, teachers incorporate project-based learning activities that allow students to explore real-world applications of Algebra and Calculus, fostering

their collaborative problem-solving skills. Throughout the process, teachers provide feedback, assess students' progress, and encourage reflection on their problem-solving strategies. By consistently implementing these teaching methods, students develop strong collaborative problem-solving skills that are applicable in both academic and real-life situations.

3.4.4. Developing Collaborative Problem-Solving Skills for Students when they are Physically Separated by Utilizing Online Communication and Guidance Techniques

The content of the method: Method 4 focuses on fostering collaborative problem-solving skills for students, even when they are physically separated, through the use of online communication and guidance techniques. This approach acknowledges the importance of adapting to the digital age and leveraging technology to enable collaboration and problem-solving. It involves creating opportunities for students to engage in collaborative activities, exchange ideas, and work together on mathematical problems, regardless of their physical location. The method emphasizes the development of effective communication skills, critical thinking, and teamwork, enabling students to collaborate successfully in virtual environments.

Implementation of the method: The implementation of Method 4 involves utilizing various online communication and guidance techniques to facilitate collaborative problem-solving among students. Teachers utilize digital platforms, such as video conferencing tools, discussion forums, and collaborative document sharing platforms, to create virtual learning spaces. They provide clear instructions and guidelines for online collaboration, ensuring students understand the expectations and goals of the activities. Teachers may assign group projects or problem-solving tasks that require students to work together remotely. They offer guidance and support through virtual interactions, providing feedback, answering questions, and facilitating discussions to enhance collaboration and problem-solving skills. Additionally, teachers encourage effective communication among students, promoting active participation, active listening, and constructive feedback within the virtual environment. By leveraging online communication and guidance techniques, students can develop and strengthen their collaborative problem-solving skills, even in situations where physical presence is not possible.

3.4.5. Integrating Algebra and Calculus Teaching In 12th Grade to Enhance Collaborative Problem-Solving Skills for Students

The content of the method: Method 5 focuses on integrating Algebra and Calculus teaching in 12th grade with the aim of enhancing collaborative problem-solving skills for students. This approach recognizes the interconnectedness of mathematical concepts and promotes a holistic understanding of mathematics. By integrating these two branches of mathematics, students can develop a deeper understanding of mathematical principles and apply them in solving complex problems. The method emphasizes the development of collaborative problem-solving skills through engaging activities, group discussions, and real-world applications of mathematical concepts. It encourages students to work together, share their ideas, and collaboratively analyze and solve mathematical problems.

Implementation of the method: The implementation of Method 5 involves the intentional integration of Algebra and Calculus teaching in 12th grade to foster collaborative problem-solving skills among students. Teachers design lessons and learning activities that incorporate concepts from both branches of mathematics, highlighting their interrelationships and practical applications. They provide opportunities for students to work in small groups or pairs, encouraging active participation, communication, and collaboration. Students engage in problem-solving tasks that require them to apply their knowledge of Algebra and Calculus, analyze complex problems, and work together to find solutions. Teachers facilitate group discussions, provide guidance, and encourage students to explain their reasoning and strategies. They may also incorporate real-world examples and applications of mathematical concepts to make the learning experience more meaningful and relevant. By integrating Algebra and Calculus teaching and fostering collaboration, Method 5 aims to enhance students' problem-solving skills and their ability to work collaboratively in mathematical contexts.

4. EXAMPLES OF APPLYING IN SOLVING PRACTICAL PROBLEMS

Problem 1: Mr. Kham Pheng wants to buy a triangular piece of land (Figure 1). The landowner informed him that he has planted two tall trees in the first row, and each subsequent row has more trees than the previous one. Following this pattern, he planted 50 rows of trees. Can you tell how many trees Mr. Kham Pheng planted in total?

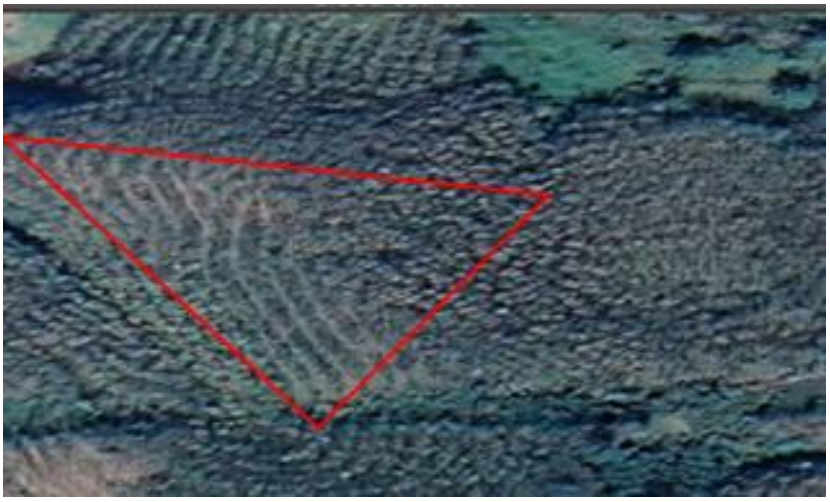

Figure 1. Image of a Tall Tree Garden in Luang Namtha Province, Laos.

Problem 2: A pig farm bought piglets for rearing (Figure 2). In the first month, they bought 30 piglets. In the second month, they bought more than in the first month, and this pattern continued for the next 10 months, with each subsequent month buying 5 more piglets than the previous month. Can you calculate how many piglets were bought in total over the 12 months?

Figure 2. Image of a Pig Farming Facility in Luang Prabang Province, Laos.

Problem 3: An elderly man agreed to repay a debt of 5,800,000 kip without interest. In the first repayment, he paid 100,000 kip, and for each subsequent repayment, he had to pay an additional 20,000 kip. The question is, how many times does he have to repay the debt until it is fully paid?

Step 1:

The teacher divides the students in the class into 6 groups by counting from 1 to 6, and students with the same number form a group.

Students begin by numbering themselves and organizing their groups, arranging desks and chairs, planning their work (reading materials, exchanging ideas, group discussions), assigning group tasks (group leader and members create a plan and ensure that everyone in the group knows and follows the timeline, a secretary takes notes and shares them with group members, individuals read the assigned material and work on their group tasks according to their own ideas before coming together to organize the results, present their work for discussion within the group, and listen to others without interrupting, take notes during group discussions, and prepare for a report when called upon by the teacher).

The teacher guides students on how to work in groups: students carefully read the problem-solving methods in the textbook.

Students read the textbook and watch a video clip on YouTube for about 30 minutes, then work together to complete the assigned task.

Desired answer:

Problem 1: The problem provides the values $a_1 = 2$; $d = 1$ and $S_{50} = ?$. Using the formula $S_n = \frac{n}{2}[2a_1 + (n-1)d]$, we can calculate $S_{50} = \frac{50}{2}[2.2 + (50-1)1] = 1325$

Therefore, a total of 1325 trees were planted.

Problem 2: The problem provides the values $a_1 = 30$; $d = 2$; $S_{12} = ?$. Using the formula $S_n = \frac{n}{2}[2a_1 + (n-1)d]$, we can calculate $S_{12} = \frac{12}{2}[2.30 + (12-1)1] = 492$ Therefore, a total of 492 pigs were purchased within 12 months.

Problem 3: The person pays off the debt with amounts of 100,000, 120,000, 140,000, 160,000,... in an arithmetic sequence. We have the sum 100,000 + 120,000 + 140,000 + 160,000 + ... = 5,800,000. Given $a_1 = 100\,000$ and $d = 20\,000$, we need to find the value of n. Using the formula $S_n = \frac{n}{2}[2a_1 + (n-1)d]$, we can set up the equation: $5\,800\,000 = \frac{n}{2}[2.100\,000 + (n-1).20\,000]$ Simplifying, we get: $10\,000\,n^2 + 90\,000n - 5\,800\,000 = 0$, we find two possible values for n: $n = -29$ and $n = 20$ However, since $n = -29 < 0$ is not a valid solution in this context, we conclude that n = 20. Therefore, it means the person has to make 20 payments to fully repay the debt.

Step 2:

The group secretary takes notes and facilitates the discussion. They write down the solutions on an A4 paper.

Each student in the group takes notes of the group's discussion and prepares to present it to the class (since each group's problem-solving process is similar, the teacher can select 2-3 groups to present their results).

The teacher allows different groups to discuss and add to the presentation of their own group.

Students from other groups present their own group's discussion if applicable (this helps them practice their communication and presentation skills outside their own group).

Step 3:

The teacher, together with the students, reviews the class discussion and evaluates the group's outcomes to determine which ones were done well (students need to identify which activities were effective or ineffective).

They identify areas that need improvement and determine what needs to be done better (students decide what needs to be continued or changed), especially when solving problems using the formula $S_n = \frac{n}{2}[2a_1 + (n-1)d]$. This phase helps students develop listening skills, self-assessment skills, and confidence. The teacher can ask additional questions such as: "If you want to know if the problem is solved correctly or not, how do you review the problem? Does anyone volunteer to explain?"

The teacher should remind students that for investigative problems (Hidden problems), they need to focus on:

The purpose of the problem, which is to find an unknown object or information, the thing that needs to be found, the hidden or unknown part that people are asking about. These can be theoretical or practical problems, abstract or concrete, serious or simple puzzles. The unknown can be found, obtained, discovered, or constructed.

The main elements of the problem are the unknown, the known, and the conditions of the problem.

To completely solve a problem, students need to have a clear understanding of the main elements, the unknown, the known, and the conditions of the problem.

5. RESULTS AND DISCUSSION

5.1. Overall Evaluation of the Research

The research focused on developing collaborative problem-solving skills for high school students in Lao People's Democratic Republic in the context of mathematics education. It presented five methods that aimed to enhance collaboration, critical thinking, and communication skills among students while solving mathematical problems. These methods included teacher training on cooperative teaching methods, utilizing practical situations in Algebra and Calculus activities, applying cooperative teaching methods in Algebra and Calculus classes, utilizing online communication and guidance techniques for remote collaboration, and integrating Algebra and Calculus teaching in 12th grade.

The research provided detailed descriptions of each method, including their content and implementation strategies. The methods demonstrated a comprehensive approach to fostering collaborative problem-solving skills by incorporating cooperative learning, problem-solving teaching, project-based learning, and real-world applications of mathematics. The research acknowledged the importance of adapting to the digital age and leveraging technology for remote collaboration.

The methods presented in the research are valuable contributions to mathematics education. They address the need to develop students' collaborative problem-solving skills, which are essential in today's interconnected and technology-driven world. By equipping teachers with effective instructional strategies and providing students with opportunities for collaborative problem-solving, the research offers practical insights into enhancing mathematics education.

5.2. Significance and Limitations of the Research

The research holds significant value in highlighting the importance of collaborative problem-solving skills and providing practical methods to develop these skills in high school students. By focusing on mathematics education, the research recognizes the potential of collaborative learning in improving students' mathematical abilities and preparing them for real-life problem-solving situations.

However, it is important to acknowledge some limitations of the research. Firstly, the research primarily focuses on the context of Lao People's Democratic Republic, which may limit its generalizability to other educational settings. Future research should consider exploring the effectiveness of these methods in diverse cultural and educational contexts.

Additionally, the research could benefit from more comprehensive evaluation measures. While it discussed the implementation of the methods, there is a need for more detailed assessment of the outcomes, including quantitative measurements of students' problem-solving skills, collaborative abilities, and long-term impact.

5.3. Future Research Directions

To further enhance the field of collaborative problem-solving in mathematics education, there are several potential directions for future research. Firstly, investigating the effectiveness of these methods across different grade levels and cultural contexts would provide valuable insights into their generalizability and adaptability.

Furthermore, future research can explore the integration of technology and digital tools to support collaborative problem-solving in mathematics education. Exploring the use of virtual reality, augmented reality, and artificial intelligence can unlock new possibilities for engaging students and fostering collaboration in problem-solving activities.

Moreover, research can delve into the role of assessment in promoting and evaluating collaborative problem-solving skills. Developing assessment methods and standards that accurately measure and quantify these skills will provide teachers and researchers with a means to monitor progress and promote skill development effectively.

6. CONCLUSION

In conclusion, the research on developing collaborative problem-solving skills in high school students in Lao People's Democratic Republic has contributed valuable methods for enhancing mathematics education. The research emphasizes the significance of collaborative problem-solving skills and offers practical strategies for teachers. While the research holds significant value, there is a need for further evaluation and exploration of these methods in diverse contexts, as well as the integration of technology and comprehensive assessment measures.

6.1. Public Interest Statement

This research article focuses on the development of collaborative problem-solving skills for high school students in the Lao People's Democratic Republic. By introducing effective methods to enhance collaboration in solving mathematical problems, the study aims to contribute to the improvement of mathematics education in the country and address the need for cooperative problem-solving skills in today's interconnected world.

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Disclaimer Statement

The views and opinions expressed in this article are solely those of the authors and do not necessarily reflect the official policy or position of any educational institution or organization.

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Authorship and Level of Contribution

Vongsy Phommanichan and Tran Viet Cuong contributed equally to this research article. They collaborated in designing the study, collecting and analyzing data, and writing the manuscript. Both authors have reviewed and approved the final version of the article.

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