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TEACHING SOME ELEMENTS OF MATHEMATICAL ANALYSIS IN THE DIRECTION OF DEVELOPING PRACTICAL PROBLEM-SOLVING COMPETENCE FOR GRADE 12 STUDENTS IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

Speciality: Theory and methodology of Mathematics teaching
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SUMMARY OF DOCTORAL THESIS

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Counterargument 1:……

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The dissertation can be accessed at**:**
- Vietnam National Library
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LIST OF PUBLISHED SCIENTIFIC WORKS RELATED TO THE DISSERTATION TOPIC

[1] **Manyvanh Inthavongsa** (2024). The current situation of teaching Mathematics toward developing real-world problem-solving competence for Grade 12 students in some upper secondary schools in the Lao People's Democratic Republic. Journal of Education, Special Issue, December.

[2] Nguyen Danh Nam, **Manyvanh Inthavongsa** (2025). Teaching for the development of real-world problem-solving competence. In Nguyễn Danh Nam (Ed.), Trends in Secondary School Mathematics Education. Thai Nguyen University Publishing House.

[3] Douangalom Phounakhom, Bui Thi Hanh Lam, Nguyen Danh Nam, **Manyvanh Inthavongsa** (2025). "The Current Status of Context-Besed Teaching in mathematics at High School of Lao Peple's Democratic Republic". Social Science and Humanities Journal, vol 9, number 5, pp. 7839-7859

[4] **Manyvanh Inthavongsa**, Nguyen Danh Nam (2025). Teaching to develop real-world problem-solving competence for Grade 12 students in the Lao People's Democratic Republic. Journal of Science and Technology, Thai Nguyen University, Vol. 230, No. 12, pp. 3–11.

INTRODUCTION

1. Reasons for choosing the topic

1.1. Orientation for innovation in educational development in the Lao People's Democratic Republic, and an indication that developing students' competency in solving real-world problems will contribute to achieving one of the goals, enabling students to apply mathematics to solve practical problems.

1.2. The necessity/role of competency in solving real-world problems.

1.3. The potential for developing students' competency in solving real-world problems through the teaching of Calculus.

1.4. The current situation of mathematics teaching in general, and Calculus teaching in particular, in Laos has paid attention to the development of students' competency in solving real-world problems.

1.5. Research studies on this issue in Laos and around the world have focused on developing certain competencies in mathematics education. However, the application of theories and practices from international research to the specific context of Vietnam still faces many challenges and opportunities that have not been fully exploited. Moreover, when reviewing educational research works in Laos, the author finds that there are almost no studies that directly and comprehensively investigate teaching in this area. This, in itself, presents both an opportunity and a challenge for the author to explore and conduct further research.

Thus, up to now, neither in the world nor in Laos or Vietnam has there been any study on realistic mathematics education aimed at developing students' competency in solving real-world problems in the teaching of mathematics at the upper secondary level in the Lao People's Democratic Republic.

Therefore, the research topic selected by the author of the dissertation is: **"Teaching some elements of Calculus in the direction of developing competency in solving real-world problems for Grade 12 students in the Lao People's Democratic Republic."**

2. Research purpose

Based on theoretical and practical research on teaching certain elements of Calculus in the direction of developing competency in

solving real-world problems, the dissertation proposes several pedagogical measures to develop this competency for Grade 12 students in the Lao People's Democratic Republic.

3. Research subjects, research objects, and scope of the study

- **Esearch subject:** The teaching process of certain elements of Calculus for Grade 12 students in the Lao People's Democratic Republic.
- **Research object:** Pedagogical measures to develop competency in solving real-world problems in teaching certain elements of Calculus for Grade 12 students in the Lao People's Democratic Republic.

4. Scientific hypothesis

If a teaching organization process and a number of pedagogical measures oriented toward developing students' competence in solving real-life problems are appropriately proposed and applied in teaching certain elements of mathematical analysis to Grade 12 students in the Lao People's Democratic Republic, they will contribute to the development of the components of real-life problem-solving competence and improve the quality of teaching and learning Mathematics.

5. Research objectives

- Study the theoretical foundations of teaching certain elements of mathematical analysis in the direction of developing real-life problem-solving competence.
- Study the curriculum and textbooks on certain elements of mathematical analysis in the Lao People's Democratic Republic, as well as the current situation of teaching in the direction of developing real-life problem-solving competence in teaching these elements.
- Propose several pedagogical measures to develop students' real-life problem-solving competence in teaching certain elements of mathematical analysis in the Lao People's Democratic Republic.
- Conduct pedagogical experiments to verify the effectiveness and feasibility of the proposed pedagogical measures.

6. Research methods

6.1 Theoretical research methods
6.2 Survey and field investigation methods
6.3 Expert method
6.4 Statistical methods

6.5 Pedagogical experimental method

7. Main contributions of the dissertation

7.1. From a theoretical perspective

- Clarify issues related to teaching certain elements of mathematical analysis in the direction of developing real-life problem-solving competence, as well as the structure of real-life problem-solving competence

- Clarify the characteristics of Grade 12 calculus content at upper secondary schools, as well as the opportunities for teaching certain elements of mathematical analysis in the direction of developing real-life problem-solving competence for Grade 12 students in upper secondary schools in the Lao People's Democratic Republic.

- Propose a teaching process for certain elements of mathematical analysis oriented toward developing real-life problem-solving competence for Grade 12 students in the Lao People's Democratic Republic.

7.2. From a practical perspective

- Clarify the current situation of teaching certain elements of mathematical analysis in the direction of developing real-life problem-solving competence for Grade 12 students in the Lao People's Democratic Republic.

- Propose several pedagogical measures to develop students' real-life problem-solving competence in teaching certain elements of mathematical analysis for Grade 12 students in the Lao People's Democratic Republic.

8. Supporting arguments

- Propose a competency framework for solving real-world problems in teaching selected topics of mathematical analysis to Grade 12 students in the Lao People's Democratic Republic.
- Propose pedagogical measures for teaching selected topics of mathematical analysis in Grade 12 mathematics that are feasible and effective for upper secondary school students.

9. Structure of the Dissertation

The dissertation consists of an introduction, a conclusion, appendices, and the following four chapters:

Chapter 1: THEORETICAL FOUNDATIONS

1.1. Overview of the Research Problem

1.1.1. Problem-Solving Teaching and Teaching for Developing Competency in Solving Real-World Problems

1.1.2. Teaching Selected Elements of Mathematical Analysis toward Developing Competency in Solving Real-World Problems

1.2. Competency in Solving Real-World Problems

1.2.1. Concept of Solving Real-World Problems

a) Problem

b) Real-world problem / Practical problem

c) Real-world situation / Practical situation

1.2.2. Competency

In this dissertation, the author adopts the concept of competency as defined by the Ministry of Education and Training of Vietnam (2018a), which states that: *"**Competency is a personal attribute formed and developed through innate qualities and the process of learning and training, enabling individuals to mobilize a combination of knowledge, skills, and personal attributes such as interest, belief, willpower, and determination to successfully perform a certain type of activity and achieve desired outcomes under specific conditions".***

1.2.3. Problem-Solving Competency

In this dissertation, the author adopts the concept of problem-solving competency based on the view of Nguyễn Thị Lan Phương (2016): *"Problem-solving competency is the ability of an individual to effectively use cognitive processes, actions, as well as attitudes, motivation, and emotions to solve problem situations in which no ready-made procedures or known solutions are available."*

1.2.4. Competency in Solving Real-World Problems

In this dissertation, the author conceives that: *"Students' competency in solving real-world problems in mathematics education*

is the ability to mobilize a combination of knowledge, skills, along with attitudes, beliefs, values, willpower, motivation, experience, and other personal qualities to propose effective solutions to real-world problems."

Based on previous studies on the components of real-world problem-solving competency, and on the author's own conception of this competency, the dissertation proposes the following components of real-world problem-solving competency:

1.2.4.1. Identifying the problem to be solved
1.2.4.2. Constructing a mathematical model
1.2.4.3. Proposing solutions based on the established model
1.2.4.4. Presenting the solution
1.2.4.5. Evaluating and further analyzing the solution

1.3. Teaching for Developing Competency in Solving Real-World Problems

1.3.1. Characteristics of Mathematics Teaching toward Developing Competency in Solving Real-World Problems
1.3.1.1. Starting from real-world situations aligned with lesson objectives
1.3.1.2. Mathematization and modeling as the core
1.3.1.3. Organizing teaching and learning activities according to the real-world problem-solving process
1.3.1.4. Enhancing interdisciplinary and real-world contexts in lessons
1.3.1.5. Teachers need a solid understanding of real-world issues to effectively play a guiding role in organizing instruction
1.3.1.6. Increasing activities of exploration, discovery, and application

1.4. Chapter 1 Conclusion

Chapter 2: FRAMEWORK OF REAL-WORLD PROBLEM-SOLVING COMPETENCY AND THE CURRENT SITUATION OF TEACHING MATHEMATICAL ANALYSIS TOWARD DEVELOPING THIS COMPETENCY FOR GRADE 12 STUDENTS IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

2.1. Framework of Real-World Problem-Solving Competency

2.1.1. Basis for Development

To develop the framework of students' real-world problem-solving competency through teaching selected topics of Grade 12 mathematical analysis, the author of the dissertation relies on the following bases:

(1) Theoretical and legal foundations

(2) Foundations based on learner characteristics and teaching approaches

(3) Scientific and practical reference bases

2.1.2. Principles for Development

The framework of students' real-world problem-solving competency through teaching mathematical analysis is developed based on the following principles:

(1) Ensuring alignment with the competency development objectives of the general education mathematics curriculum in the Lao People's Democratic Republic

(2) Ensuring scientific validity and systematic organization

(3) Ensuring practicality and feasibility

(4) Ensuring assessment-oriented orientation

2.1.3. Development Process

In the process of developing the framework of real-world problem-solving competency for upper secondary school students, the author followed these steps:

Step 1: Define real-world problem-solving competency

Step 2: Study the process of developing real-world problems and investigate issues related to developing this competency

Step 3: Compile domestic and international literature on factors affecting students' real-world problem-solving competency through teaching real-world problems

Step 4: Draft the competency framework

Step 5: Seek expert feedback

Step 6: Revise the competency framework

Step 7: Finalize the competency framework

2.1.4. Results of Expert Feedback Analysis on the Real-World Problem-Solving Competency Framework

After three rounds of the Delphi survey, with continuous adjustments to the competency components and their performance criteria based on expert feedback, and refinement of terminology for maximum accuracy and appropriateness, combined with strict application of the KAMET principles, all five competency components achieved a high level of consensus and were officially accepted.

2.1.5. Framework of Real-World Problem-Solving Competency

components of practical problem-solving competence	manifestations of practical problem-solving competence	Assessment criteria
I. Ability to identify the problem to be addressed	Posing and formulating questions related to the problem, and analyzing the real-world context in order to fully identify and clearly define the problem to be solved.	1.1 Identifying the real-world problem to be solved 1.2 Expressing and presenting characteristics, manifestations, and phenomena using scientific language
II. Ability to construct a mathematical model	Formulating a mathematical model; representing and translating real-world situations into common language; using mathematical language, diagrams, figures, and tables; and transforming real-world problems into mathematical problems in order to simplify the situation.	2.1 Transforming a real-world problem into a mathematical problem 2.2 Describing the given data and formulating questions/problems corresponding to the issue to be solved using mathematical language
III.Ability to propose solutions to the problem based on the established mathematical model	Selecting the optimal solution and providing personal justification for the chosen approach; constructing a logical framework for problem-solving; formulating the problem by proposing hypotheses; calculating and organizing data; and applying appropriate mathematical knowledge, methods, and tools to solve the problem based on the established model	3.1 Collecting information, developing a plan, and reaching agreement on the plan 3.2 Formulating a plan to solve the mathematical model 3.3 Proposing solutions to address the real-world problem
IV.Ability to present the solution	Writing and presenting the solution; collecting data and evidence; organizing data; using appropriate mathematical methods and tools; drawing conclusions; and revising conclusions when necessary	4.1 Collecting and organizing information related to the problem 4.2 Assigning tasks, implementing the solution according to the plan, and deriving the results of the proposed solution
V.Ability to evaluate and further investigate the solution	Verifying and thoroughly evaluating the solution in relation to the real-world problem addressed, thereby understanding the results obtained and further analyzing the solution to ensure its suitability to real-world contexts.	5.1 Translating the results of solving the mathematical model into the results of the real-world problem

Based on this competency framework, the author of the dissertation conducted a survey on the current situation of teaching selected topics of Grade 12 mathematical analysis toward developing students' real-world problem-solving competency. This framework was also used to design tools for assessing the development of students' real-world problem-solving competency after the implementation of pedagogical measures in the pedagogical experiment.

2.2. Assessment in Teaching for Developing Real-World Problem-Solving Competency

- ❖ Purpose of Assessment
- ❖ Content of Real-World Problem-Solving Competency Assessment
- ❖ Assessment Methods and Forms
- ❖ Methods, Tools, and Techniques for Assessing Real-World Problem-Solving Competency

2.3. Analysis of the Grade 12 Mathematics Curriculum in the Lao People's Democratic Republic

2.3.1. Characteristics of Grade 12 Mathematics

2.3.2. Curriculum Objectives

2.3.3. Curriculum Content

2.3.4. Teaching Resources

2.3.5. Assessment and Evaluation of Mathematics Learning Outcomes

2.4. Current Situation of Teaching Selected Topics of Mathematical Analysis toward Developing Real-World Problem-Solving Competency

2.4.1. Survey Objectives

To investigate the current situation of mathematics teaching aimed at developing students' real-world problem-solving competency, analyze the advantages and challenges encountered during the teaching process, and provide a basis for proposing measures to improve the quality of teaching selected topics of mathematical analysis with a focus on developing students' real-world problem-solving competency.

2.4.2. Survey Participants and Survey Period

2.4.3. Survey Content

2.4.4. Survey Methods and Tools

2.5. Evaluation of the Current Situation of Teaching Selected Topics of Mathematical Analysis toward Developing Real-World Problem-Solving Competency for Grade 12 Students in the Lao People's Democratic Republic

2.5.1. Analysis of Grade 12 Students' Real-World Problem-Solving Competency in the Lao People's Democratic Republic

The assessment of students' real-world problem-solving competency showed:

1. **Identifying the problem:** Over 90% understood and identified the problem, though some still struggled.
2. **Constructing a mathematical model:** 59.3% could not simplify or model the situation; only 7% succeeded.
3. **Proposing solutions:** 51.1% failed to create models or represent problems; few could select appropriate methods.
4. **Presenting the solution:** 47.6% could organize information partially; only 20% presented fully and logically.
5. **Evaluating and analyzing the solution:** 50.6% gave incorrect results; only 7.6% evaluated and presented solutions accurately.

This indicates that while some competencies are developing, overall students' skills in modeling, problem-solving, and evaluation remain limited.

2.5.2. Analysis of the Current Situation of Mathematics Teaching toward Developing Real-World Problem-Solving Competency

2.5.2.1. Survey Results from Teachers

*(1) **Teachers' understanding of real-world problem-solving competency, its manifestations, and students' competency levels***

❖ The research results on teachers' understanding of the concept of practical problem-solving competence (GQVĐTT) show that over 90% of teachers are familiar with teaching aimed at developing GQVĐTT, indicating that most teachers have been exposed to and are aware of competence-based teaching in general, and teaching for developing practical problem-solving competence through mathematical analysis in particular. However, only 47.3% of teachers correctly understand the GQVĐTT competence, while a relatively high proportion of teachers still have misconceptions. Additionally,

3.2% of teachers have no understanding of the components of GQVĐTT competence.

❖ The research results on teachers' understanding of the manifestations of practical problem-solving competence (GQVĐTT) indicate that most teachers do not fully understand its expressions. The majority (75.3%) only recognize students' competence at the level of understanding the problem; 10.8% identify the competence of presenting solutions, and only 1.1% correctly recognize the competence of discovering alternative solutions or new problems. This shows that teachers still have limitations and insufficient understanding of the manifestations of GQVĐTT competence.

❖ The research results on the level of students' practical problem-solving competence (GQVĐTT) in teaching show that the majority of students (approximately 57%) demonstrate a low level of this competence; they are only able to "recognize real-life situations in which mathematical knowledge can be applied."

(2) ***Current Situation of Teachers Organizing Teaching toward Developing Real-World Problem-Solving Competency***

❖ The research results on the level of interest and frequency of implementing the development of students' practical problem-solving competence (GQVĐTT) in teaching mathematics at the upper secondary level show that most teachers are concerned and highly concerned about developing this competence in students. However, there is still a small proportion of teachers who are not interested in developing this competence. Thus, most teachers are aware of and have been exposed to teaching approaches aimed at developing GQVĐTT competence. Nevertheless, only 22% of teachers regularly implement teaching activities to develop this competence in students. The proportion of teachers who have implemented it but not on a regular basis is relatively high. In addition, there remains a proportion of teachers who "have never" or "rarely" carried out the development of GQVĐTT competence in mathematics teaching. This may stem from various causes, including limitations in teachers' instructional competence, the lack of strong direction from upper secondary schools in promoting innovation in mathematics teaching methods, and insufficient attention to improving teachers' teaching capacity.

❖ The research results on the extent to which active teaching methods are used to develop students' practical problem-solving competence

(GQVĐTT) show that most teachers pay attention to and use active teaching methods; however, the frequency of use remains low. Problem discovery and problem-solving methods, as well as group-based teaching, are more commonly used by teachers. In contrast, methods such as mind mapping, project-based learning, game-based learning, and discovery learning are rarely used, and some teachers have never applied them.The reasons for this may include a lack of instructional materials guiding teachers in the use of active teaching methods at upper secondary schools, and the fact that most teachers have limited opportunities to participate in professional training on innovating mathematics teaching methods.

❖ The survey results on the extent to which different assessment tools are used to evaluate Grade 12 students' practical problem-solving competence (GQVĐTT) show that teachers mainly continue to use traditional assessment tools (through tests and questions). The use of modern competence-based assessment tools, such as rating scales, observation checklists, rubric-based evaluation forms, and learning portfolios, remains limited (with fewer than 20% of teachers using them). This situation stems from the fact that mathematics teachers have had limited opportunities to participate in training and professional development programs on student assessment and evaluation. In addition, their capacity to apply information technology in designing assessment tasks and analyzing assessment results is still limited, leading to reluctance in using advanced techniques, methods, and tools for competency-based assessment.

2.5.2.2. Survey Results from Students

➢ The research results on students' perceptions when solving problems with real-life contexts show that about 50.3% of students recognize the significance of learning mathematics when engaging in such problems. Approximately 40% of students report being very interested in solving problems with real-life contexts, while 6.3% express a desire for teachers to incorporate more real-life situations into lessons. Finally, only 3.3% of students report being highly excited when solving problems with real-life contexts.

➢ The research results on the difficulties students encounter when solving problems with real-life contexts indicate that students face various challenges. Approximately 68% of students experience difficulties due to a lack of habit in solving real-life problems,

insufficient mastery of prior knowledge and fundamental mathematical concepts, and limited practical problem-solving competence (GQVĐTT). Meanwhile, about 13.3% of students believe that mock exams and national examinations do not include problems with real-life contexts.

2.5.3. Some Difficulties and Challenges in Teaching for Developing Real-World Problem-Solving Competency

- Difficulties and Challenges for Teachers:

Difficulties and Challenges from the Cognitive Perspective: Currently, teaching is still influenced by the mindset of "teach what is tested." This approach, combined with exams containing few real-world problems, leads to the neglect of teaching with real-world problem situations. Additionally, limited classroom time often causes such teaching to be skipped.

In Terms of Activities and Techniques: Many teachers believe that textbooks and workbooks lack sufficient real-world problems, and reference materials are limited. This makes it difficult and time-consuming to find or design real-world problem situations, requiring significant effort from teachers.

- Difficulties and Challenges for Students:

- Many students do not yet recognize the benefits of mathematics in solving real-world situations.
- Students are also limited in translating from natural language to mathematical language due to limited practice and real-world experience, which leads to difficulties in modeling and problem-solving.

2.6. Chapter 2 Conclusion

Based on the survey results, it is evident that teaching selected topics of mathematical analysis in general, and real-world problem situations in particular, is essential for developing students' real-world problem-solving competency. The surveys indicate that integrating real-world contexts into mathematics teaching helps students better understand the dialectical relationship between mathematics and practice. This highlights that, to contribute to the ongoing educational reform, it is necessary to strengthen the connection between real-world contexts and mathematics instruction.

Chapter 3
SOME PEDAGOGICAL MEASURES TO DEVELOP STUDENTS' PRACTICAL PROBLEM-SOLVING COMPETENCE

3.1. Orientation for Developing the Measures

Orientation 1: Measures that help students practice the ability to apply mathematics to real-life situations, gradually approach interdisciplinary knowledge, and be able to solve problems in practical contexts; aiming to develop each component of students' practical problem-solving competence.

Orientation 2: Measures that contribute to improving the curriculum, developing a system of real-world contextual problems, innovating teaching content and methods, as well as assessment methods and tools, in the direction of strengthening the connection between mathematics and real-life applications.

Orientation3: Measures aimed at creating opportunities for organizing instruction that develops practical problem-solving competence, which can be implemented during the teaching of certain elements of grade-12 mathematical analysis in high schools.

Orientation 4: The measures must be feasible, appropriate for high school students and the material conditions of high schools in the Lao People's Democratic Republic, and applicable to the process of solving practical problems.

3.2. Some Pedagogical Measures to Develop Practical Problem-Solving Competence for Grade 12 Students

3.2.1. Measure 1: Developing the Components of Practical Problem-Solving Competence

- Purpose of the measure: The purpose is to develop each component of practical problem-solving competence.

Step 1: Train students to recognize the problem that needs to be solved.

Implementation: To develop this ability in students, teachers need to organize activities that help students explore the overall problem in real-life situations, guide them to clearly identify mathematical information from these situations, thereby enabling them to detect the

problem, and clearly determine the given information and the problem to be solved.

Example3.1: On the occasion of International Children's Day (June 1st), a cinema screened an animated film for the audience. The cinema has 20 rows of seats. The first row has 20 seats, the second row has 21 seats, the third row has 22 seats, and so on—the number of seats in each row increases by 1 compared to the previous row. For this screening, the cinema sold all the tickets issued, and the total revenue from ticket sales was 70,800,000 kip. Calculate the price of each ticket (in kip), given that the number of tickets sold equals the number of seats in the cinema and all tickets have the same price.

Step 2: Train students in the skill of constructing mathematical models.

Implementation:

Constructing a mathematical model begins with analyzing the real-life situation, in which learners identify the objective to be solved and the related quantities. Based on this, the problem is simplified and appropriate assumptions are made to eliminate unnecessary factors while still preserving the essence of the real phenomenon. Next, the relationships between the quantities are expressed in mathematical language through formulas, equations, functions, or statistical models, thereby forming the mathematical model.

Example3.5: Ms. Buasavan sells fabric for making shirts at the Morning Market in Vientiane. She sold to the first customer half of the roll plus half a meter; to the second customer, she sold half of the remaining roll plus half a meter; to the third customer, she again sold half of the remaining roll plus half a meter; ... and by the time she sold to the seventh customer half of the remaining roll plus half a meter, there was no fabric left. How many meters of white fabric were in the original roll?

Step 3: Train students in the ability to propose solutions to the problem based on the established model and present their solutions.

• **Implementation method:** Develop students' skills in finding solutions to problems based on the established model and presenting those solutions. To cultivate this skill, teachers guide students in carrying out learning tasks and require them to present their work regularly in class, thereby helping them develop their thinking as well as their ability to present ideas clearly and coherently

Example 3.7: (Application of derivatives) A water container is in the shape of a cone with the diameter of its top surface being $100cm$ and the height being $120cm$. Water is poured into the container at a rate of $60cm^3/s$, which is the rate at the moment when the water level is at a certain height. Find the rate at which the water level rises at the moment when the water level is at $80cm$?

Step 4: Develop students' skills in evaluating and further analyzing solutions

• **Implementation method:** The development of students' real-world problem-solving competence is carried out through specific problem-solving activities. To train students in evaluating and deeply analyzing solutions, the author of the dissertation proposes the following procedure

- Organize students to work in groups to evaluate and further analyze solutions.
- Train students to self-assess their real-world problem-solving competence.

3.2.2. Measure 2: Design problems with real-life contexts and organize project-based learning

a) Purpose of the measure

The purpose of the measure to develop a resource system for applying Mathematics to real-life situations through practical problems and supplementary materials, as well as adjusting the number of examples and exercises in Mathematics teaching and organizing project-based learning, is to provide students with opportunities to independently solve real-world problems through the steps of the competence-development process for real-world problem solving, under the guidance of the teacher."

b) Implementation of the measure

Step 1: Construct real-life problems

- Constructing real-world problems from a mathematical model (pure mathematics) can be carried out through the following specific activities:

Topic: Sequences (developing problems with real-life contexts)

Activity 1: Identify the learning objectives of the topic or lesson.

The real-world-related objectives of this topic are as follows:

To solve certain real-life problems and to apply knowledge of sequences to handle several practical situations.

Activity 2: Select a mathematical model or a pure mathematical problem that can be connected to real-world contexts.

For example, it can be considered as the general term of a sequence.

Problem: Given an arithmetic sequence, write the general formula of the sequence and determine how many terms the sequence has

Activity 3: Identify the conditions in a real-world context or situation that are appropriate for the selected mathematical model

For example, consider it as the general term of a sequence. For the pure mathematical problem of writing a sequence that forms an arithmetic progression, the choice of a real-life context depends on the situation. For instance, with the above sequence, we obtain the general term formula as …

Activity 4: Formulate the real-world problem

Example 3.17: Ms. Souk buys a washing machine with an initial price of 1,700,000 kip. It is known that after each year of use, its value decreases by 150,000 kip.

a) Write a formula for the value of the machine after years of use.

b) If the value of the machine decreases to 200,000 kip, how many years can Ms. Souk use the machine?

Project 1 (Topic: Sequences): "Applying knowledge of arithmetic and geometric sequences to solve real-life problems"

Project 2 (Topic: Antiderivatives – Integrals): "Applying knowledge of antiderivatives and integrals to solve real-life problems"

Through this project, the connection between mathematics and real life can be recognized by applying problems with real-life contexts that use knowledge of antiderivatives and integrals to solve problems arising from practical situations in daily life and production.

The objectives of these projects are to develop the components of students' real-world problem-solving competence through the stages of project implementation and the problem-solving steps in real-life contextual problems designed and developed by the dissertation author

3.2.3. Measure 3: Design several process-based assessment tools to evaluate the development of students' real-world problem-solving competence

a) Purpose of the measure

The measure is to support teachers in designing and using formative assessment tools (observation sheets, checklists, rubrics, students' self-assessment journals, and teachers' journals) in assessing students' real-world problem-solving competence.

b) Implementation of the measure

Step 1. Identify the assessment objectives and the indicators of real-world problem-solving competence that need to be assessed.

Step 2. Select assessment tools that are appropriate for the objectives and the context of use

The observation sheet is used when it is necessary to directly monitor students' behaviors, attitudes, interactions, level of participation, and ways of handling situations during the learning process

A checklist is appropriate when the teacher needs to determine whether students have performed or not performed the basic requirements of a task

A rubric is appropriate when it is necessary to assess students' levels of achievement based on specific criteria and different quality levels

A learning journal is appropriate when it is necessary to explore students' thinking processes, experiences, difficulties, ways of overcoming them, and their level of self-awareness.

Step 3. Design the specific content of each assessment tool.

Step 4. Guide teachers to pilot the tools and make necessary adjustments.

Step 5. Conduct assessment during the teaching–learning process.

Step 6. Analyze the assessment results and use them to support students

Example 3.19. Teacher's Observation Sheet

Purpose: To assess the manifestations of real-world problem-solving competence through teaching selected elements of mathematical analysis, discussions, and the implementation of practical tasks

Information: Student's full name: ..... Class: .....

Lesson/Topic: ..... Date: .....

Number	Indicators to be observed	Level 1 Limited	Level 2 Fair	Level 3 Good	Level 4 Proficient
1	Identifies the given information in the problem involving elements of calculus and the requirements that need to be addressed in the real-world situation				
2	Relates appropriate knowledge of selected elements of mathematical analysis (calculus)				
3	Constructs a model using selected elements of mathematical analysis (calculus)				
4	Proposes a solution/approach				
5	Presents and explains the results				
6	Shows cooperation and makes adjustments when receiving feedback				

Teacher's notes:……..

Example 3.20: Checklist for Assessing Learning Products/Tasks

Purpose: To check the extent to which the core requirements of the learning task 'Applying integrals to calculate the area of a plane figure' have been completed

Task/Product title: .....

Group/Student: .....

Criteria	Yes	No	Evidence/Notes
Accurately identifies the real-world problem that needs to be solved			
Collects the necessary data			
Establishes an appropriate mathematical model			
Perform calculations / mathematical reasoning accurately			
Interpret the result in the appropriate (task-specific) language.			
Propose comments or recommendations			
The product is clearly presented and shows collaboration			

3.3. Conclusion of Chapter 3

The dissertation proposes three teaching measures for calculus elements aimed at developing real-world problem-solving competence for Lao high school students:

(1) Training competency components through problems with real-lifecontexts.

(2) Constructing problems with real-life contexts and organizing project-based learning.

(3) Designing several process-based assessment tools to evaluate students' real-world problem-solving competence.

These measures have been pedagogically tested to verify their feasibility and effectiveness.

Chapter 4: PEDAGOGICAL EXPERIMENT

4.1. Purpose of the Experiment

The purpose of the pedagogical experiment is initially to verify the validity of the scientific hypothesis proposed in the dissertation and to examine the feasibility of the pedagogical measures aimed at developing the components of real-world problem-solving competence for Grade 12 high school students, as proposed in Chapter 3.

To evaluate the effectiveness of the teaching measures proposed in Chapter 3, the dissertation author assesses them through three aspects:

(1) Whether the proposed teaching measures can be implemented in teaching certain calculus topics in high schools.
(2) Whether implementing these measures truly helps students develop the ability to apply mathematics to solve real-life problems.
(3) Whether the proposed teaching measures effectively help learners develop real-world problem-solving competence.

4.2. Organization of the Experiment

4.2.1. Subjects and Duration of the Experiment

4.2.1.1. Pre-experiment Assessment for Students

4.2.1.2. Analysis of Students' Performance Before the Experiment

4.2.2. Procedure for Conducting the Experiment

4.2.3. Methods of the Pedagogical Experiment

4.2.3.1. Basis and Content of the Evaluation

4.2.3.2. Methods for Evaluating the Pedagogical Experiment

4.3. Content of the Pedagogical Experiment

4.4. Analysis of Experimental Results

4.4.1. Some General Remarks

4.4.2. Effectiveness and Feasibility of the Measures

Table 4.4. Results of the survey on the perceived necessity of the proposed measures

Evaluation Criteria	Quantity/ Percentage	Level				Average Score
		Very necessary	Necessary	Less necessary	Not necessary	
Measure 1	Quantity	2	5	2	1	2,80
	Percentage %	20%	50%	20%	10%	
Measure 2	Quantity	3	4	2	1	2,90
	Percentage %	30%	40%	20%	10%	
Measure 3	Quantity	3	5	1	1	3,00
	Percentage %	30%	50%	10%	10%	

Thus, the data in Table 4.4 show that the proposed measures are evaluated as highly necessary. In particular, the measures related to "teaching mathematics for real-world problem solving," namely Measure 1, Measure 2, and Measure 3, are all rated at a very necessary level, with average scores in the range of $2.60 \le \overline{x} \le 3.39$ This indicates that teachers place strong emphasis on students' practical and experiential activities, thereby contributing to the development of the components of real-world problem-solving competence.

Although there are some differences in the level of necessity among the measures, in general, the participants share the view that the measures proposed in the dissertation are appropriate and necessary in the teaching process aimed at developing real-world problem-solving competence within the current general education curriculum, guiding learners to apply mathematical knowledge to real-life situations.

Table 4.5. Results of the survey on the feasibility of the proposed measure

Evaluation Criteria	Quantity/ Percentage	Level				Average Score
		Very necessary	Necessary	Less necessary	Not necessary	
Measure 1	Quantity	3	5	2	0	3,10
	Percentage %	30%	50%	20%	0%	
Measure 2	Quantity	2	6	2	0	3,00
	Percentage %	20%	60%	20%	0%	
Measure 3	Quantity	3	3	3	1	2,80
	Percentage %	30%	30%	30%	0%	

From the survey results and the analysis of the necessity and feasibility of the proposed measures to develop real-world problem-solving competence for high school students, teachers need to pay attention to the organization and implementation of these measures.

a) Evaluation from teachers

Students' real-world problem-solving competence still has many limitations; many students do not yet know how to transform real-life problems into mathematical ones. Therefore, the proportion of students who can effectively apply this competence to solve problems remains low. In particular, the competence of constructing mathematical models accounts for 42.85%, the competence of presenting solutions is 47.61%, and the competence of evaluating and deeply analyzing solutions is still weak, with only about 23.80% of students reaching this level.

b) Evaluation from students in the experimental class

Most students surveyed on the levels of the components of real-world problem-solving competence achieved mainly levels 2 to 3, indicating that they still have limitations and have not yet performed well in the steps of developing this competence. The component most developed by students is the ability to propose solutions based on the established model, with 23 students reaching level 3 (54.76%). In contrast, the least developed component is the ability to construct mathematical models, with only 3 students achieving a very good level (7.14%).

4.4.3. Quantitative Analysis

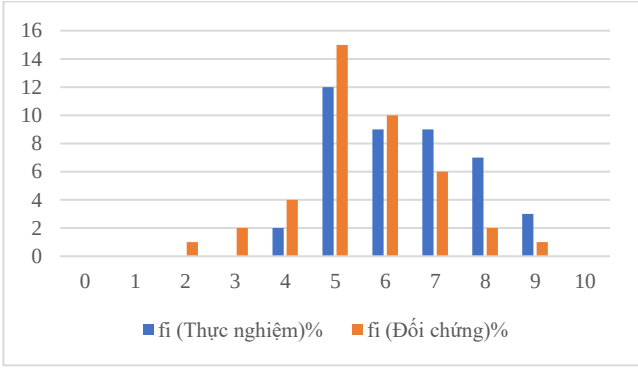

Figure 4.3. Line graph comparing test scores after the experiment

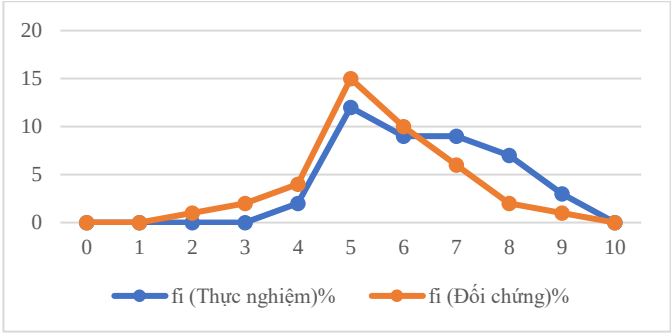

Figure 4.4. Line graph comparing post-experiment test scores

From Figure 4.4, it can be seen that the peaks of the two frequency polygons differ significantly. Specifically, the peaks at values 2, 3, 4, 5, and 6 for the experimental group are lower than those of the control group, while the peaks at values 7, 8, and 9 for the experimental group are higher than those of the control group. This initially indicates that the real-world problem-solving competence of students in the experimental group is higher than that of the control group.

Therefore, to confirm the quality of the pedagogical experiment, the dissertation author conducted statistical data analysis and obtained the following results:

Table 4.9. Statistical data processing table for the experimental and control groups

Experimental class $(n_{TN} = 42)$					control class $(n_{ĐC} = 41)$				
x_i	$n_{i(TN)}$	$x_i - \overline{x}$	$(x_i - \overline{x})^2$	$n_{i(TN)}.(x_i - \overline{x})^2$	x_i	$n_{i(ĐC)}$	$x_i - \overline{x}$	$(x_i - \overline{x})^2$	$n_{i(TN)}.(x_i - \overline{x})^2$
0	0	-6,38	40,7044	0	0	0	-5,51	30,3601	0
1	0	-5,38	28,9444	0	1	0	-4,51	20,3401	0
2	0	-4,38	19,1844	0	2	1	-3,51	12,3201	12,3201
3	0	-3,38	11,4244	0	3	2	-2,51	6,3001	12,6002
4	2	-2,38	5,6644	11,3288	4	5	-1,51	2,2801	11,4005
5	12	-1,38	1,9044	22,8528	5	15	-0,51	0,2601	39,015
6	9	-0,38	0,1444	1,2996	6	10	0,49	0,2401	4,401
7	9	0,62	0,3844	3,4596	7	6	1,49	2,2201	13,3206
8	7	1,62	2,6244	18,3708	8	2	2,49	6,2001	12,4002
9	3	2,62	6,8644	20,5932	9	1	3,49	12,1801	12,1801
10	0	3,62	13,1044	0	10	0	4,49	20,1601	0

4.4.4. Qualitative Analysis

Based on the data in Table 4.8, the results before and after the experiment show that the differences among the components of students' real-world problem-solving competence are not large; however, students show great interest when participating in these activities. The components of students' real-world problem-solving competence have shown improvement, specifically as follows:

1. ***Competence in identifying the problem to be solved:***

Before the experiment, 19 students (45.23%) had difficulty understanding real-life problems. Afterward, this increased to 35 students (85.33%), showing the need to emphasize developing the ability to recognize mathematical aspects in real-life situations.

2. ***Competence in constructing mathematical models***

Before the experiment, only 15 students (35.71%) could model and use mathematical language to simplify real-life problems. Afterward, 26 students (61.9%) improved, showing enhanced ability to represent and transform real-life situations mathematically.

3. ***Competence in proposing solutions based on the established model:***

Before the experiment, only 17 students (40.47%) could plan, model, and apply knowledge to solve problems. Afterward, 28 students (66.66%) improved, showing enhanced ability to identify problems and choose appropriate solution approaches.

4. ***Competence in presenting solutions:***

Before the experiment, only 19 students (45.23%) could plan, present, and solve problems using appropriate methods and tools. Afterward, 33 students (78.57%) improved, demonstrating clearer, more logical problem-solving and greater engagement in real-life applications.

5. ***Competence in evaluating and further analyzing solutions:***

Before the experiment, only 13 students (30.95%) could review, represent, and report solutions while applying mathematical reasoning. Afterward, 18 students (42.85%) improved, showing better evaluation, analysis, and use of mathematical tools, with increased interest in real-world problem-solving.

Thus, for students in the experimental class, the pedagogical measures implemented have had a positive impact on the formation and development of the components of real-world problem-solving competence.

4.5. Conclusion of Chapter 4

In summary, although the experiment was conducted on a limited scale, the results show that the scientific hypothesis of the study has been validated and initial evidence has been obtained regarding the feasibility of teaching aimed at developing students' real-world problem-solving competence

GENERAL CONCLUSION

The dissertation has achieved the following main results:

- It provides an overview, analysis, and synthesis of theoretical and practical issues related to the development of real-world problem-solving competence, including concepts of competence, problem-solving competence, real-world problem-solving competence, teaching methods for real-world problem solving, and proposes a teaching process for developing this competence in high schools.

- Based on expert consultation, the dissertation proposes a framework of components, indicators, and evaluation criteria for real-world problem-solving competence. The situational survey also clarifies certain current conditions and limitations in students' real-world problem-solving competence.

- From these findings, the author proposes three pedagogical measures to develop real-world problem-solving competence for high school students through teaching selected topics of Grade 12 calculus in the Lao PDR

+ Measure 1: Develop the components of real-world problem-solving competence.

+ Measure 2: Construct problems with real-life contexts and organize project-based learning.

+ Measure 3: Design several process-based assessment tools to evaluate students' real-world problem-solving competence.

The results of the dissertation have been validated through pedagogical experiments, including a control group at Saysettha High School, and through the analysis of students' learning outcomes over the course of the experimental teaching period. Thus, it can be concluded that the research objectives have been achieved, the research tasks have been completed, and the scientific hypothesis is acceptable