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TEACHING THE TOPIC OF COORDINATE METHOD IN THE PLANE FOR GRADE 10 TOWARD ENHANCING REAL-WORLD CONTENT

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ABSTRACT

This paper presents teaching measures for the topic of Coordinate Method in the Plane (Grade 10 Mathematics) toward enhancing real-world content, meeting the requirements of the 2018 General Education Program of Vietnam. Based on a survey of the current situation at high schools and an analysis of the cognitive characteristics of grade 10 students, the study proposes three pedagogical measures: (1) Developing a system of real-world problems on the coordinate method in the plane; (2) Organizing teaching activities toward enhancing real-world content; (3) Exploiting and utilizing the advantages of information technology in teaching. Each measure is illustrated with specific examples using practical contexts such as maritime navigation, flight trajectories, satellite dish design, and telecommunications coverage. The results of pedagogical experimentation at Dai Mo High School, Hanoi, show that the proposed measures are feasible and effective, contributing to improving learning outcomes, developing mathematical modeling competence, and enhancing students' learning interest.

KEYWORDS: Coordinate method, real-world content, mathematics teaching, modeling, mathematical competence.

1. INTRODUCTION

The 2018 General Education Program for Mathematics has clearly defined the goal of developing students' competencies, emphasizing "*creating opportunities for students to experience and apply Mathematics to practice; establishing connections between mathematical ideas, between Mathematics and practice*" (Ministry of Education and Training, 2018, p. 6). This requires teachers to design teaching activities linked to practical contexts, helping students see the meaning and applications of mathematics in daily life.

The Realistic Mathematics Education (RME) theory, proposed by Freudenthal in 1971, emphasizes that mathematics should be viewed as a human activity connected to reality, starting from situations

with real contexts, which may be imaginary situations or practical situations that students can imagine (Freudenthal, 1973; Gravemeijer & Doorman, 1999). This perspective is entirely consistent with the current educational innovation direction in Vietnam.

The topic of Coordinate Method in the Plane holds a special position in the Grade 10 Mathematics curriculum. The emergence of the Cartesian coordinate system marked a great turning point in human thought: for the first time, an intuitive spatial image (geometry) could be represented and calculated with absolute precision using numbers and equations (algebra). This "spatial digitization" nature makes the coordinate method the topic with the richest potential for exploiting practical applications in the high school curriculum.

However, a survey of the current situation at high schools shows that teaching this topic still has many limitations. Teachers face difficulties in designing and selecting appropriate practical problems (32%), limited class time, exam pressure leaning toward theory, and a scarcity of reference materials on practical problems (Nguyen, 2017). Therefore, enhancing real-world content in teaching the Coordinate Method in the Plane is both an urgent requirement and an opportunity to achieve the goal of developing students' competencies.

This paper focuses on analyzing and proposing three specific teaching measures, accompanied by illustrative examples and preliminary experimental results to confirm the feasibility and effectiveness of the measures.

2. LITERATURE REVIEW

2.1. Teaching Toward Enhancing Real-World Content

Teaching toward enhancing real-world content is an orientation for organizing the teaching process in which teachers proactively select, design, and systematically use situations, problems, and learning tasks linked to daily life, labor, production, and social issues. Through this, students not only acquire subject knowledge but also understand the practical meaning of that knowledge, seeing the connection between what they learn and the problems of the surrounding life (Tran, 2018; Nguyen, 2017).

Real-world problems are understood as problems whose premises or conclusions contain elements related to practical activities (Cao & Nguyen, 2024). These problems can be divided into two types: (1) problems linked to reality - placed in real or life-like practical contexts; (2) practical problems (quasi-real) - constructed based on situations that may occur in reality but are hypothetical.

2.2. The Mathematization Process According to PISA

According to the OECD theoretical framework in PISA assessments, to solve problems with practical content, the mathematization process operates through five basic steps (Niss, Blum, & Galbraith, 2007; Blum & Ferri, 2009):

1. **Starting from a real problem:** identifying and understanding the context of a real-life situation.
2. **Restating the problem:** using mathematical concepts and identifying relevant mathematical knowledge.
3. **Transforming into a mathematical problem:** through hypothesizing, generalization, and formalization.
4. **Solving the mathematical problem:** using mathematical methods and tools.
5. **Making the solution meaningful:** comparing with the original practical context, identifying limitations and reasonableness.

This process can be condensed into three stages: (1) Transitioning from the real problem to the mathematical domain; (2) Solving mathematically; (3) Reflecting on and evaluating the results.

2.3. The Role of Reality in Teaching the Coordinate Method

Enhancing real-world content in teaching the Coordinate Method in the Plane brings core pedagogical values (Cheng, 2013; Karakoç & Alacacı, 2015):

First, reality is the starting motivation and the environment for consolidating knowledge. According to Nguyen (2015), mathematics teaching activities should not begin immediately with abstract definitions but should originate from the need to solve practical problems. For example, the need to accurately determine the position of a ship at sea leads to the need to form the concepts of point coordinates and vectors.

Second, reality is an essential path for forming and developing mathematical modeling competence - one of the five core competency components to be developed for students according to the 2018 General Education Program. Teaching the coordinate method linked to practice is the process of training students in language conversion skills: from a real problem (such as motion trajectories, land boundaries), they must know how to establish an appropriate coordinate system and convert physical data into coordinate parameters.

Third, reality contributes to general technical education and career orientation. In the context of the Fourth Industrial Revolution, coordinate thinking is the foundation of many fields of science and technology, from architectural design, satellite orbits, to global positioning systems.

3. RESEARCH METHODS

3.1. Situation Survey

The study surveyed 40 Mathematics teachers at high schools in Hanoi about the current situation of teaching the Coordinate Method in the Plane topic toward enhancing practical content. The survey instrument included a questionnaire with a 5-point Likert scale (1 - Strongly disagree to 5 - Strongly agree). Data were processed using descriptive statistics.

3.2. Pedagogical Experimentation

The experiment was conducted at Dai Mo High School, Hanoi, in the second semester of the 2025-2026 school year. The experimental class was 10D2 (47 students) taught according to the proposed measures; the control class was 10D1 (45 students) taught in the conventional way. Both classes had equivalent levels (pre-test mean scores were 6.61 and 6.71, respectively).

The experimental content included the following lessons: Equation of a Circle and Three Conic Sections. After the experiment, a common 45-minute test was administered to both classes. Results were evaluated using both qualitative methods (observation, interviews) and quantitative methods (t-Student test)

4. TEACHING MEASURES

Based on the orientation for developing measures including: (1) closely following the program objectives and ensuring systematicity; (2) selecting practical contexts that are familiar, diverse, and mathematically meaningful; (3) enhancing interdisciplinary elements and technology application; (4) ensuring feasibility and suitability for teaching conditions, the study proposes three specific measures.

4.1. Measure 1: Developing a System of Real-World Problems on the Coordinate Method in the Plane

Objective

To develop and standardize a system of real-world problems to provide learning resources for teaching the Coordinate Method in the Plane topic. This exercise system helps transform abstract mathematical knowledge into tools for solving practical problems, thereby arousing interest and clarifying the practical meaning of mathematics.

Content and Implementation

The system of real-world problems is built based on the objectives of the 2018 General Education Program and the requirements to be achieved for the topic. The problems are organized into groups corresponding to the main knowledge strands:

Group 1: Problems applying coordinate vectors in situations involving forces and velocities. Problems on force analysis on inclined planes, velocity synthesis of airplanes with wind or ships with currents. Through these, students understand the meaning of vectors, vector addition, vector decomposition along two directions, and the dot product.

Group 2: Problems applying lines and circles in maps, influence zones, and flat geographic space. Situations on determining travel routes, radar coverage, device operating ranges, maritime collision prediction. Through these, students see the role of lines, circles, distance formulas, and relative positions in practice.

Group 3: Problems applying the three conic sections in architecture and optics. Situations on arch tunnels or elliptical flower beds, suspension bridges or arch bridges in parabolic form, satellite dishes, headlight reflectors. Students clarify the meaning of foci, axes of symmetry, major/minor axes, and conic equations in each specific situation.

The problem development process follows 5 steps:

1. **Identifying lesson objectives and requirements**
2. **Selecting the exercise system:** choosing practical contexts with reliable sources that can be quantified by coordinates.
3. **Modeling the problem:** pedagogical processing, removing distracting elements, coordinate-based transformation.
4. **Designing a sequence of questions according to cognitive levels:** from Recognition - Comprehension to Application and Higher-order Application.
5. **Summarizing, comparing, and interpreting practically:** guiding students to interpret the practical meaning of the found solutions and discuss the limitations of the model.

Illustrative Examples

Example 1: Flight Path Correction Due to Wind Effects (Group 1)

Context: An airplane needs to fly straight north, but there is a wind blowing from the southwest at 60 km/h. The airplane flies with an airspeed of 550 km/h. How many degrees west should the pilot steer the airplane to fly straight north?

Modeling:

Choose the coordinate system Oxy: origin O at the airplane's position, Oy points north, Ox points east.

Wind velocity vector: $\vec{v}_{\text{wind}} = (30\sqrt{2}; 30\sqrt{2})$

Airplane velocity vector (steering west by angle α): $\vec{v}_{\text{plane}} = (-550 \sin \alpha; 550 \cos \alpha)$.

Condition for flying straight north: total x-component = 0

$$-550 \sin \alpha + 30\sqrt{2} = 0 \Rightarrow \sin \alpha = \frac{30\sqrt{2}}{550} \approx 0.077 \Rightarrow \alpha = 4.42.$$

Practical interpretation: The pilot cannot point the airplane's nose straight north but must steer it approximately 4.42° west to counteract the wind's push. In reality, the airplane's flight management system continuously updates wind velocity to adjust the angle in real time.

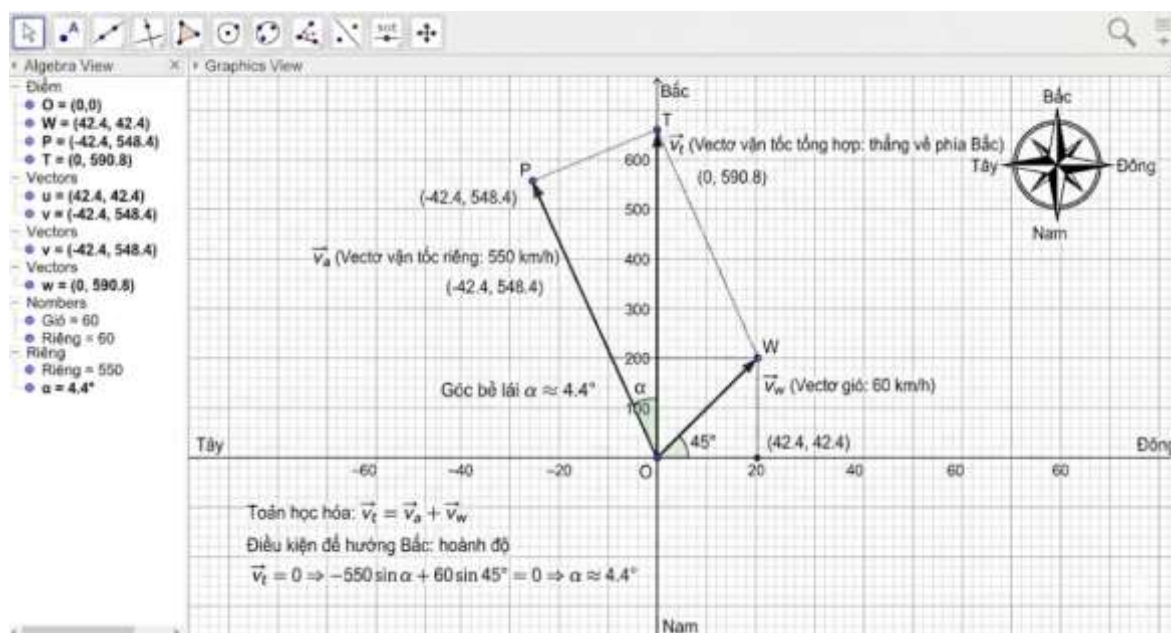


Figure 1: Vector velocity diagram in the flight path correction problem

Example 2: Automatic Irrigation System (Group 2)

Context: A rotating automatic sprinkler is placed at $I(5;4)$ with a maximum spray radius of 5m. Nearby, there is an internal path along the line $\Delta: 3x+4y-16=0$. Determine whether the sprinkler water reaches the path, and if so, how long the wet section is, to calculate the cost of anti-slip matting.

Modeling:

The irrigation area is circle (C): $(x-5)^2+(y-4)^2=25$

Distance from center I to line Δ :

$$d(I, \Delta) = \frac{|3 \cdot 5 + 4 \cdot 4 - 16|}{\sqrt{3^2 + 4^2}} = \frac{|15 + 16 - 16|}{5} = \frac{15}{5} = 3 \text{ (m)}.$$

Since $d(I, \Delta) < R$ ($3 < 5$), the line intersects the circle, so water reaches the path.

Length of the wet section (chord):

$$AB = 2\sqrt{R^2 - d^2} = 2\sqrt{5^2 - 3^2} = 2\sqrt{25 - 9} = 2 \cdot 4 = 8 \text{ (m)}.$$

Matting cost: $8 \times 200.000 = 1\,600\,000$ VND

Example 3: LORAN Maritime Navigation Problem (Group 3)

Context: A ship is offshore, 40 miles from a straight coastline. On the coast, there are two LORAN stations A and B, 300 miles apart. From the received signals, the captain determines that the ship is 80 miles closer to station A than to station B. Determine the ship's coordinates.

Modeling:

Place A(0;150), B(0;-150) on the Oy axis, the coastline is the Oy axis, and the ship is 40 miles from the coast, so the x-coordinate is 40.

Let P(40;y) be the ship's position. The ship is 80 miles closer to A than B: $PB - PA = 80$.

By the definition of a hyperbola: $|PB - PA| = 2a \Rightarrow a = 40, c = 150$

Hyperbola equation: $\frac{y^2}{1600} - \frac{x^2}{20900} = 1$. Substitute $x = 40$:

$$\frac{y^2}{1600} - \frac{x^2}{20900} = 1.$$

$$\frac{y^2}{1600} = 1 + \frac{1600}{20900} = \frac{20900 + 1600}{20900} = \frac{22500}{20900}$$

$$y = \frac{600}{\sqrt{209}} \approx 41.5.$$

Thus the ship's coordinates: P(40; 41,5)

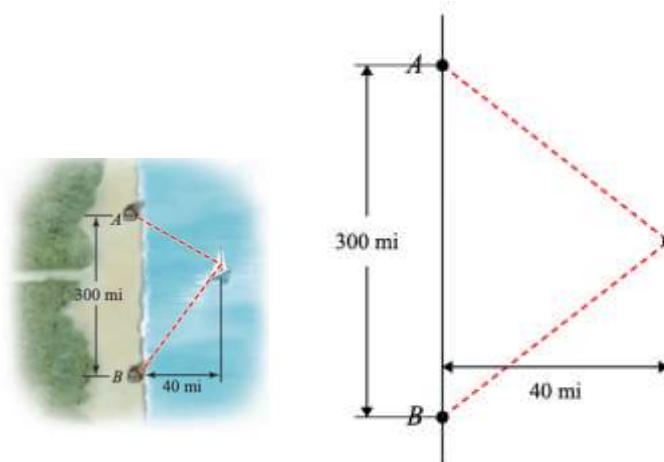


Figure 2: Ship positioning model using hyperbola in the LORAN system

Practical meaning: The hyperbola is not just an abstract geometric object but a mathematical model used in real positioning systems.

4.2. Measure 2: Organizing Teaching Activities toward Enhancing Real-World Content

Objective

To organize teaching activities that help students master the knowledge and skills of the topic and apply them to describe, analyze, and solve situations linked to daily life, science, and technology. Simultaneously, develop mathematical modeling competence, problem-solving competence, and mathematical thinking and reasoning competence.

Implementation

Teaching activities are organized according to a four-step process:

Step 1: Approaching the situation and identifying the real problem. The teacher provides a practical context and presents the problem. Students extract data, remove distracting elements, and restate the core requirement. Teacher and students jointly analyze to flexibly choose the optimal method (pure geometry, vectors, or coordinates).

Step 2: Mathematizing the practical situation. Students simplify reality (considering the ship as a point mass, the coast as a straight line). Under the teacher's guidance, students actively establish an appropriate Oxy coordinate system and convert real elements into equations and coordinate systems.

Step 3: Solving the problem in the mathematical environment. The teacher observes and provides computational support when needed. Students apply coordinate method formulas (distance, angle, equations of curves) to solve the mathematical model.

Step 4: Interpreting results and comparing with reality. Students convert mathematical results into practical answers and check for logical consistency. If there are contradictions, they repeat the modeling loop. The teacher summarizes the key knowledge.

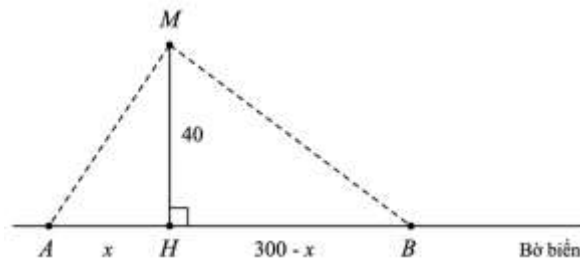
Illustrative Example

Activity: Applying Hyperbola to the LORAN Maritime Navigation Problem (Duration: 15 minutes)

Step 1: Approaching the situation and creating cognitive conflict (5 minutes)

The teacher presents the LORAN problem. Students read carefully and underline key terms: "40 miles from the coast," "A and B are 300 miles apart," "80 miles closer to A than B."

The teacher asks a guiding question: "If the coastline is a straight line and the ship drops a perpendicular to the coast at H. Let x be the distance from H to A. Use the Pythagorean theorem to express the distances from the ship to A and B, then formulate an equation."

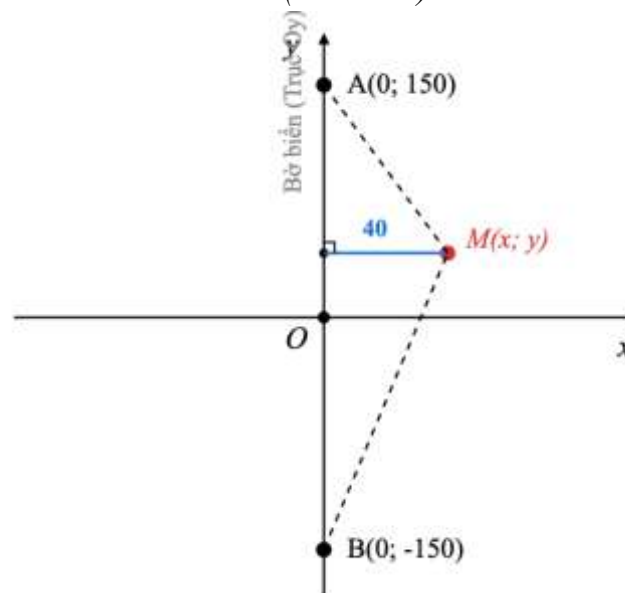


Students derive the irrational equation:

$$\sqrt{1600 + (300 - x)^2} - \sqrt{1600 + x^2} = 80$$

The teacher emphasizes the difficulty of solving this equation, creating motivation: "We need a more powerful tool - the Coordinate Method."

Step 2: Modeling using the Coordinate Method (6 minutes)



The teacher guides: A, B are on Oy, 300 apart, O is the midpoint $\Rightarrow A(0;150), B(0;-150) \Rightarrow c = 150$.

The ship is 80 miles closer to A than B $\Rightarrow MB - MA = 80 \Rightarrow 2a = 80 \Rightarrow a = 40$.

Students calculate: $b^2 = c^2 - a^2 = 150^2 - 40^2 = 22500 - 1600 = 20900$

Hyperbola equation: $\frac{y^2}{1600} - \frac{x^2}{20900} = 1$

Substitute $x^2 = 1600$ (40 miles from the coast):

$$\frac{y^2}{1600} - \frac{1600}{20900} = 1 \Leftrightarrow y^2 = 1600 \left(1 + \frac{16}{209}\right) \approx 1722.48 \Rightarrow y \approx 41.5$$

Step 3: Reporting, discussion, and knowledge consolidation (4 minutes)

A group representative presents. The teacher organizes a comparison: the irrational equation in Step 1 versus the coordinate system in Step 2 - clearly, the coordinate method significantly simplified the problem.

The teacher concludes: The LORAN signal only tells us that the ship lies on a branch of a hyperbola. In practice, to know the exact position, two pairs of transmitter stations are used; the intersection of two hyperbolas is the ship's position.

4.3. Measure 3: Exploiting and Utilizing the Advantages of Information Technology

Objective

To use information technology as a tool to support visualization, dynamic simulation, linking practical data, and verifying results. Thereby, concepts, theorems, formulas, and geometric relationships in the coordinate plane become easier to observe, manipulate, and closer to students.

Content and Implementation

Exploiting digital platforms (GeoGebra, Desmos, satellite maps, dynamic simulation videos) helps create a bridge between physical images of reality and mathematical models. Teachers can extract coordinate structures from situations such as: satellite orbits around Earth, arch cross-sections, radar coverage, surveillance camera ranges.

Notes for implementation:

Ensure students directly manipulate, not just observe.

Integrate technology alongside manual computation practice.

Choose problems and contexts appropriate to students' levels.

Prepare GeoGebra files and backup plans when computers are unavailable.

Control time and reasonably allocate activities.

Use technology for formative assessment.

Illustrative Examples

Example : Elliptical Satellite Orbit

Step 1: Visualizing the context

The teacher uses a GeoGebra simulation of a satellite orbiting Earth in an elliptical orbit. Students observe and note: the satellite's orbit is elliptical, with Earth at one focus.

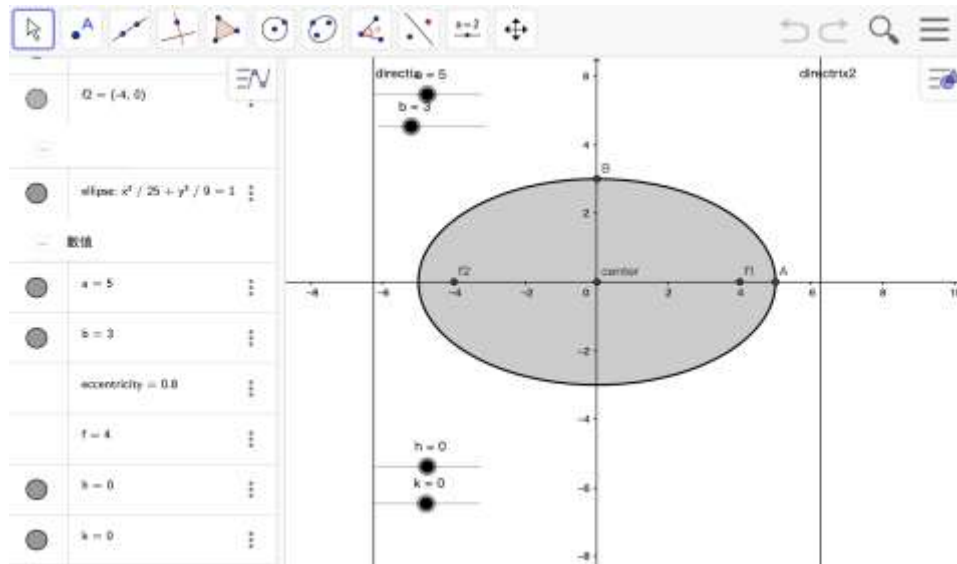


Figure 3: Simulation of elliptical satellite orbits with different eccentricity values on GeoGebra

Step 2: Interacting with real data

The teacher provides Sputnik I data: $a = 6955$ km, $e = 0.052$. Earth's radius $R = 6357$ km.

Students calculate: $e = \frac{c}{a}$.

$$c = ae = 6955 \times 0.052 = 361.66 \text{ km}$$

$$a + c = 6955 + 361.66 = 7316.66 \text{ km}$$

Maximum distance from satellite to Earth's surface:

$$7316.66 - 6357 = 959.66 \text{ km}$$

Then use GeoGebra to represent the orbit and verify visually.

Step 3: Extended reasoning

Students change the eccentricity e in the software and observe: when e is small, the orbit is nearly circular; when e increases, the ellipse becomes flatter and the focus moves farther from the center.

5. PEDAGOGICAL EXPERIMENTATION

5.1. Qualitative Results

Observations of the experimental classes showed that students participated more actively. When problems were set in practical contexts, students showed greater interest, took more initiative in reading and understanding problems, discussing with peers, and finding ways to establish appropriate mathematical models. Many students initially learned to relate coordinate knowledge to practical situations and interpret results according to the problem's meaning, rather than merely performing calculations. Compared to the control class, experimental class students demonstrated better collaboration, presentation, and argumentation skills during group discussions.

5.2. Quantitative Results

The post-experiment test results are summarized in Table 1.

Table 1: Distribution of post-experiment test scores

Class	N	[4.5;5.5)	[5.5;6.5)	[6.5;7.5)	[7.5;8.5)	[8.5;9.5)	[9.5;10]	Mean
Experimental	47	3	6	10	15	8	5	7.22
Control	45	6	10	14	9	4	2	6.50

The t-Student test result: $t = 2.50 > 1.99 = t_{0,05;90}$, rejecting H_0 and accepting H_1 . The difference in mean scores between the experimental and control classes is statistically significant. This demonstrates that organizing teaching of the Coordinate Method in the Plane topic toward enhancing real-world content has produced positive effects.

6. CONCLUSION

The study has proposed three teaching measures for the Coordinate Method in the Plane topic for Grade 10 toward enhancing real-world content:

1. **Developing a system of real-world problems** with groups of exercises applying vectors, lines - circles, and the three conic sections, following a 5-step process that ensures pedagogical and scientific soundness.
2. **Organizing teaching activities** following a 4-step process: approaching the situation, mathematizing, solving the problem, and interpreting results - helping students fully experience the mathematical modeling cycle.
3. **Exploiting the advantages of information technology** such as GeoGebra for visualization, dynamic simulation, and result verification, transforming abstract concepts into vivid visual experiences.

The experimental results at Dai Mo High School show that these measures are feasible and effective: the experimental class achieved a higher mean score (7.22 vs. 6.50), while also demonstrating stronger modeling competence and learning interest. The study contributes to achieving the objectives of the 2018 General Education Program in developing students' competence to apply mathematics to practice.

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