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Conclusion

The synergy between industry and academia is a transformative force in the modernization of vocational instruction. By prioritizing collaborative curriculum design and shared resources, this model empowers students, streamlines industrial recruitment, and bolsters national economic resilience. In a world where the pace of change is dictated by industrial innovation, the ability to teach through an integrated industry-academia lens is essential for any vocational system aiming to thrive in the competitive global economy.

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DESIGNING APPLIED GEOMETRY EXAM QUESTIONS TO ASSESS REAL-WORLD PROBLEM-SOLVING COMPETENCE IN UPPER SECONDARY AND HIGHER EDUCATION

Abstract

This study establishes a framework of five design principles and evaluation criteria for applied geometry exam questions to meet the requirements of competency-based development and STEM education. The findings confirm that embedding geometry problems within practical contexts is an effective solution for assessing learners' mathematical modeling and problem-solving skills. The study provides a crucial theoretical and practical foundation for innovating mathematics assessment in the current educational landscape.

Keywords:

applied geometry, mathematical modeling, competency-based assessment, exam design, STEM education.

Rationale: Modern education is shifting from knowledge transmission to **competency-based assessment**. However, geometry examinations remain largely formal and detached from reality, failing to reflect the role of mathematics in engineering and STEM.

Gap: Systematic research on designing applied geometry exams—integrating principles, criteria, and practical examples for both secondary and higher education—is still lacking.

Objectives: This study aims to:

1. Establish a **theoretical foundation** for applied geometry design.
2. Propose a **framework of principles and criteria** for quality evaluation.
3. Develop a **standardized design process**.

4. Provide **illustrative problems** in practical contexts.

2. Theoretical foundation

2.1. Applied Geometry in Mathematics Education Applied geometry involves using geometric concepts to model and solve real-world problems in fields such as architecture, engineering, and industrial production. In education, this process follows a cycle: starting with a **practical situation**, transforming it into a **mathematical model**, and deriving a solution.

2.2. Competency-based Assessment Modern assessment must evaluate various cognitive and functional levels. For applied geometry, these include:

- **Recognition & Understanding:** Identifying and interpreting geometric models.
- **Application:** Solving problems in both familiar and novel contexts.
- **Higher-order Thinking:** Mathematical modeling and optimization.

Exam structures must be deliberately designed to reflect these hierarchy levels to accurately measure learner competence.

3. Research methods

The study employs three primary methods:

- **Document Analysis:** Reviewing literature on mathematics education and competency-based assessment to build the theoretical framework.

- **Theoretical Synthesis:** Systematizing design principles and evaluation criteria based on existing research.

- **Illustrative Design:** Constructing specific applied geometry problems to demonstrate the framework's feasibility.

4. Principles for designing applied geometry examinations

4.1. Practicality Problems must originate from authentic life or technical contexts with plausible, realistic data.

4.2. Mathematical Modeling The assessment must reflect the modeling cycle (Blum & Leiss, 2007), requiring learners to:

1. **Structure:** Identify geometric elements from real situations.
2. **Mathematize:** Establish diagrams and select appropriate geometric tools.
3. **Solve:** Apply theorems and perform calculations.
4. **Interpret & Validate:** Translate mathematical results back into the original practical context.

Evaluating multiple stages of this cycle provides a deeper assessment of problem-solving competence.

4.3. Competence Differentiation Examinations must be structured across hierarchical levels—from basic recognition to advanced, open-ended applications—to effectively categorize learner proficiency.

4.3. Competence Differentiation (Continued)

The suggested proportions for exam structure are: **Basic (40%)**, **Application (30%)**, **Advanced Application (20%)**, and **Open-ended (10%)**. This hierarchy targets core competencies (Niss, 2015), specifically focusing on:

- **Spatial Thinking:** Identifying structures and spatial relationships.
- **Modeling:** Transforming reality into geometric representations.
- **Problem Solving & Interpretation:** Applying tools and validating results in real-world contexts.

4.4. Interdisciplinary (STEM) & Integration Framework

Examinations should integrate fields such as Physics (optics/statics), Technology (engineering), Geography (surveying), and Economics (optimization). The proposed framework links three pillars:

1. **Context:** Real-life starting points.
2. **Process:** Mathematical modeling and reasoning.

3. **Assessment:** Measuring specific competencies (spatial, modeling, solving).

4.5. Transparency

Ensuring clarity in solutions, detailed scoring rubrics, and explicit marking criteria.

5. Criteria for evaluating exam quality

Content Criteria	Measurement Criteria
Accuracy: Mathematical correctness.	Validity: Measuring intended competencies.
Practicality: Authentic context.	Reliability: Consistency across raters.
Modeling Potential: Capacity for mathematization.	Discrimination: Differentiating student levels.
STEM Integration: Interdisciplinary elements.	Feasibility: Suitability for time/conditions.

6. Illustrative examples

6.1. Case Study: A-frame Roof Optimization

- **Context:** Cost estimation for an isosceles triangular roof.
- **Parameters:** Width (\$6m\$), Height (\$2.5m\$), Length (\$10m\$).
- **Economic factor:** Roofing material price: \$120,000 \text{ VND}/\text{m}^2\$.
- **Task:** Calculate total surface area and total cost, requiring students to apply the Pythagorean theorem in a construction context.



Figure 1

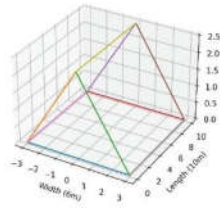


Figure 2

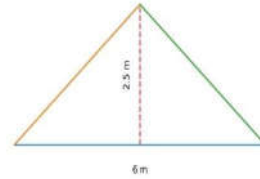


Figure 3

The questions require students to:

- 1) Identify the geometric model - the roof consists of two faces of a prism (Figure 2). (2 points)
- 2) Calculate the length of the roof edge: $AB = \sqrt{AH^2 + BH^2} = \sqrt{3^2 + 2,5^2} \approx 3,9m$ (2 points)
- 3) Calculate the roof area: $S = 2 \times 3,9 \times 10 = 78m^2$ (3 points)
- 4) Calculate the basic material cost: $78 \times 120,000 = 9,360,000 \text{ VND}$. (2 points)
- 5) Analyze the optimal option for the roof area. (1 point)

6.2. Cylindrical water tank design problem

A manufacturing facility needs to produce a cylindrical water tank with a volume of 2 m^3 .



Figure 4

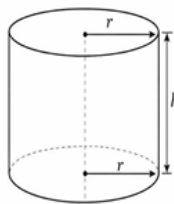


Figure 5

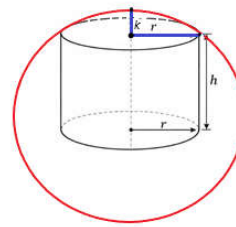


Figure 6

Requirements:

Question 1 (2 points): Decompose the water tank into basic geometric solids: a cylinder and two spherical caps. $V = V_1 + 2V_2$

Question 2 (2 points): Establish the relationship between radius and height.

$$R = \sqrt{(R-k)^2 + r^2}; \quad r = \sqrt{2Rk - k^2}$$

Question 3 (3 points): Formulate the volume expression.

$$V_1 = \pi r^2 h; \quad V_1 = \frac{\pi k^2}{3}(3R - k); \quad V_1 = \frac{\pi k}{6}(3r^2 + k^2)$$

The spherical-cap volume is denoted by the given expression in the source text, where R is the radius of the sphere, k is the height of the spherical cap, and r is the base radius of the spherical cap.

Question 4 (2 points): Express the material area, including the lateral area of the cylinder and the area of the two spherical caps: $S_{sq} = 2\pi rh$; $S_{CC} = 2\pi Rk$

Question 5 (1 point): Find the optimal dimensions of the cylinder when the volume is constant and material consumption is minimized.

6.3. Problem of determining the taper angle in lathe machining

Technical context

In mechanical manufacturing, many tapered shaft components are used in technical joints such as machine spindles, tapered couplings, or centering parts. When machining such parts on a lathe, the worker needs to determine the taper angle accurately in order to adjust the tool rest or set up the cutting tool appropriately.

Suppose a tapered shaft component has the following parameters: large-end diameter 60 mm, small-end diameter 40 mm, tapered-part length 100 mm.



Figure 7

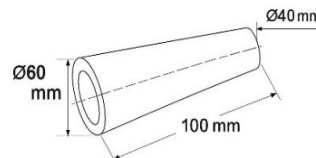


Figure 8

Examination questions

Question 1 (Recognition - 2 points)

Determine the radii of the two ends of the taper from the given diameter data and determine the difference in radius between the two ends of the component, where D and d are the diameters of the two bases, R is the large-end radius, r is the small-end radius, and h is the length of the tapered part.

$R = 30 \text{ mm}$; $r = 20 \text{ mm}$; therefore, $R - r = 10 \text{ mm}$.

Question 2 (Understanding - 2 points)

The taper angle is the angle at the apex of the cone that generates the frustum. It is formed by two generatrices symmetric about the axis of the cone. If the cone is cut by a plane passing through its axis, an isosceles triangle is obtained. The apex angle of this triangle is precisely the taper angle.

Taper ratio: as given in the source formula $K = \frac{D-d}{l} = 2 \tan \alpha$.

Slope: as given in the source formula $u = \tan \alpha = \frac{D-d}{2l} = \frac{R-r}{l}$.

Question 3 (Application - 3 points)

Establish a right triangle representing the longitudinal cross-section of the tapered part and write the formula for determining the taper angle; the angle in the formula is half of the taper angle: $\tan \alpha = \frac{h}{R-r}$.

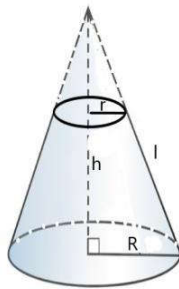


Figure 9

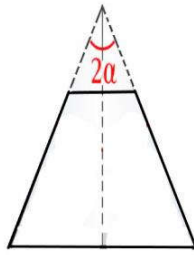


Figure 10

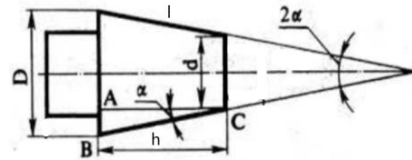


Figure 11

Question 4 (Advanced application - 2 points)

Calculate the taper angle value of the component (rounded to the nearest minute).

$$\tan \alpha = \frac{h}{R-r} = \frac{100}{10} = 10; \alpha = \arctan 10 \approx 84,29^\circ$$

Question 5 (Open-ended question - 1 point)

Technical Implications: If the taper angle deviates from the design, it directly impairs the mechanical joint's performance, leading to **improper fit**, **increased vibration**, and **premature wear** of components. Such errors can result in assembly failure or reduced machine lifespan.

Educational Significance: This problem serves as a practical bridge between trigonometry and industrial engineering. Key learning outcomes include:

- **Contextual Understanding:** Translating geometric variables into functional machine design parameters.

- **Competence Development:** Strengthening mathematical modeling skills by solving authentic industrial tasks.

- **STEM Integration:** Demonstrating the indispensable role of mathematics in manufacturing, thereby enhancing the relevance and applicability of mathematics in the classroom.

7. Discussion. Applied geometry assessment enhances modeling competence and clarifies the role of mathematics in STEM and occupational contexts. However, practical implementation is hindered by teachers' unfamiliarity with problem design, a lack of standardized item banks, and rubric complexities. This study's primary limitation is its theoretical focus; future research must involve pedagogical experiments to empirically validate the framework and criteria across diverse learner samples.

8. Conclusion. This study established a comprehensive framework of principles and criteria for competency-based applied geometry examinations. Findings indicate that effective assessments must integrate authentic contexts, explicit modeling requirements, differentiated difficulty levels, and transparent rubrics. Theoretically, it clarifies the nexus between geometry, modeling, and assessment; practically, it provides a reference for innovating mathematics testing. Continued experimental verification is recommended to ensure broad applicability.

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EVALUATING THE EFFECTIVENESS OF PROJECT-BASED LEARNING IN DEVELOPING ENGLISH SPEAKING SKILLS FOR STUDENTS AT THE HANOI UNIVERSITY OF MINING AND GEOLOGY

Abstract

This study evaluates the effectiveness of Project-Based Learning (PBL) in enhancing the English speaking proficiency of non-English major students at the Hanoi University of Mining and Geology (HUMG). A quasi-experimental design was implemented across several English classes during the 2024 and 2025 academic years, with 234 valid survey responses collected post-intervention. The results indicate that a majority of students perceived significant improvements in motivation, confidence, fluency, vocabulary, and pronunciation. Despite relying on self-reported data, the findings suggest that PBL is an effective pedagogical method for developing communicative competence within the English as a Foreign Language (EFL) context. The study also discusses pedagogical implications and proposes directions for future research.

Keywords:

Project-Based Learning, English speaking skills, EFL, higher education, communication skills.

1. Introduction

Developing speaking skills is a paramount yet challenging objective in teaching and learning English as a Foreign Language (EFL), particularly for students in technical fields who often have limited opportunities for real-world communication. According to the interactionist perspective in second language acquisition, language development occurs through meaningful communication and the "negotiation of meaning" between learners (Michael Long, 1996). Providing frequent opportunities for language production is considered a prerequisite for enhancing speaking competence.

In the trend of learner-centered educational reform, Project-Based Learning (PBL) has gained increasing attention. According to Larmer et al. (2015), PBL is not merely an isolated activity but a comprehensive instructional strategy that bridges the gap between theory and practice. This model is rooted in John Dewey's (1938) experiential learning theory and Lev Vygotsky's (1978) social constructivism, emphasizing the central role of interaction, collaboration, and meaningful participation in knowledge construction. In language teaching, PBL shares similarities with Task-based Learning, where students engage in goal-oriented communicative activities to create specific products (Rod Ellis, 2003).

Numerous international studies have demonstrated that PBL contributes significantly to increasing learner motivation, confidence, and speaking effectiveness in EFL contexts. However, in Vietnam, research