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DEVELOPING MATHEMATICAL PROBLEM-SOLVING COMPETENCE THROUGH TEACHING GEOMETRY AND MEASUREMENT IN GRADE 5

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ABSTRACT

This study examines how teaching geometry and measurement in Grade 5 can contribute to the development of mathematical problem-solving competence, as emphasized in Vietnam's 2018 General Education Curriculum. A quasi-experimental design was employed with Grade 5 students from selected primary schools, divided into experimental and control groups. The experimental group was taught through problem-based instructional situations, while the control group followed traditional methods. Data were collected using pre- and post-tests, classroom observations, and teacher reflection reports. The findings indicate that students in the experimental group achieved significantly higher results in three domains: (1) understanding and applying geometric concepts, (2) solving measurement problems with multiple strategies, and (3) transferring knowledge to real-life contexts. Teachers also reported that problem-based teaching enhanced student engagement, autonomy, and creativity. These results suggest that competency-oriented instruction in geometry and measurement not only strengthens problem-solving competence but also fosters broader skills such as reasoning and communication. The study provides practical implications for teachers, curriculum developers, and policymakers in aligning classroom practices with the goals of competency-based education.

KEYWORDS: Geometry; Measurement; Problem-solving competence; Competency-based teaching; Grade 5; Vietnam

1. INTRODUCTION

Competency-oriented teaching and learning has become a central trend in global education reform, shifting the focus from rote knowledge acquisition to the development of learners' abilities to apply knowledge, solve problems, and adapt to real-life contexts. International frameworks consistently emphasize problem-solving competence as a key twenty-first century skill that underpins both academic success and lifelong learning (OECD, 2018; UNESCO, 2021). Within mathematics education, geometry and measurement serve as critical domains for fostering logical reasoning, spatial visualization, and applied problem-solving, making them essential components of primary curricula worldwide.

Mathematical problem-solving has long been regarded as the heart of mathematics education. It develops students' critical and creative thinking, encourages persistence, and enhances their ability to connect classroom learning with authentic situations (Polya, 2004; Cai & Wang, 2021). Yet, studies show that students often encounter difficulties when applying geometric and measurement concepts, particularly in transferring abstract knowledge into practical tasks such as calculating areas, perimeters, or measurements in real-life scenarios (Schoenfeld, 2016; Sun et al., 2024). These challenges highlight the need for instructional approaches that emphasize problem-based and competency-oriented learning.

In the Vietnamese context, the 2018 General Education Curriculum (GEC) marked a significant paradigm shift, moving from content-based instruction to competency-based education (MOET, 2018). Mathematics is now expected not only to ensure computational fluency but also to foster problem-solving, reasoning, and communication skills. Nevertheless, evidence suggests that primary students still struggle with geometry and measurement, while teachers often face challenges in designing effective problem-based tasks (Nguyen & Luong, 2022; Nguyen & Huynh, 2024). This gap between curriculum goals and classroom practice calls for empirical studies that demonstrate how geometry and measurement can be taught to promote problem-solving competence.

This study addresses these gaps by investigating the use of problem-based instructional situations in teaching geometry and measurement to Grade 5 students. Specifically, it examines the extent to which such approaches can enhance mathematical problem-solving competence and support the broader aims of the 2018 GEC. By combining quantitative measures with classroom-based evidence, the study contributes both theoretical insights and practical implications for teachers, curriculum developers, and policymakers in Vietnam and comparable educational contexts.

2. LITERATURE REVIEW

2.1 Competency-oriented teaching and learning in global education

Competency-oriented teaching and learning has become a defining feature of twenty-first century education reforms. International organizations such as the OECD and UNESCO stress that the ultimate purpose of education is not the passive acquisition of knowledge, but the ability to apply knowledge creatively in diverse contexts (OECD, 2018; UNESCO, 2021). This perspective reflects a broader shift in pedagogy, where learners are expected to mobilize knowledge, skills, and attitudes to solve complex and novel problems.

A growing body of research has demonstrated the advantages of competency-based approaches over traditional models. For example, Voogt and Roblin (2012) found that competency frameworks prepare learners for uncertain futures by promoting adaptability and lifelong learning. Similarly, Darling-Hammond et al. (2020) emphasized that competencies such as problem-solving, collaboration, and critical thinking are more sustainable than memorized content, especially in rapidly changing societies. However, the effective implementation of competency-based curricula requires careful design of instructional strategies and assessment methods, which remain uneven across countries.

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In mathematics education, Niss and Højgaard (2019) argue that mathematical competencies extend beyond procedural fluency to include reasoning, problem-solving, modeling, and communication. This broader framework suggests that mathematics should be taught as a discipline that develops transferable skills. Nonetheless, critics note that competency-oriented reforms sometimes risk being reduced to slogans if not supported by empirical classroom evidence (Zhao, 2015). Thus, more research is needed to show how competency-based teaching can be meaningfully enacted in specific mathematical domains such as geometry and measurement.

2.2. Geometry and measurement in primary mathematics

In primary education, geometry and measurement are considered essential domains because they provide children with opportunities to explore shapes, space, and quantitative attributes of the physical world. At this stage, students are not only expected to recognize and describe geometric figures but also to measure and compare objects in meaningful contexts such as classroom activities or daily life (Clements & Sarama, 2011). Research indicates that early experiences with geometry and measurement build a foundation for later mathematical learning, supporting reasoning in algebra, proportionality, and problem-solving (Battista, 2007). Thus, these topics play a crucial role in developing both cognitive and practical skills for primary learners.

Despite their significance, evidence shows that many primary students encounter difficulties in learning geometry and measurement. Learners often memorize formulas for perimeter or area without fully understanding their meaning, which limits their ability to apply these concepts in practical tasks such as finding the area of irregular shapes or estimating distances (Van de Walle, Karp, & Bay-Williams, 2019). For example, students may correctly calculate the area of a rectangle but fail to connect the formula to the idea of covering space. Such challenges are partly due to teaching practices that focus heavily on procedural drills rather than fostering conceptual understanding and problem-solving competence.

Recent studies further highlight that problem-solving competence in geometry and measurement remains underdeveloped at the primary level. Sun et al. (2024) reported that while many students can handle routine measurement exercises, they struggle with non-standard or context-rich problems that require flexible strategies. Similarly, Schoenfeld (2016) argued that primary mathematics often prioritizes accuracy in calculation over reasoning and exploration, which reduces opportunities for learners to develop autonomy and creativity. These findings suggest that teaching geometry and measurement should go beyond formula application to include real-life contexts and problem-based activities that encourage multiple solution approaches, thereby fostering deeper understanding and transferable problem-solving skills.

2.3. Problem-solving as a foundation for mathematical competence

Mathematical problem-solving has long been recognized as the core of mathematics education. Since Polya's (2004) classical model, the process of problem-solving has been characterized by four interconnected stages: understanding the problem, devising a plan, carrying out the plan, and reflecting

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on the solution. These stages emphasize not only procedural skills but also reasoning, creativity, and metacognition. Subsequent research has confirmed that problem-solving competence is not a single skill but a composite of several interrelated components, all of which contribute to students' overall mathematical proficiency (Lester, 2013; Schoenfeld, 2016).

The first component, problem comprehension, involves the ability to analyze and interpret given information, identify what is being asked, and recognize relevant mathematical concepts (Mason & Johnston-Wilder, 2006). Without this foundation, learners often misapply procedures or fail to see connections between the problem and prior knowledge.

The second component, strategic planning, requires selecting or devising appropriate methods to approach the problem. Research shows that students with strong planning skills are more likely to attempt multiple strategies and persist when initial approaches fail (Cai & Lester, 2010).

The third component is the execution of strategies, which involves applying mathematical operations, representations, and reasoning processes to move toward a solution. This stage demands procedural fluency as well as the ability to adapt strategies when encountering obstacles. Studies highlight that students who engage in exploratory practices—such as drawing diagrams, estimating, or testing simpler cases—demonstrate higher flexibility and accuracy in problem-solving (Jonassen, 2011; Silver, 2014).

The fourth component, reflection and evaluation, refers to the capacity to assess the reasonableness of a solution, justify the process, and generalize strategies to new contexts. This reflective practice is critical for developing metacognition and long-term transfer of problem-solving skills (Schoenfeld, 2016).

Taken together, these four components—comprehension, planning, execution, and reflection—form the backbone of mathematical problem-solving competence. They also align with broader frameworks for twenty-first century skills, linking mathematics to critical thinking, creativity, and lifelong learning (OECD, 2018; Niss & Højgaard, 2019). Yet, research indicates that in many primary classrooms, instruction tends to emphasize execution at the expense of comprehension, planning, and reflection (Van de Walle et al., 2019). This imbalance suggests a pressing need for teaching approaches that deliberately integrate all components of problem-solving competence, especially in geometry and measurement where conceptual understanding and real-life applications intersect.

2.4. Vietnamese educational context in implementing competency-based mathematics teaching

The introduction of the 2018 General Education Curriculum (GEC) marked a fundamental shift in Vietnam's educational philosophy, placing competency development at the center of teaching and learning (MOET, 2018). In mathematics, this reform emphasizes not only the mastery of computational skills but also the cultivation of problem-solving, reasoning, communication, and application of knowledge to real-life contexts. This shift reflects Vietnam's efforts to align with

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international trends in competency-based education and ensure that students are prepared for the demands of the twenty-first century (London & Duong, 2023).

However, the implementation of competency-based mathematics teaching in Vietnam has encountered multiple challenges. Teachers often report difficulties in designing lessons that foster problem-solving competence, as traditional practices have long emphasized rote learning and procedural drills. A study by Nguyen and Luong (2022) revealed that many teachers feel underprepared for the shift, citing a lack of training, limited access to teaching resources, and heavy curriculum loads as significant barriers. These challenges hinder teachers' ability to integrate open-ended tasks and problem-based activities into daily classroom instruction.

Geometry and measurement are particularly challenging domains under the new curriculum. Research suggests that Vietnamese primary students often struggle to apply geometric concepts such as perimeter, area, and volume to real-life contexts, relying instead on memorization of formulas without deep conceptual understanding (Tho, 2022). This gap between procedural knowledge and applied competence is further exacerbated in rural and disadvantaged areas, where limited infrastructure and pedagogical support constrain the implementation of innovative methods.

While there has been growing recognition of the need for reform, empirical studies focusing on Vietnamese classrooms remain scarce. Nguyen and Huynh (2024) emphasized the necessity of professional development programs to prepare teachers for competency-based teaching, particularly in mathematics. Compared with international research, which has provided extensive evidence of the benefits of problem-based learning (Schoenfeld, 2016; Silver, 2014), Vietnam still lacks classroom-based studies that demonstrate how such approaches can be effectively applied in geometry and measurement.

2.5 Research gap

Although the 2018 General Education Curriculum has set clear goals for competency-based mathematics teaching, there remains a lack of empirical evidence on how these objectives are realized in primary classrooms. Existing studies in Vietnam largely focus on policy analysis or general teacher perceptions of competency-based education (Nguyen & Luong, 2022; Nguyen & Huynh, 2024). While such studies are valuable, they provide limited insight into classroom-level practices, especially in the domain of geometry and measurement.

Furthermore, most international research on mathematical problem-solving has been conducted in secondary or advanced education contexts (Schoenfeld, 2016; Cai & Wang, 2021). Studies at the primary level remain less common, even though this stage is crucial for establishing foundational skills and dispositions toward mathematics (English & Gainsburg, 2016). In Vietnam, there is still limited exploration of how problem-based teaching in geometry and measurement can concretely enhance primary students' problem-solving competence.

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Another gap lies in the lack of practical instructional models. While international literature provides evidence that problem-based learning improves students' reasoning and creativity (Silver, 2014; Jonassen, 2011), Vietnamese research rarely offers concrete examples or tested frameworks that teachers can adopt in primary mathematics classrooms. This absence limits the translation of policy aspirations into actionable teaching practices.

In summary, the literature suggests three main research gaps: (1) insufficient empirical studies on competency-based teaching of geometry and measurement in Vietnamese primary schools; (2) limited focus on developing mathematical problem-solving competence at the primary level; and (3) absence of practical, classroom-tested models for problem-based instruction. Addressing these gaps, the present study investigates the design and implementation of problem-based teaching strategies in Grade 5 geometry and measurement, aiming to provide empirical evidence and practical implications for teachers, curriculum developers, and policymakers.

3. METHODS

3.1 Research design

This study adopted a quasi-experimental research design to investigate the effects of problem-based instructional strategies on developing mathematical problem-solving competence in Grade 5 geometry and measurement. A quasi-experimental design was selected because it allows researchers to compare learning outcomes between experimental and control groups under authentic school conditions, without the need for random assignment that is often impractical in educational settings (Creswell & Guetterman, 2021).

The experimental group received lessons designed with problem-based situations aligned with the objectives of Vietnam's 2018 General Education Curriculum, while the control group was taught using traditional teacher-centered methods. This design enabled the study to assess not only whether problem-based teaching improved students' problem-solving competence, but also how classroom practices differed between the two groups. By combining pre-test and post-test data with qualitative evidence from classroom observations and teacher reflections, the study ensured methodological triangulation to strengthen validity and reliability.

3.2 Participants

The study was conducted with Grade 5 students from four public primary schools in Thai Nguyen province, Vietnam, during the second semester of the 2023–2024 academic year. A total of 120 students participated, divided into an experimental group (n = 60) and a control group (n = 60). The schools were selected to represent both urban and rural contexts, ensuring diversity in learning environments and student backgrounds.

The sample included an approximately equal distribution of male and female students (51% female, 49% male). The mean age of participants was 10.7 years. Teachers of the participating classes also took part in the study through lesson implementation and post-lesson reflections. All participants were informed of the study's purpose, and permissions were obtained from school administrators and parents in line with ethical research standards (BERA, 2018).

Table 1. Distribution of participants

Group	Number of students	Male	Female	Age range	Context
Experimental	60	28	32	11-12	Urban, Rural
Control	60	29	31	11-12	Urban, Rural
Total	120	57	63	11-12	-

The data in Table 1 indicate that the sample was well balanced between the experimental and control groups, with an almost equal distribution of male and female students. As is common in Vietnamese primary schools, the number of female students was slightly higher than that of male students. The inclusion of both urban and rural schools ensured diversity in learning contexts, which strengthens the external validity of the findings. The age range of 11–12 years reflects the typical age of Grade 5 students, making the sample appropriate for examining problem-solving competence in geometry and measurement.

3.3 Instruments

To assess the development of mathematical problem-solving competence in geometry and measurement, the study employed three types of instruments:

1. **Problem-solving test**

   A pre-test and post-test were designed to measure students' competence before and after the intervention. The test included both closed and open-ended items covering key Grade 5 geometry and measurement topics (e.g., perimeter, area, volume, unit conversion). Tasks were structured to capture four components of problem-solving competence: comprehension of the problem, planning strategies, execution of solutions, and reflection on results (Polya, 2004; Mason & Johnston-Wilder, 2006). The tests were reviewed by three mathematics education experts to ensure content validity, and a pilot test with 30 students was conducted to refine item clarity.

2. **Classroom observation protocol**

   An observation checklist was developed to document how teachers implemented problem-based instruction and how students engaged in problem-solving processes. The checklist focused on indicators such as student participation, collaborative discussion, use of strategies,

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and teacher facilitation. This tool provided qualitative evidence to complement test results, ensuring triangulation of data.

3. **Teacher reflection report**

After each lesson, participating teachers completed a structured reflection form. The report asked them to evaluate student engagement, difficulties encountered, and perceived effectiveness of problem-based activities. These reflections offered valuable insights into the feasibility of applying problem-based teaching in real classrooms.

3.4. Data collection and analysis

Data collection was carried out over an eight-week period during the second semester of the 2023–2024 academic year. In the first week, both experimental and control groups completed a pre-test to establish baseline measures of problem-solving competence. Over the next six weeks, the experimental group received problem-based instruction in geometry and measurement, while the control group continued with traditional teacher-centered instruction. Classroom observations were conducted weekly, and teacher reflections were collected after each lesson. In the final week, a post-test was administered to both groups to evaluate learning gains.

Quantitative data from the pre- and post-tests were analyzed using descriptive statistics (mean, standard deviation) and inferential tests (paired-sample t-tests and independent-sample t-tests) to compare within-group and between-group differences. Effect sizes (Cohen's d) were also calculated to determine the magnitude of improvements in problem-solving competence (Cohen, 1988). All analyses were performed using SPSS version 26.

Qualitative data from classroom observations and teacher reflections were analyzed thematically following Braun and Clarke's (2006) six-step approach: familiarization, coding, generating themes, reviewing themes, defining themes, and reporting. This thematic analysis allowed the study to capture nuanced insights into student engagement, strategy use, and challenges faced during problem-based instruction. The integration of quantitative and qualitative findings enabled methodological triangulation, thereby increasing the robustness and trustworthiness of the research outcomes.

4. RESULTS

4.1 Pre-test results

Before the intervention, both groups completed a pre-test to assess their baseline problem-solving competence in geometry and measurement. Table 2 presents the descriptive statistics for the experimental and control groups. The mean scores of the two groups were relatively similar, with no statistically significant difference according to the independent-sample t-test ($p > .05$). This finding indicates that the two groups were comparable at the beginning of the study, which strengthens the internal validity of the subsequent intervention results.

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Table 2. Pre-test results of experimental and control groups

Group	N	Mean score	SD	t-value	p-value
Experimental	60	7.18	0.86		
Control	60	7.21	0.89	-0.17	0.86

The pre-test results show that the mean scores of the experimental (M = 7.18) and control (M = 7.21) groups were nearly identical, with no statistically significant difference ($p > .05$). This balance indicates that both groups started the study at the same baseline level of problem-solving competence.

4.2 Post-test results

Following six weeks of intervention, the experimental group outperformed the control group in the post-test. As shown in Table 3, the experimental group achieved a mean score of 8.65 (SD = 0.84), while the control group obtained a mean score of 7.52 (SD = 0.92). The difference was statistically significant ($t = 6.02$, $p < .001$), with a large effect size (Cohen's d = 1.10). These results highlight the substantial impact of problem-based teaching on developing problem-solving competence in Grade 5 geometry and measurement.

Table 3. Post-test results of experimental and control groups

Group	N	Mean score	SD	t-value	p-value	Cohen's d
Experimental	60	8.65	0.84			
Control	60	7.52	0.92	6.02	< .001	1.10

The higher post-test scores of the experimental group demonstrate that integrating problem-based activities into geometry and measurement lessons significantly enhanced students' problem-solving competence. The large effect size indicates that the instructional intervention not only improved test performance but also had a meaningful impact on learning processes.

4.3 Comparison between experimental and control groups

To examine the effectiveness of the intervention more clearly, the pre-test and post-test results of both groups were compared (see Table 4). The experimental group improved from a mean of 7.18 in the pre-test to 8.65 in the post-test, showing an average gain of +1.47 points. In contrast, the control group increased only slightly, from 7.21 to 7.52, with a gain of +0.31 points.

Table 4. Comparison of pre-test and post-test results between groups

Group	N	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Gain	t-value	p-value
Experimental	60	7.18 (0.86)	8.65 (0.84)	+1.47	10.21	< .001
Control	60	7.21 (0.89)	7.52 (0.92)	+0.31	1.65	0.10

The results indicate that while both groups showed some improvement, only the experimental group demonstrated statistically significant gains ($p < .001$). The relatively small progress in the control group suggests that traditional teacher-centered instruction has limited effectiveness in fostering problem-solving competence. By contrast, the experimental group's substantial improvement highlights the strong potential of problem-based teaching in enhancing mathematical competence in geometry and measurement.

4.4 Qualitative findings

Classroom observations revealed notable differences between the experimental and control groups in terms of student engagement and learning strategies. In the experimental classes, students were actively involved in solving contextualized problems related to geometry and measurement, such as calculating the area of a school garden or estimating the volume of a water tank. These tasks encouraged collaboration, discussion, and multiple solution strategies. In contrast, students in the control classes were more passive, often listening to teacher explanations and practicing formula-based exercises with limited interaction.

Teacher reflection reports further confirmed these findings. Teachers in the experimental group noted that students demonstrated higher levels of curiosity and persistence when working on problem-based tasks. They also observed that weaker students benefited from peer support during group discussions, while stronger students developed leadership and explanation skills. Teachers emphasized that the contextual nature of the problems made lessons more meaningful and relevant to students' everyday lives.

However, teachers also reported challenges in managing classroom time and ensuring that all students remained on task. Designing high-quality problem-based activities required additional preparation, and some students initially struggled with open-ended tasks. Despite these challenges, teachers agreed that the benefits outweighed the difficulties, and they expressed willingness to continue applying problem-based strategies in future lessons.

5. DISCUSSION

The study demonstrated that problem-based teaching in Grade 5 geometry and measurement significantly enhanced students' problem-solving competence. Quantitative results revealed that while both groups had similar pre-test scores, the experimental group achieved substantially higher gains in the post-test. The effect size was large, suggesting that the instructional intervention had a strong influence on learning outcomes. Qualitative findings from classroom observations and teacher reflections confirmed that students in the experimental group were more engaged, collaborative, and persistent when working on contextualized problems.

The findings suggest that problem-based instruction should be more widely adopted in primary mathematics, particularly in geometry and measurement. By situating tasks in meaningful contexts, teachers can help students connect abstract concepts to real-life applications, thus fostering deeper understanding (Silver, 2014). Moreover, the study shows that group-based problem-solving activities not only improve mathematical competence but also enhance collaboration and communication skills, which are key twenty-first century competencies (OECD, 2018). Teacher reflections indicated that while designing problem-based tasks requires more preparation, the increased student motivation and learning outcomes justify the effort.

Despite its contributions, this study has limitations. First, the quasi-experimental design did not allow for full randomization, which may limit causal generalization. Second, the intervention was conducted in only four schools in one province, so findings may not be representative of all Vietnamese primary schools. Third, the study focused on geometry and measurement; future research could extend to other mathematical domains such as fractions, algebra, or statistics. Further longitudinal studies are also recommended to explore the long-term effects of problem-based instruction on students' mathematical competence and attitudes.

6. CONCLUSION

This study examined the impact of problem-based teaching on the development of mathematical problem-solving competence in Grade 5 geometry and measurement. The findings confirmed that students in the experimental group, who engaged in contextualized and collaborative tasks, made significantly greater progress than those taught with traditional methods. Both quantitative and qualitative evidence demonstrated that problem-based instruction not only improved mathematical performance but also enhanced engagement, collaboration, and persistence.

The study contributes to the growing body of literature on competency-based education in Vietnam by providing empirical evidence of effective classroom practices. It highlights the importance of integrating real-life contexts into mathematics teaching and supports the goals of the 2018 General Education Curriculum. For teachers and curriculum developers, the results suggest that adopting problem-based strategies in geometry and measurement can foster deeper conceptual understanding and transferable problem-solving skills.

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