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Context familiarity and authenticity: Examples from the content of plane geometry in Vietnamese textbooks

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Abstract

The incorporation of real-world contexts into mathematical problems has become increasingly significant on a global scale, which is also reflected in Vietnamese education reform. This emphasis has resulted in the development of different series of textbooks designed to enhance student engagement and foster active learning through real-world problem contexts. In particular, the geometry and measurement strand presents substantial opportunities for the integration of contexts. In this study, we investigate the theoretical foundations of contexts, context familiarity, and context authenticity in mathematics education, with a focus on the plane geometry content in ninth-grade Vietnamese textbooks. The analysis is supported by four illustrative examples drawn from three reformed textbook series, demonstrating how context familiarity and authenticity are represented. A 5-point Likert-type survey of 109 students (72 males and 37 females) revealed that the soccer context was rated as less familiar than the airplane context overall, with no significant difference in familiarity ratings between boys and girls. Both the bike-riding and tripod contexts were rated as moderately authentic but not highly so. The authors also acknowledge several limitations and offers certain recommendations for future research in the area of contextual mathematics education.

Keywords: context, familiarity, authenticity, plane geometry, ninth-grade textbook

INTRODUCTION

The significance of real-world context in mathematics education has become increasingly recognized. Recent educational reforms (Drijvers et al., 2019; Wang et al., 2017) and international assessment frameworks (International Association for the Evaluation of Educational Achievement [IEA], 2021; Organization for Economic Cooperation and Development [OECD], 2024) strongly advocate for the integration of contextual elements in mathematical problems. In line with this global trend, on December 26, 2018, the Vietnam Ministry of Education and Training launched a comprehensive general education curriculum, along with subject-specific curricula, including mathematics. The mathematics curriculum includes guidelines and recommendations for applying mathematical concepts to real-world contexts, such as addressing interdisciplinary and practical issues, relating mathematics to graphic and technical drawing, and exploring topics related to economics and finance (The Ministry of Education and Training, 2018). In response to the directives of the general and mathematics curricula, different series of mathematics textbooks have been developed and published. These reformed textbooks emphasize comprehensible content, focusing on real-world problems to engage students and foster a transition from passive learning to active knowledge acquisition under teacher guidance (Nga, 2023).

Textbooks serve as a crucial function in shaping students' understanding of school subjects by transforming national curriculum guidelines into practical instructional materials (Valverde et al., 2002). They often have a more immediate impact on classroom instruction than the curriculum itself (Wijaya et al., 2015). According to Reys et al. (2004), textbooks frequently function as the main tools for teaching and learning in classrooms. Mathematics teachers globally depend extensively on authorized textbooks for daily instructions and teaching methods, often more than in

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Contribution to the literature

- This study advances research on contextualized mathematics problems by examining familiarity and authenticity through a thematic literature review and an illustrative case study of ninth-grade Vietnamese textbooks.
- We also evaluate how context is embedded, particularly in geometry and measurement, rather than just its presence.
- The findings highlight the need for carefully selected contexts to enhance student learning and inform future curriculum development.

other subjects (Reys et al., 2004). Thus, the content and context in textbooks can serve as a suggestion for teachers' instructional process, which potentially influences students' learning experiences, shapes their engagement with the material, and impacts how they apply their knowledge in real-world situations. In Wijaya et al.'s (2015, p. 61) words, "the students learn what is 'taught' by the textbook".

Among the three strands mentioned in the mathematics curriculum, geometry and measurement could provide numerous opportunities for integrating problems within contextual settings. Freudenthal (1973, p. 403) described geometry as "grasping space," emphasizing that this space must be explored, understood, and mastered by children to enhance their ability to navigate and interact effectively within it. He, along with his colleagues, developed an approach to geometry education that became known as realistic geometry education (RGE). This approach connects fundamental geometrical concepts to phenomena that students encounter in their daily lives, grounding geometrical understanding in real-world experiences (Van den Heuvel-Panhuizen, 2020). Selecting appropriate real-world contexts is also a critical consideration. Two of the key criteria for determining the suitability of a context, which can impact students' performance, are its familiarity and authenticity (Stacey, 2015).

For OECD (2023, p. 22), contexts are chosen based on their relevance to students' interests, lives, and the responsibilities they will encounter upon integrating into society as "constructive, engaged and reflective" citizens. Therefore, the context used in program for international student assessment (PISA) must be familiar to students to the extent that a brief text can provide sufficient information, allowing students to feel confident in understanding the question (Stacey, 2015). However, given the complexity of individual experiences and interpretations, a constructivist perspective posits that no single problem context can provide a universally familiar and meaningful application for all students (Boaler, 1993). As a result, there was conflicting evidence on the relationship between context familiarity and success rate (Almuna Salgado, 2017; de Lange, 2007).

Attaining authenticity in mathematical problems is also a challenging endeavor (Stacey, 2015). The term context is typically used normatively to denote the requirement that both teaching and the associated problems are authentic and reflective of real-life situations (Wedege, 1999). Despite this, many researchers and students have raised concerns that contextualized problems often lack authenticity, as they are frequently not genuine simulations of out-of-school situations but rather ordinary school mathematics problems "dressed-up" with an out-of-school context (Palm, 2006, p. 42). Instead, the problems should require students to engage in a concept, problem, or issue that mirrors one they have encountered or are likely to encounter in their everyday lives outside of the school setting (Newmann et al., 2007).

Numerous studies in Vietnam have examined the trend of incorporating contexts into mathematics problems and designing contextualized problems (see, e.g., Cuong & Duyen, 2018; Ngu, 2021; Trung & Dung, 2020). However, research on the characteristics of contexts in mathematical problems remains limited. Trung et al. (2020) conducted one of the few studies in this area. They categorized contexts into four types and analyzed their distribution across algebra, calculus, and geometry problems in traditional mathematics textbooks before curriculum reform from grade 6 to grade 11. Their findings indicated that fantasy and unfamiliar contexts dominate, while familiar and authentic contexts are significantly underrepresented.

CONTEXT: BACKGROUND KNOWLEDGE

Definition of Context and Relevant Theories

Context could be understood and classified in multiple ways in an educational setting. Several researchers also argue that defining this term within the mathematics education presents challenges (Little & Jones, 2007; Vappula & Clausen-May, 2006). Context could mean the learning environment, i.e., various situations in which learning occurs (Nunes et al., 1993). Besides the "environment" meaning of context, the term can also denote the attributes of a problem presented to students, encompassing the words, pictures, or situations embedded in the problem that aid their comprehension and engagement with the problem (Van den Heuvel-Panhuizen, 2005). As defined in OECD (2023, p. 25), the term "context" (also referred to as "situation") refers to the particular aspect of an individual's world in which problems are situated. Building on the definitions of context provided by Almuna Salgado (2016) and Trung (2018), we define context as the environment surrounding a mathematical problem, either real-world or imaginary scenarios beyond school settings.

Various theoretical frameworks address the role of contexts in mathematics education, one of which is the definition of PISA's mathematical literacy. OECD (2023, p. 22) defines it as "an individual's capacity to reason mathematically and to formulate, employ, and interpret mathematics to solve problems in a variety of real-world contexts". Also, since the assessment of mathematical literacy among 15-year-olds necessitates consideration of students' characteristics, it is essential to identify content, language, and contexts that are appropriate for this age group (OECD, 2023). The definition of mathematical literacy, as stated by Stacey (2015), necessitates that the items utilized in PISA be authentic. They should, she pointed out, to the greatest extent possible, challenge students to use mathematics in ways that reflect its application in real-life situations outside of school. Additionally, these items must not only be authentic but also appear authentic, ensuring that students perceive their engagement as meaningful and relevant (Stacey, 2015).

Several researchers have also explored the application of mathematics in real-life situations and its connection to culture. D'Ambrosio (1985, p. 45) differentiated between "academic" mathematics and "ethnomathematics". This perspective is the foundation for the ethnomathematics program. The program has facilitated the development of instructional aids and materials and has created opportunities for designing curricula that incorporate context and cultural values into mathematics (Chavarría-Arroyo & Albanese, 2023). In Vietnam, it is essential to employ real-world contexts that are appropriate to Vietnamese culture, including both national and regional aspects (Trung et al., 2020). These contexts should be accessible and aligned with the broader cultural values of humanity (Trang et al., 2021).

Contextual teaching is a methodology that emphasizes the use of "context" as a central element in the teaching process. This teaching methodology, as mentioned by Williams (2007), connects academic concepts to real-world situations, enabling students to understand the relevance of their learning to their own lives. This can effectively meet students' inquiries into the rationale behind learning mathematics because they want to know not just the procedural aspects of solving mathematical problems but also "why they need to learn the mathematics in the first place" (Williams, 2007, p. 572). A directly relevant approach is contextual teaching and learning (CTL). In CTL, experiences facilitate students' connections with both internal and external contexts. By starting with their existing knowledge, past experiences, and concurrent classes or situations, students engage in activities within various external contexts, including the school, home, workplace, and the Internet (Berns & Erickson, 2001).

Among the theoretical frameworks, realistic mathematics education (RME) is one of the most particularly notable. In RME theory, the connection to reality is integral not only in the application of skills at the end of the learning process but also in the use of real-world contexts as foundational sources for learning mathematics (Van den Heuvel-Panhuizen, 2005). Hence, context, as emphasized by Gravemeijer and Doorman (1999, p. 119), serves as a vital starting point for students to explore mathematical concepts within situations that are "experientially real" to them. A related theory that focuses specifically on geometry education is RGE, as previously mentioned in the introduction. This reformed approach is characterized by introducing students to the world of geometry, including language, objects, and constructions, through problems set in real-world phenomena to evoke their geometrical intuition (Van den Heuvel-Panhuizen, 2020). Similarly, Doorman et al. (2020, p. 285) describe an exploratory approach to geometry as a process involving "watching, acting, thinking, and seeing," where students first engage with geometrical concepts by observing real-world phenomena around them. This approach emphasizes the need for students to engage with real-life contexts before progressing to formal geometry.

Use of Contexts: Beacon or Shadow?

As described in the introduction, the authentic engagement of students with real-world contexts has the potential to enhance motivation. This view is supported by Boaler (1993) who stated that incorporating real-world, local community, and personalized examples for students to analyze and interpret is believed to demonstrate mathematics as a tool for comprehending reality. This approach is posited to dismantle their perceptions of mathematics as an abstract and disconnected discipline. Likewise, Walkerdine (1989, as cited in Boaler, 1993) found that such perspective emphasizing the practical utility of mathematics is recognized to inspire and captivate students' interest, particularly girls. Female students, as discussed by de Lange (1995), can benefit from contexts that might initially seem distant from their experiences, which will be further elaborated in the example section.

The impact of context on students' performance is frequently underestimated. Boaler (1993) noted that a particularly intriguing misconception regarding the use of contexts in school mathematics textbooks and assessment schemes is the belief that contextual problems influence students' motivation but have minimal impact on mathematical performance. This misconception, in her point, often leads to the arbitrary inclusion of contexts in problems and classroom examples in an attempt to reflect real-life situations and enhance the appeal of mathematics. However, Lave (1988) proposed that the specific context in which a mathematical problem is presented can influence overall performance. Carraher et al. (1985) conducted a study involving five students aged 9 to 15 and discovered that students performed better on mathematical problems set in real-life contexts compared to traditional school-word problems and context-free computational problems using the same numbers and operations. When identical calculations appear in different contexts, they are not perceived as the same (Joffe, 1990). Similar results were observed in Hughes' (1986, as cited in Van den Heuvel-Panhuizen, 2005) research, which involved 60 children aged three to five. They performed significantly better in addition to problems presented within a game context compared to those in a formal setting without real-world references.

However, it is essential to acknowledge the challenges in selecting familiar contexts that effectively engage students. Students might assess the relevance of the context based on their personal experiences (Widjaja, 2013). For example, as Adda (1989) suggested, while problems involving the price of sweets may be presented to students, they must be cautious not to base their answers on the price of sweets purchased that morning. An instance was documented by Gravemeijer (1994, as cited in Widjaja, 2013), where students disengaged from a context involving the equitable distribution of Coca-Cola bottles among peers due to their dislike of Coca-Cola itself. Stacey (2015, p. 74) also recounted an incident where a boy expressed difficulty with a word problem because he did not understand the reference to "Georgina", a name mentioned in the problem that was unrelated to its solution but posed a barrier to his progress. One of the difficulties in creating perceptions of authenticity would arise when students are required to engage in a problem as though it were real while simultaneously disregarding factors that would be relevant in the actual real-life scenario (Boaler, 1993). Students' interpretations of contexts, as noted by Carraher and Schliemann (2002), often differ from those of adults, which poses a challenge in guiding children to effectively navigate contextual problems.

Although Palm (2008) suggested that students are more likely to consider real-world aspects of a situation when word problems include more detailed contextual information, a rigorous study by De Bock et al. (2003) found that enhancing contextual authenticity through videos unexpectedly decreased students' success in selecting appropriate mathematical models that accurately reflected real-world situations. The researchers concluded that students may not have anticipated the need to engage deeply with the video content, which leads to a superficial processing of information. Merely increasing authenticity is not always beneficial; instead, careful consideration should be given to how students interact with and interpret contextual information.

Context can be a beacon, igniting motivation, or it can be a shadow, casting barriers. As discussed by de Lange (2007), the precise role that context plays in a given problem remains frequently misunderstood. Nearly a century of inconsistent research on problem context suggests that the relationship between context and students' performance requires more careful investigation (Almuna Salgado, 2017). Looking from the lens of PISA's assessment of mathematical literacy, it is not of primary concern whether students perform better or worse on contextual problems compared to 'naked number' problems; rather, what is crucial for PISA is ensuring that the choice of context does not systematically influence the performance of specific groups of students (Stacey, 2015, p. 80).

The following is a brief description of familiarity and authenticity of context, which require consideration when choosing context. A deeper understanding of the nuances of context may enable teachers to more effectively support students in solving contextual problems.

Context Familiarity

Although familiarity is a key characteristic of context that has attracted significant research interest, most studies do not offer a clear definition of the term. This may be due to the fact that students interpret and construct meaning differently in various situations, making it inaccurate to assume a universal familiarity or understanding of a given context (Boaler, 1993). We suggest defining context familiarity as the degree to which an individual is acquainted with or has prior knowledge, experience, or understanding of the context in which a problem is presented. This familiarity varies among individuals and can range from low to high. This definition specifically focuses on the context embedded within the problem, whereas some students' assessments of context familiarity appeared to reflect their familiarity with the underlying problem structure, which is problem familiarity, rather than the context itself (Chipman et al., 1991).

Familiarity plays a critical role in education. Song and Bruning (2016) found that familiar contexts enhance students' deep comprehension, increase motivation, and lower perceived difficulty. Moreover, by personalizing the learning environment to align with students' interests and prior knowledge, novel elements that students must process is minimized, thereby reducing intrinsic cognitive load (Kleinman, 2017). It is also suggested by Trang et al. (2021) that contexts should be drawn from students' daily lives, including family, school, local and global issues such as population growth, energy conservation, food security, and environmental protection, to support students' problem-solving, though real-life challenges are often complex and require more than just mathematical knowledge. These authors also observed that in Vietnam, socio-economic disparities result in problems that may be familiar to urban students being unfamiliar to those in mountainous regions. Therefore, teachers must possess a deep understanding of diverse contexts to effectively integrate them into their instruction.

Familiarity has been examined in depth, specifically in mathematics education. An equitable assessment of mathematical literacy ensures that no additional difficulty is introduced due to a context that is unfamiliar to students from diverse cultural backgrounds (OECD, 2023). For Boaler (1993), it is likely safe to assume that students are unlikely to transfer mathematical knowledge acquired in school to "real life version of the task" (p. 14) when the contexts are unfamiliar or perceived simply as another form of "school mathematics" (p. 15). While not all school-based knowledge automatically translates to real life, Boaler (1993) contends that activities set in engaging contexts can deepen students' grasp of the underlying mathematics and thus enhance the likelihood of successful transfer. As Freudenthal (2002, as cited in Chavarría-Arroyo & Albanese, 2023) also indicated, familiar contexts serve as entry points for mathematical practice, which allows students to apply common sense and cognitive strategies before progressing to more formalized levels.

As noted above, however, the relationship between the familiarity of contexts and students' performance is often subject to debate. Hembree (1992) conducted a meta-analysis of forty-four studies involving American students from year 4 to undergraduate levels, and the findings indicated that improved performance was statistically significant and predominantly linked to contexts that were familiar to the students. Nonetheless, Washburne and Osborne (1926, as cited in Almuna Salgado, 2017) acknowledged that while unfamiliarity with contexts contributes to some difficulty in problem-solving, its impact is not as significant as might be assumed. In accordance with this viewpoint, Chipman et al. (1991) identified only a slight positive effect of context familiarity on performance and noted that unfamiliarity tended to increase omission rates. Another notable study by Huang (2004) found that students did not perform better and required more time to solve problems with familiar contexts, which failed to support their initial hypothesis. The study also suggested that while many engaging mathematical problems originate from real-life situations, familiar contexts do not necessarily make problems appear easier or lead to improved problem-solving performance.

It is also worth mentioning that in more familiar contexts, certain students tended to incorporate personal knowledge into their reasoning rather than relying solely on mathematical arguments "in order to build an intended solution" (Almuna Salgado & Stacey, 2014, p. 61). Overfamiliarity can also influence how students communicate their answers, as they may assume that detailed explanations are unnecessary because the arguments are already widely understood (Almuna Salgado, 2017). "Irrelevant" or "seductive" details, such as character names or settings, can impose extraneous cognitive load by distracting students from the essential mathematical structures (Walkington & Hayata, 2017, p. 521).

Context Authenticity

In addition to utilizing engaging contexts to enhance motivation, a significant concern with the use of contexts is their authenticity. For OECD (2023), the PISA 2022 framework aims to clearly and explicitly demonstrate the relevance of mathematics to 15-year-old students, while ensuring that the developed items are situated in meaningful contexts. PISA item writers place significant emphasis on authenticity to ensure an accurate assessment of students' ability to apply mathematics in real-world contexts beyond the classroom (Stacey, 2015). In RME, aligning problems with out-of-school figurative contexts to their corresponding real-life situations is not considered a primary concern (Palm, 2006). The fantasy world of fairy tales and even the abstract realm of mathematics can serve as suitable contexts for a problem, provided they feel real to students and can be meaningfully experienced in their minds (Van den Heuvel-Panhuizen, 2005). However, as noted by Fitzpatrick and Morrison (1971, p. 239), for a performance measure to be considered relevant to real-life situations, "it must be taken under conditions representative of the stimuli and responses that occur in real life".

Niss (1992) defined authenticity as the quality of a context that accurately represents a real-life situation that has either occurred or is likely to occur,

> We define an authentic extra-mathematical situation as one which is embedded in a true existing practice or subject area outside mathematics, and which deals with objects, phenomena, issues, or problems that are genuine to that area and recognized as such by people working in it (p. 353).

One factor that may influence the authenticity of a context is the reading load. Early PISA problems faced criticism for their high reading demands (Stacey, 2015), thereby making it essential to keep the reading load manageable in later surveys (OECD, 2023). However, as Stacey (2015, p. 78) noted, some strategies for simplifying text can compromise authenticity, much like a flower that withers once picked–real-world problems often do not “stay alive” when translated into written form.

Palm (2006) has created a framework for the characteristics that make a school problem authentic. We consider the three aspects, including event (what happens in the problem), question (what is being asked in the problem), and information/data (what is provided for solving the problem), the most important in determining whether a context is authentic because they directly affect how closely a mathematical problem aligns with real-life situations. Other aspects, such as presentation, solution strategies, and circumstances, influence how students approach the problem rather than determining whether the context itself is authentic. By focusing on event, question, and information/data, we ensure that the core context embedded in a mathematical problem is authentic before considering secondary factors that influence how students engage with it.

CONTENT OF PLANE GEOMETRY

In Vietnam’s general education, mathematics is a compulsory subject from grade 1 to grade 12. The Ministry of Education and Training (2018) points out that geometry and measurement are one of the three essential strands of mathematics education that foster logical thinking, mathematical creativity, spatial imagination, intuition, aesthetic experiences, mathematical culture, and practical skills. At the lower middle school level, this strand provides students with basic knowledge and skills in both solid and plane geometry. In plane geometry, 9th graders learn about geometric relationships and common plane shapes, focusing on triangles, quadrilaterals, regular polygons, and circles. The specific content of plane geometry and the corresponding standard requirements in grade 9 are listed in detail in **Appendix A**.

The curriculum not only builds a strong foundation in geometry but also integrates practical applications to enhance its relevance in real-world settings. For instance, trigonometric ratios are connected to real-life applications such as measuring distances and angles, which are essential in fields like engineering and physics. Understanding the properties of regular polygons is particularly valuable in disciplines like design, architecture, art, and technology. Even when real-world applications are not explicitly outlined in curriculum requirements, they can still be embedded within textbook problems.

This contextualized approach not only cultivates an appreciation for geometry in the natural world but also enhances students’ spatial creativity. The inclusion of practical applications in the curriculum necessitates that the context be both familiar and authentic to ensure effective learning and relevance to students’ lives. Familiar contexts guarantee that students can relate to the problems based on their own experiences, while authentic contexts ensure that the problems reflect real-life situations, thereby enhancing students’ ability to apply their knowledge in scenarios encountered in the real world.

MATERIALS AND METHOD

An illustrative case study was used to examine selected examples from ninth-grade mathematics textbooks, with a focus on how context is integrated into problems within the geometry and measurement strand. Four examples in this paper were drawn from three ninth-grade textbook series: *Cánh diều* (kites), *Chân trời sáng tạo* (Creative horizons), and *Kết nối tri thức với cuộc sống* (Connecting knowledge to life). These textbooks were introduced in the 2024 academic year and are widely used in public schools. The examples were analyzed in relation to the themes identified in the literature review in order to provide concrete illustrations of theoretical concepts.

A quantitative survey was employed, with its content and structure evaluated by an expert in mathematics education. The survey, administered to 113 ninth-grade students, used a five-point Likert-type scale to assess two scales: context familiarity and context authenticity. The scale ranges from 1 (very unfamiliar/very unauthentic) to 5 (very familiar/very authentic). Four incomplete responses were excluded, resulting in a final sample of 109 students (72 males, 37 females). Participants rated the familiarity of the first two examples and the authenticity of the subsequent two examples.

Regarding context familiarity, we conducted paired-samples t-tests to compare students’ familiarity ratings between the two contexts. Additionally, independent-samples t-tests were performed to evaluate gender differences in familiarity ratings for each example. For context authenticity, paired-samples t-tests were also conducted to determine whether the event, question, and information/data dimensions differed significantly between the two contexts. Each example’s subscale comprised three items (one per dimension), resulting in acceptable internal consistency (α = .751 and α = .823, respectively). Coded responses from the three dimensions were averaged to create a composite authenticity score, which offers a more reliable and valid measure than any single item by minimizing random error (Koo & Yang, 2025). A paired-samples t-test was then conducted to compare overall authenticity between two contexts. All statistical analyses were performed using SPSS version 27, with an alpha level of .05 for all tests.

The figure below depicts an airplane taking off from position A on the airport runway, ascending along line AB, which forms a 20-degree angle with the horizontal line AC. After 5 seconds, the airplane reaches a height of BC = 110 meters. How can we find the length AB?

Source: https://shutterstock.com

Figure 1. Airplane problem (Anh et al., 2023a, p. 88)

9.6. On the soccer field, when the ball is placed at the penalty spot, the goal kicking angle is 36 degrees. The distance between the ball and each goalpost is 11.6 meters. If the ball is positioned 11.6 meters away from the penalty spot, what will the new goal kicking angle be?

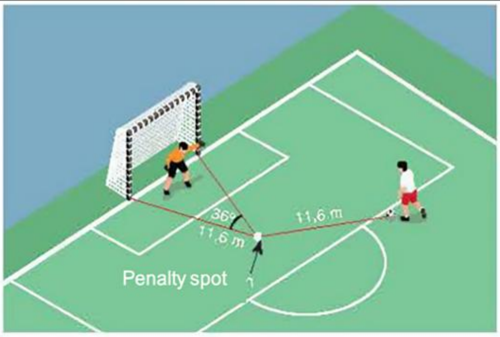

Figure 2. Soccer problem (Cuong et al., 2023, p. 71)

RESULTS AND DISCUSSION

Examples of Context Familiarity

The problem in **Figure 1** is placed in the warm-up section in the sub-chapter "The applications of trigonometric ratios of acute angles". The context relates to transportation, specifically air travel, a common experience for many individuals. Students may also have seen airplanes taking off either firsthand or through the media, which makes the mathematical problem more relatable. This connection centers the individual's perspective within the context, aligning with the principles of the RGE approach.

However, considering this context from the perspective of an airplane pilot may be unfamiliar to most students. de Lange (1995) raised the question of how closely contexts need to align with students' experiences. He questioned the suitability of a context involving an airplane pilot, given that most students lack such experience. Nonetheless, he found that such contexts are effective, including for female students, as demonstrated by the use of this airplane context in a trigonometry and vectors booklet tested at a predominantly girls' school. The survey results also indicated no significant difference in familiarity ratings for this context between male students (mean [*M*] = 4.08, standard deviation [*SD*] = 1.08) and female students (*M* = 4.14, *SD* = 1.11), *t* (107) = -.234, *p* = .815. Both genders found this context reliably familiar.

The problem depicted in **Figure 2** is extracted from the exercise section belonging to sub-chapter "Inscribed angles". The context is about a widely known and popular sport among teenagers–soccer. Many students are likely familiar with the basic rules and layout of soccer, including the penalty spot and the idea of scoring a goal, although the concept of a goal kicking angle may require additional clarification. Applying the knowledge of distances and angles to a real-world context, like a soccer field, can make the problem more engaging and relevant. Nevertheless, it is worth mentioning that while many students are likely familiar with soccer, some may not find it engaging if they do not play or follow the sport. Traditionally, boys might be more engaged with soccer due to higher participation rates and greater media representation, but interestingly, no significant

5. At 6 a.m., An rides his/her bicycle from his home (point A) to school (point B). The journey from A to B involves traveling uphill along segment AC and downhill along segment CB. Given that the total distance AB is 762 meters, angle A is 6 degrees, and angle B is 4 degrees.

a) Calculate the height h of the slope.

b) Determine the time An arrives at school, given that his/her speed is 4 km/h when traveling uphill and 19 km/h when traveling downhill.

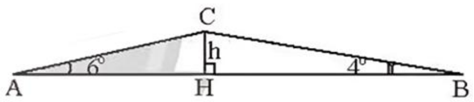

Figure 3. Bike-riding problem (Hien et al., 2023, p. 71)

gender difference was found in familiarity ratings for this context, with male students (M = 3.54, SD = 1.23) and female students (M = 3.11, SD = 1.10), t (107) = 1.80, p = .074. Overall, students rated this context (M = 3.39, SD = 1.202) as significantly less familiar than the airplane context (M = 4.10, SD = 1.088), t (108) = 5.332, p < .001. Conducting the tests separately by gender yielded similar results.

Female students, in a study by Boaler (1994), demonstrated lower performance in contexts that were likely more familiar to them (e.g., fashion rather than soccer). She speculated that their relative underachievement in fashion-related problems stemmed from the attractive and familiar context diverting their focus from the mathematical structure. Therefore, it might not be prudent to assume boys would perform better than girls in soccer context, as their familiarity and interest in this context could potentially lead to distractions.

Examples of Context Authenticity

The problem presented in **Figure 3** originates from the sub-chapter "Relationships between the angles of a right triangle and its sides." To what extent the context is authentic depends firstly on the "event". This aspect pertains to the scenario described in the problem. For a school problem simulating a real-life situation, it is essential that the event described either occurred or has a reasonable likelihood of occurring (Palm, 2006). Ensuring that the event mirrors real-life experiences increases the likelihood that students will find the problem meaningful. The event in question involves a riding his/her bicycle from home to school, traveling uphill and downhill. This event is plausible and authentic. Many students commute by bicycle, and it is common for such journeys to involve traveling uphill and downhill.

A real-life event alone is insufficient; the "question" posed must also be something that would naturally arise in that scenario. This aspect refers to the alignment between the questions given in the school problem and a corresponding out-of-school situation, and thus for a real-life situation to be authentically represented, the question in the school problem must be one that could plausibly arise in the described real-life event (Palm, 2006). If a mathematical problem asks something that no one in real life would need to know, the problem might lose its degree of authenticity.

From the perspective of the character in this context, who is An, it is less likely that he/she would need to calculate the height of a slope based on angles and distances while commuting. This type of calculation is more relevant to engineering or architectural contexts rather than everyday student experiences. The second question–determining the time of arrival at school based on varying speeds uphill and downhill–is more authentic. It mirrors real-life considerations such as estimating travel times; however, some students might typically think in terms of average speed without breaking it down into specific segments based on incline. While students may not explicitly calculate slope heights or use precise trigonometric calculations in their daily commutes, they do engage with the underlying principles when considering travel routes, durations, and the effort required for different terrains.

In an authentic context, the aspect of information/data is also considered significant. It pertains to the alignment between the information provided in the school problem and the corresponding information from real-world scenarios (Palm, 2006). The problem might become artificial if it supplies information that would not be accessible or available in real life. As Palm (2006) also noted, this aspect encompasses the values, models, and conditions specified within the problem.

The problem illustrated in **Figure 4** is taken from the sub-chapter "Circumscribed and inscribed circles of triangles". Firstly, the model of a camera mounted on a tripod is frequently observed. A tripod offers a stable and secure support structure for the camera, which serves to minimize camera shake. Secondly, the specified condition is also authentic. A tripod operator comprises three points, referred to as feet, positioned at the vertices of a typically equilateral triangle with fixed, predetermined edge lengths (Pipitone & Adams, 1992). Thirdly, the radius specified in the problem is commonly referred to as the build-up radius of the spreader. For typical tripod spreaders, this radius ranges from approximately 40 to 70 centimeters (Amazon, n. d.; Manfrotto, n. d.; Proaim, n. d.). Therefore, the provided value of 4 decimeters in the problem is considered relatively authentic.

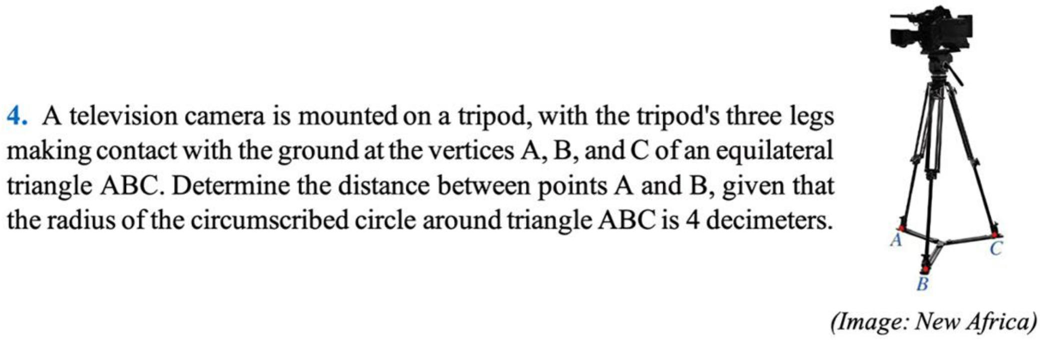

Figure 4. Tripod problem (Anh et al., 2023b, p. 74)

Table 1. Paired samples statistics

Pair	Context	M	SD	*t* (108)	*p*
Pair 1. Event	Bike-riding	3.68	1.12	.342	.733
	Tripod	3.64	1.09		
Pair 2. Question	Bike-riding	3.50	1.11	3.527	< .001
	Tripod	3.07	1.27		
Pair 3. Information/data	Bike-riding	3.28	1.29	-.451	.653
	Tripod	3.33	1.25		

Students' authenticity ratings did not differ significantly for the event and information/data dimensions across the two contexts (see **Table 1**). However, for the question dimension, students perceived the calculation of the distance between two vertices of a tripod as less authentic than the questions posed in the bike-riding context. The composite scores indicated no significant difference in students' authenticity ratings between the bike-riding context (M = 3.48, SD = 0.96) and the tripod context (M = 3.45, SD = 1.04), $t(108) = 1.52$, $p = .131$. Overall, the results indicate that students perceived each scenario as moderately authentic but not strongly so.

CONCLUSION

Recently, the incorporation of contexts in mathematical problems has garnered increased attention, as reflected in reform documents and curricula worldwide, including Vietnam. A common practice involves the arbitrary inclusion of contexts in assessment problems and classroom examples to mirror real-life situations and enhance the engagement and appeal of mathematics (Boaler, 1993). However, it is hypothesized that thoughtfully selected contexts can enhance performance and promote effective cognitive strategies for solving contextual problems (Almuna Salgado, 2017). Two crucial criteria for assessing the suitability of a context are its familiarity and authenticity.

This paper addressed several theories related to contexts in mathematics education, such as RME, PISA's mathematical literacy, ethnomathematics, and CTL. Building on previous research, a definition of context has been proposed. The analysis of the ninth-grade plane geometry curriculum in Vietnam's educational reform highlights the integration of practical applications to ensure relevance to real-world contexts. This shift necessitates that the context be both familiar and authentic to facilitate effective student learning. The paper presents two examples illustrating context familiarity and two further examples demonstrating authenticity, with a focus on event, question, and information/data dimensions. A 5-point Likert-type survey was administered to 9th grade students to assess both the familiarity and authenticity of these selected contexts.

Globally, mathematics teachers depend heavily on approved textbooks for their daily instruction, more than in other subjects, to decide what topics to cover, how to teach them, and which exercises to assign (Robitaille & Travers, 1992, as cited in Reys et al., 2004). Hence, it is recommended that textbook authors should incorporate more familiar and authentic multi-step modeling problems. In Vietnam, studies on mathematical modeling have shown that when contexts are realistic and authentic, students exhibit a more positive attitude toward these tasks and employ a broader range of problem-solving strategies (see, e.g., Tran et al., 2020). In the classroom, teachers are encouraged to engage students in discussions about whether a context felt familiar and authentic and explore the reasons why. This metacognitive activity reinforces how math problems represent real-life situations and guides teachers in designing contextual problems for assessments.

The subjectivity in context analysis is one of the limitations of this paper. This may introduce biases and fail to accurately reflect the diverse experiences of all students. Additionally, the paper's exclusive focus on the plane geometry content of the ninth-grade curriculum restricts the scope of the analysis. To obtain a more comprehensive understanding of context familiarity and authenticity, it is necessary to consider different strands of mathematics and various grade levels. Future research should extend the analysis beyond plane geometry examine contexts across various grade levels. Also, determining the appropriate extent to which context should be familiar and authentic in different areas of mathematics is essential. Further studies could explore the impact of cultural and regional differences on the perception of context familiarity and authenticity, as well as the long-term effects of using familiar and authentic contexts on students' mathematical understanding, problem-solving skills, and attitudes towards mathematics.

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Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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APPENDIX A

Specific Content of Plane Geometry and the Corresponding Standard Requirements in Grade 9

Table A1. Specific content of plane geometry and the corresponding standard requirements in grade 9 (The Ministry of Education and Training, 2018, p. 74-76)

Content		Standard requirements
Trigonometric ratios in right triangles	Trigonometric ratios of acute angles. Relationships between the angles of a right triangle and its sides	– Recognizing the values of sine, cosine, tangent, and cotangent of an acute angle. – Explaining trigonometric ratios of special acute angles, such as 30-degree, 45-degree, and 60-degree angles, as well as of two complementary angles. – Calculating either exact or approximate value of the trigonometric ratio of an acute angle using a handheld calculator. – Explaining some relationships between the angles of a right triangle and its sides. To be more specific, the right triangle side is equal to the hypotenuse multiplied by the sine of the opposite angle or multiplied by the cosine of the adjacent angle, and a right triangle side is equal to the other right triangle side multiplied by the tangent of the opposite angle or multiplied by the cotangent of the adjacent angle. – Solving various real-life problems involving trigonometric ratios of acute angles, such as calculating the length of a line segment, calculating the magnitude of an angle, solving right triangles, etc.
Circles	Circles. The relative positions of two circles	– Recognizing the center of symmetry and axis of symmetry of a circle. – Comparing the length of diameter and chord. – Describing the three relative positions of two circles, including intersecting, touching, and non-intersecting.
	The relative positions of a straight line and a circle. The tangent to a circle	– Describing the three relative positions of a straight line and a circle, including intersecting, touching, and non-intersecting. – Explaining whether a line is tangent to a circle and the properties of two intersecting tangents.
	Central angles and inscribed angles	– Recognizing central angles and inscribed angles. – Explaining the relationships between arc measures and both central angle measures and inscribed angle measures. – Explaining the relationship between the measures of an inscribed angle and a central angle that both intercept the same arc.
	Circumscribed and inscribed circles of triangles	– Defining the circumscribed circle of a triangle. – Determining the center and radius of the circumscribed circle of a triangle, including special cases for right triangles and equilateral triangles. – Defining the inscribed circle of a triangle. – Determining the center and radius of the inscribed circle of a triangle, including special cases for equilateral triangles.
	Inscribed quadrilaterals	– Recognizing inscribed quadrilaterals and explaining the theorem stating that the sum of two opposite angles of a inscribed quadrilateral is 180 degrees. – Determining the center and radius of the circumcircle of a rectangle or a square. – Calculating the arc length, the area of a circular sector, and the area of an annulus. – Solving various real-life problems involving circles, such as those concerning circular motions in Physics or the calculation of areas of circular-related shapes, like circular segments.
Regular polygons	Regular polygons	– Recognizing regular polygons. – Recognizing rotation. – Describing types of rotation through which the regular polygons remain the same. – Recognizing regular polygons in nature, art, architecture, manufacturing technology, etc. – Recognizing the aesthetics of the natural world expressed through regularity.