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Pre-service mathematics teachers: Designing context-based tasks

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Abstract

In the era of ever-evolving education, integrating real contexts into mathematics learning is essential to improve student engagement and understanding. The problem so far is that learning, including assessments used in mathematics learning, has not used context. This condition causes mathematics learning carried out by teachers (including pre-service teachers) to be meaningless because mathematics learning is still considered a very abstract material, less applicable, and less relevant to everyday life. This study aimed to explore prospective mathematics teachers' skills in designing context-based assignments. This study uses a qualitative descriptive method involving three pre-service mathematics teacher students as research subjects. Data were collected through document analysis, observation, and in-depth interviews. Data analysis was conducted qualitatively, with data reduction, presentation, and conclusion stages. The study results showed that students understand the importance of using context in mathematics learning. However, there are still some obstacles to its practical application. Students often struggle to choose relevant and meaningful contexts and design tasks that can effectively integrate mathematical concepts with those contexts. Based on these findings, pre-service teacher students must improve their abilities in applying the context of everyday life and the environment around them to mathematics learning.

Keywords:
Context, HOTS, Mathematics, Pre-service teachers, Task

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1. INTRODUCTION

Mathematics teaches students how to think, reason and be logical through certain mental activities that form a continuous flow of thought (Aksu & Koruklu, 2015; Sheromova et al., 2020). Mathematics learning culminates in the formation of a flow of understanding of mathematical learning materials in the form of specific formal-universal mathematical facts, concepts, principles, operations, relations, problems and solutions (Fouze & Amit, 2018;

Widodo, Irfan, et al., 2020). This mental process can strengthen students' tendency to learn mathematics's importance and benefits (Aisyah et al., 2023; Pusporini et al., 2023; Umbara & Nuraeni, 2019). In addition, learning mathematics also develops moral values, such as freedom, skills, assessment, accuracy, systematic, rationality, patience, independence, discipline, determination, tenacity, self-confidence, openness and creativity (Bose & Seetso, 2016; Chowdhury, 2018; Harefa et al., 2024). Thus, to internalize these values optimally, a strategic role is needed from educators in designing learning tasks and activities that not only develop mathematical thinking skills but also encourage character formation through reflective and meaningful learning experiences.

Context-based tasks must be relevant to students' experiences to be meaningful. However, the context chosen often does not align with students' culture, environment, or everyday experiences (Gravemeijer & Doorman, 1999). Designing new tasks and teaching activities is a challenge for teachers and pre-service teachers (Kim, 2020; Rapanta et al., 2020). They must be able to engage students in meaningful activities and create an environment that allows students to construct and reflect on their learning (Guerrero-Ortiz, 2019). Context-based mathematics tasks in the real world provide elements or information that must be organized and modeled mathematically (Csáky et al., 2015; Wijaya et al., 2014; Wijaya et al., 2018). Context-based mathematics problems cannot be separated from the inclusion of context in the problem posed (Chapman, 2006; Ekawati et al., 2017). Several previous studies have used students' environmental contexts, such as tourist destinations, Sarangan Lake, Mozart, Sumur Gumuling Taman Sari, and batik (Alvian et al., 2021; Kusuma et al., 2024; Lisnani et al., 2025; Murtafiah et al., 2024). These contexts are used for mathematics learning, including in the development of mathematics learning assessments.

Solving mathematical problems in real-world contexts, referred to in this context as context-based tasks, requires an interaction between the real world and mathematics, often described as a modeling process (Wijaya et al., 2018). A comprehensive analytical approach is needed to assess the quality of context-based tasks, namely through horizontal and vertical analysis. Horizontal analysis examines general characteristics such as physical aspects and learning components, while vertical analysis evaluates the depth of the relationship between the real-world context and the mathematical processes involved in problem solving.

However, issues related to designing context-based tasks have rarely been explicitly addressed in previous research. Context-based tasks should be relevant to students' experiences to be meaningful. However, the context chosen is often not appropriate to the students' culture, environment, or daily experiences (Gravemeijer & Doorman, 1999). This creates a dilemma between focusing on understanding mathematical concepts and overly complex context details. If the context is too dominant, the mathematical concepts being developed can become obscured (Palm, 2009). Furthermore, designing context-based tasks requires more creativity, research, and time, while teachers often face time constraints in preparing a variety of engaging contexts (Chapman, 2006). Thus, in-depth exploration of the challenges and strategies for designing context-based tasks remains a crucial need in mathematics education research. a with overly complex context details. If the context is too dominant, mathematical concepts can become obscured (Palm, 2009). Designing context-based tasks requires more creativity, research, and time. Teachers often struggle to create a variety of engaging contexts within limited teaching time (Chapman, 2006).

Horizontal analysis is a study that focuses on general characteristics in teaching material, such as physical aspects and learning components contained therein. In this context, attention is directed to various learning features that directly support the learning process, such as practice questions, examples of material sections, assignments, and competency tests. This analysis assesses how these features can help students understand the material. Therefore, the learning elements contained in the material are analyzed in depth to see their consistency and relevance in supporting the achievement of learning objectives. Vertical analysis examines how the textbook is presented and how it contains context. Then, it is grouped into three categories, namely type of context (such as no context, camouflage context, relevant and essential context), type of information (such as matching, missing, and redundant), and kind of cognitive demands (such as connection, reproduction, and reflection) (Wijaya et al., 2018). The distinction between 'learning-environment context' and 'task context' can also be applied when the term 'context' is used in assessment as with learning situations. In assessment situations, 'context' can refer to the environment in which students are assessed, the tools and formats used, and the rules that apply to assessment (van den Heuvel-Panhuizen, 2005).

Understanding the context of teaching materials becomes increasingly important by considering horizontal and vertical analysis. The context is not only limited to the structure and content of the material but also includes how the material is presented and connected to real situations students face. This approach allows for a more comprehensive evaluation of the quality of teaching materials, including the extent to which the context presented can support students' conceptual understanding and critical thinking skills. Understanding this context also has strong relevance in the realm of assessment. As in learning, assessment is also influenced by the environment's context and the accompanying tasks. Therefore, analysis of the context in the evaluation becomes essential to ensure that the instruments used truly reflect authentic conditions and can measure student competencies fairly and meaningfully.

The distinction between ‘learning-environment context’ and ‘task context’ is also relevant when the term context is used for assessment. In the evaluation context, this distinction helps understand the various factors influencing assessments' design and implementation. Just as in learning situations, in assessment situations, the term context can refer to multiple aspects, such as the environment in which students are assessed, the assessment tools and formats used, and the rules or procedures that govern the assessment process (van den Heuvel-Panhuizen, 2005). Understanding this context is essential so that assessments can be conducted in a way that is fair, relevant, and accurately reflects students’ abilities.

Levels in mathematical assessment are divided into three level, such as: lower, midle and high level (De Lange, 1995; Drijvers et al., 2016; Jones et al., 2015; Suurtamm et al., 2016). The lower level is used to recognize most of the traditional mathematics and traditional tests, and this level of assessment is related to objects, definitions, technical skills, and standard algorithms. Evaluation at this level does not require students to connect concepts or apply knowledge in more complex contexts (Wijaya et al., 2015; Wijaya et al., 2018). The middle level is characterized by the ability to make connections, integrate information, and solve problems. At this level, students are asked to remember or understand information and connect the concepts they have learned to solve more complex situations (Retnawati et al., 2017). This assessment is providing concrete examples for this category is often a challenge because of the limited availability of tests or assessment instruments that clearly and validly operationalize skills at the intermediate level, so this level is frequently underrepresented in assessment practices in the field (Braun et al., 2020; Nortvedt & Buchholtz, 2018). Higher levels are more difficult than lower and middle levels. The assessment is structured with very complex things: mathematical thinking and reasoning, communication, critical attitude, interpretation, reflection, creativity, generalization and mathematics.

Mathematical tasks can encourage higher-order thinking in students. Therefore, teachers must engage students in challenging tasks for effective mathematical learning. Hence, by working on mathematical tasks, teachers improve their mathematical knowledge and capacity for mathematical didactic design (Hidayat & Aripin, 2023; Pepin, 2015; Widodo et al., 2025; Widodo et al., 2023). Context is not limited to real-world situations. The crucial thing is that context creates situations for learners that are real and relevant to their common sense understanding (Kohar et al., 2019).

A teaching itinerary is a deliberate sequence that begins in an informal context and can be used to visualize mathematical ideas concretely (such as everyday life situations, manipulative materials, and games). The teaching itinerary continues in a transitional context that, through exploration and reflection, leads to progressive schematization and generalization of mathematical knowledge and ends in a formal context, where the representation and formalization of mathematical knowledge are practised through conventional procedures and notations, thus completing learning from the concrete to the symbolic (Alsina, 2020). Therefore, designing mathematical tasks is something teachers do every day and requires a broad view of what needs to be considered for their development. From our perspective, designing mathematical tasks requires teachers to know the learning objectives they want to achieve and the teaching context in which the increased They must also have a broad knowledge of the mathematical content to be taught and consider the sequence of tasks that enhance leaf functions (Nieminen et al., 2022). They must clearly understand the depth of content they wish to present based on the desired educational level of the assignment. The different roles of realistic contexts as important levers in mathematics learning: Using contexts makes students think of mathematics as a valuable tool for solving real-world problems and not just as a collection of abstract, unconnected knowledge (Wijaya et al., 2018).

The contexts in which mathematics tasks are framed play an essential role in developing student mathematical competencies. According to PISA, a context suitable for such a mathematics task strives to be relevant to students, to shift between the mathematical and the everyday, and to apply to the production of a task solution. Students may develop essential mathematics using such contexts (OECD, 2019a, 2019b; Wijaya et al., 2024). In other words, an understanding of context and the importance of knowing and doing mathematics needs to encompass the social context in which students do mathematics, that is, the norms that privilege specific ways of thinking and understanding in that context and the pedagogies that enable students to participate in that context. Therefore, future research must explore what learning opportunities are offered to students when engaging in context-based mathematical tasks (Guo, 2022). Insight into what these learning opportunities look like by examining the thinking of a female secondary school teacher as she 'talks about' her class doing context-based tasks in her secondary school (Brown & Redmond, 2017; Deslis & Desli, 2023).

The representation, context, questions and instructions of the task provide information about the work with students, which is why the design of mathematical tasks is part of the development of teaching practices to organize teaching (Pincheira & Alsina, 2022; Siswono et al., 2018). Previous research has shown that preservice teachers have considered task objectives, classroom organization, students' prior knowledge, and various starting point principles for all or most of their tasks; measurement and evaluation principles for almost half of their functions; and instructions for using materials and principles of student misconceptions and difficulties for some of their functions (Gün & Taş, 2021). The most frequently applied aspects of inquiry include using relevant context, applying ways of acting that reflect the inquiry process, developing critical and reflective thinking, evaluating information and constructing arguments based on available sources (Pedaste et al., 2015). Pre-service teachers' beliefs about inquiry have been shown to reflect various aspects of investigation, such as difficulty in explaining it (Arsal, 2017; Herranen et al., 2019). However, difficulty in summarizing inquiry into a precise definition does not necessarily constitute a barrier to inquiry-based teaching (Arsal, 2017; Herranen et al., 2019).

Based on the previous description, this study aims to explore the skills of pre-service mathematics teachers in designing context-based tasks that are relevant, meaningful, and appropriate to students' experiences. The main focus of this study is to identify the extent to which pre-service teachers are able to integrate real-world contexts with mathematical concepts in a balanced manner in the task design process. To achieve this goal, the research question posed is: How do pre-service mathematics teacher students develop the skills to design context-based tasks?

2. METHOD

2.1. Research Design

The type of research used is qualitative research with a case study approach. Qualitative research studies a symptom, event, fact, or occurrence to create a clear and detailed image of the outcomes of research student activities (Creswell, 2012a, 2012b; Fraenkel & Wallen, 1990). This research focuses on exploring the skills of student mathematics teachers in designing context-based assignments. This objective aligns with the case study approach, as it seeks to deeply understand the processes experienced by a small number of participants (three participants). The case study approach allows researchers to capture the real-world dynamics and complexities of student problem-design activities, including their thinking patterns, the challenges they face, and the strategies they employ. Through case studies, researchers can utilize various data sources, such as document analysis, observation, and interviews, to build a comprehensive and contextual understanding of the case under study. In addition, this case study research allows for an examination of the dynamics and complexity of real situations (Hancock et al., 2021; Schwandt & Gates, 2018; Yazan, 2015), including how students integrate mathematical concepts with real-world contexts and how they consider the needs and characteristics of learners. Case studies provide space for a deeper understanding of pre-service teachers' practices, challenges, and potential for professional development by focusing on one group or individual within a particular context.

2.2. Research Subject

The subjects in this study were three pre-service mathematics teacher students with relatively equal mathematical abilities. These pre-service mathematics teachers were selected because they are preparing to become future educators, making it crucial to examine early on how they integrate mathematical concepts with real-life contexts when designing context-based assignments. Furthermore, pre-service mathematics teachers are a group currently developing content knowledge and pedagogical knowledge, two key components that determine their teaching competence. Therefore, examining how these two aspects integrate in designing context-based assignments can provide important insights into their readiness as future professional educators.

Subject selection was conducted using a purposive sampling technique because the researcher needed participants with characteristics consistent with the research focus: mathematics education students with comparable academic abilities and basic experience in designing learning assignments. The limited number of subjects (three) aligns with the characteristics of qualitative case study research, which emphasizes in-depth exploration of specific cases. This number allows the researcher to explore in detail the thinking processes, strategies, and challenges experienced by each subject in designing context-based assignments, while also comparing the emerging skill patterns among them. For publication purposes and to maintain confidentiality, the three subjects are coded S1, S2, and S3. Thus, the results of this study are expected to provide a comprehensive understanding of the readiness and skills of pre-service mathematics teachers in integrating real-world contexts into the design of learning tasks.

2.3. Data Collection

The instrument used in this study was a context-based task that experts had validated. The questions used in this study are part of the Knowledge of Content and Teaching (KCT) instrument, which was developed and validated in previous research by mathematics learning experts (Suprihatiningsih et al., 2025). The instrument has been declared content-valid and appropriate for measuring pre-service teachers' ability to integrate mathematical content knowledge with teaching strategies. The instruments used to collect data for this research are "Create three questions each using a context that demands high order thinking skills, medium order thinking skills and lower order thinking skills that make it easier for students to understand the concept of two-variable linear equation systems".

2.4. Data Analysis

After the data was obtained from three research subjects, the data was then analyzed. Qualitative data analysis refers to data reduction, data presentation, and conclusion. The data analysis used in this study uses a framework as in Table 1 (Wijaya et al., 2014).

Table 1. Analysis of framework

Task Characteristic	Sub-Category	Explanation
Type of context	No Context	Refers only to objects, symbols, or mathematical structures.
	Camouflage Context	Experiences from everyday life or common-sense reasoning are not needed; the mathematical operations required to solve the problems are already obvious; or the solution can be found by combining all numbers in the text.
	Relevant and Essential Context	Common sense reasoning within the context is needed to understand and solve the problem; mathematical operation is not explicitly given; or mathematical modelling is required.
Purpose of context-based task	Application	The task is given after the explanation section
	modeling	The task is given before the explanation section.
Type of information	Matching	The tasks contain exactly the information needed to find the solution.
	Missing	The tasks contain less information than needed, so students need to find missing information.
	Superfluous	The tasks contain more information than needed, so students need to select the information they need.
Type of cognitive demand	Connection	Reproducing representations, definitions or facts; Interpreting simple and familiar representations; Memorization or performing explicit routine computations/procedures.
	Reproduction	Integrating and connecting across content, situations or representations; non-routine problem solving; Interpreting problem situations and mathematical statements; or engaging in simple mathematical reasoning.
	Reflection	Reflecting on and gaining insight into mathematics; constructing original mathematical approaches; communicating complex arguments and complex reasoning; or generalizing

3. RESULTS AND DISCUSSION

3.1. Results

Subject S1, in compiling context-based tasks, has three questions for each category. The context-based questions made by subject S1 can be seen in Table 2.

Table 2. The results of context-based questions given by S1

Level	Question
Higher	The mother bought 4 shampoos and 2 bottles of soap for 50,500 IDR, while the mother bought 2 shampoos and 2 bottles of soap for 41,000 IDR. Determine the price if the mother wants to buy 6 packs of shampoo and 4 bottles of soap. In addition, the mother will pay for her shopping using a credit card, which will give her a discount of 10%.
Middle	Ani bought 2 shampoos and 2 bottles of mouthwash for 55,000 IDR, while Ani bought 4 shampoos and 3 bottles of mouthwash for 93,250 IDR. Determine the price Ani must pay if she buys 6 bottles of shampoo and 4 bottles of mouthwash!
Lower	Andi bought 3 bottles of sauce and 2 packets of sweet soy sauce for 37,000 IDR. Make a mathematical model of two-variable linear equation systems from the illustration

Note: Ani and Andi are not their real names in context-based questions

Based on the results in Table 2, the high-skilled subjects' ability to design context-based tasks is demonstrated through the clarity of the structure and the variety of cognitive levels within each question category (HOTs, MOTs, and LOTs). This is supported by interview results, which indicate that the subjects understand the different characteristics of the three types of questions. Subject S1 explained:

"In the HOTs, MOTs, and LOTs questions I created, the difference is that in the HOTs questions, I ask students to find the value of x (the variable for Mama Lemon) and y (the variable for mosquito repellent). After that, I ask students to find the value of x and y, then I ask students to find the price based on the conditions stated in the question and a discount. Then, for the MOTs questions, I ask students how much shampoo (x) and mouthwash (y) cost. For the LOTs questions, I ask students to create a mathematical model from the illustration in the question."

This quote demonstrates that subject S1 is able to differentiate the cognitive demands of each question category. In the LOTs questions, the subject focuses on representational skills through the creation of a mathematical model. In the MOTs questions, the subject directed students to perform direct calculation procedures, while in the HOTs questions, the subject added elements of reflection and application of concepts in the context of buying and selling involving discounts. This indicates that subjects with high ability not only understood the mathematical structure of a system of linear equations in two variables but were also able to integrate it with real-world contexts to build a variety of levels of student thinking.

Subject S2, in compiling context-based tasks, has three questions for each category. The context-based questions made by subject S2 can be seen in Table 3.

Table 3. The results of context-based questions given by S2

Level	Question
Higher	It is known that a supermarket has a 10% shopping discount if Boni wants to buy 1 shirt with a normal price of 84,950 IDR and 3 pants with a normal price of 178,350 IDR. How much should Boni pay after he gets a 10% shopping discount?
Middle	Boni bought 1 shirt and 3 pants for 263,300 IDR, while Mustofa bought 3 shirts and 2 pants for 373,750 IDR. How much did each shirt and pair of pants cost?

Level	Question
Lower	It is known that the price of 3 bottles of sauce and 2 cans of mosquito repellent is 41,400 IDR, while the price of 2 bottles of *lasegar* and 3 boxes of milk is 20,800 IDR. If the sauce and lasegar are assumed to be x, then the mosquito repellent and milk are assumed to be y, then what is the mathematical model?

Note: Boni and Mustofa are not their real names in context-based questions

Based on the results in Table 3, the subject's clarification of the reasons for selecting categories indicates a good conceptual understanding of the differences in the characteristics of HOTs, MOTs, and LOTs questions in the context of mathematics learning. Interview results support this finding. Subject S2 explained:

> *"HOTs questions require critical and creative thinking skills, which are categorized as higher-order thinking skills in problem-solving. MOTs tend to require students to think and use factual, procedural, and conceptual knowledge to solve a problem. LOTs include imitating, following, remembering, quantifying, or identifying."*

This explanation demonstrates that the subject can relate each question category to different levels of thinking. The subject's understanding of the characteristics of HOTs questions requires students to think critically and creatively, as their solutions depend not only on the application of formulas but also on understanding the problem context. In the MOTs category, students are directed to systematically use factual, procedural, and conceptual knowledge in solving problems, especially those related to the steps for solving systems of linear equations in two variables. Meanwhile, in the LOTs category, the subject understands that the questions are simpler and oriented towards the ability to remember, imitate, or identify information from the problem text.

This is also evident in the problem design developed by the subjects, where LOTs problems simply require students to transform contextual statements into mathematical models. Thus, the interview results confirm that the subjects possess the ability to differentiate cognitive levels when developing context-based tasks systematically and in accordance with the cognitive taxonomy framework.

Subject S3, in compiling context-based tasks, has three questions for each category. The context-based questions made by subject S3 can be seen in Table 4.

Table 4. The results of context-based questions given by S3

Level	Question
Higher	Elsa bought 4 kg of oranges and 2 kg of apples for 30,000 IDR; Farida bought 3 kg of oranges and 4 kg for 50,000 IDR. If Alda buys 2 kg of oranges and 3 kg of apples with 100,000 IDR, the change that Alda will receive is …
Middle	Aldi bought 1 cheese and 2 packs of klin for 75,000 IDR, Agung bought 2 cheese and 4 packs of klin for 107,000 IDR. The price of 1 cheese and 1 pack of klin is ...
Lower	Agung bought 2 soaps and 1 pack of coffee for 49,000 IDR, Riska bought … and 2 packs of coffee for 79,000 IDR. If Dela bought 1 soap and 1 pack of coffee, how much money should Dela pay…

Note: Elsa, Farida, Aldi, Agung, Riska, and Dela are not their real names in context-based questions

Based on the results in Table 4, the subject's reasoning for constructing HOTs, MOTs, and LOTs questions indicates a fairly good understanding of the differences in cognitive levels in solving context-based tasks. The subject explained that HOTs questions require students to think more complexly because they involve multiple steps to solve and process information independently. He stated:

> *"Students are asked to calculate how much change they will receive if their bill is Rp100,000. This question requires students to think at a higher level because they must first calculate the cost of all their purchases and then subtract it from the amount they have."*

This quote demonstrates that the subject understands that the characteristics of HOTs questions lie not only in the context used, but also in the thinking process, which requires deeper analysis, planning, and mathematical reasoning.

Furthermore, from follow-up interviews, the subject emphasized that the context used in constructing the assignment is close to students' lives, namely the daily buying and selling of basic necessities. The subject stated:

> *"The context I used in creating the two-variable linear equation system assignment is the context of buying and selling related to basic daily necessities."*

According to the subject, using this kind of context helps students understand the application of mathematical concepts in real life. He added:

> *"Context-based learning is important to help students understand mathematical problems related to everyday life."*

Furthermore, the subject also differentiated between types of tasks based on the level of thinking required. He explained:

> *"In HOTs problems, I ask students to find and determine the solution to the problem and calculate the change they need. In MOTs problems, students are only asked to determine the price of each item. In LOTs problems, students are asked to determine the total cost."*

This explanation demonstrates the subject's awareness of the gradation of thinking levels from LOTs to HOTs. HOTs problems are designed to train critical thinking and contextual problem-solving skills, while MOTs problems focus on procedural application, and LOTs problems on concept introduction and simple calculations. Thus, this interview confirms the finding that the subject is able to differentiate levels of cognitive complexity based on the thinking demands required in each problem type and demonstrates the ability to systematically relate mathematical concepts to real-world contexts.

Subjects of S1, S2 and S3 can create higher level questions in the category of type of context with the sub-category of relevant and essential context, namely common-sense reasoning in the context needed to understand and solve problems, mathematical operations are not given explicitly and mathematical modelling is needed. Higher level questions are also included in the category of type of cognitive demand with the sub-category of connection, namely memorizing or performing explicit routine calculations/procedures, reproduction, namely integrating and connecting various contents, situations, or representations, non-routine problem solving, interpretation of problem situations and mathematical statements and reflection, namely reflecting and gaining insight into mathematics, building an original mathematical approach.

3.2. Discussion

Levels in mathematics assessment are divided into lower, middle and high (De Lange, 1995; Drijvers et al., 2016; Jones et al., 2015; Suurtamm et al., 2016). These levels refer to the difficulty level and type of thinking skills required to solve mathematical problems or tasks, ranging from applying basic procedures to complex and reflective problem-solving. Their use can help assess students' thinking skills more comprehensively, detect learning needs, measure learning progress, and monitor students' cognitive development while learning mathematics.

The lower level is only used to recognize most traditional mathematics and tests. This level of assessment is tied to objects in mathematics, definitions in mathematics, technical mathematical skills and standard algorithms, such as basic mathematical operations. Assessment at this level is procedural and does not require students to connect concepts or apply knowledge in more complex contexts. Therefore, assessment at this level does not yet reflect the high-level thinking skills needed in meaningful mathematics learning.

The middle level in cognitive taxonomy is characterized by the ability to make connections, integrate information, and solve problems. At this level, students are not only asked to remember or understand information but also to connect concepts that have been learned to solve more complex situations. However, providing concrete examples for this category is often a challenge. This is due to the limited availability of tests or assessment instruments that clearly and validly operationalize skills at the middle level, so this level is often underrepresented in assessment practices in the field.

Higher level is more difficult compared to lower and middle level. This is because we deal with very complex situations: mathematical thinking and reasoning, communication, critical attitude, interpretation, reflection, creativity, generalization and mathematics. The difficulty at this level is due to the involvement of higher-order thinking skills that include deep mathematical thinking and reasoning, the ability to communicate ideas clearly, and a critical attitude towards information and problem-solving processes. Therefore, assessment at a higher level assesses not only what students know but also how they think and use mathematical knowledge in broad and non-routine contexts.

The findings reveal that all three pre-service teachers tended to design context-based tasks using shopping situations such as buying daily goods (rice, coffee, soap, cheese, etc.). This preference indicates that their contextual thinking is still dominated by familiar, everyday contexts that are easily translated into mathematical representations. From the theoretical perspective of contextual task design (Palm, 2009; Stillman, 2011), such selection reflects the early stage of contextual awareness—where teachers draw from their immediate experiences rather than from diverse socio-cultural or disciplinary contexts.

When asked about the reasons for choosing this context, the subject stated, "The context that I used in creating a two-variable linear equation system assignment was the context of buying and selling related to basic daily needs." This response illustrates that participants perceive contextualization mainly as embedding mathematical content into a real-life setting, not yet as a means to foster complex reasoning or multiple representations. Consequently, while they can link mathematics to daily life, the tasks often remain at the procedural or semi-conceptual level.

In terms of cognitive demand, participants demonstrated varying levels of task complexity. One subject was able to construct tasks categorized as HOTS, requiring students to perform multi-step reasoning (e.g., determining total cost and calculating change), as reflected in the excerpt: "Students were asked to calculate how much change they would receive if their bill was Rp100,000... students were required to think at a higher level because they had to first calculate the cost of all their purchases and then subtract it from the amount they had." This shows that the subject's task design incorporated elements of problem-solving and reasoning. However, the other two subjects produced tasks predominantly classified as MOTS and LOTS, where students merely identified prices or performed single-step calculations.

The differences among the three subjects indicate variations in pedagogical readiness and cognitive task awareness. One subject demonstrated a better understanding of how to embed higher-order thinking into contextual problems, whereas the other subjects tended to reproduce textbook-like problems. This aligns with KCT (Knowledge of Content and Teaching) theory (Ball et al., 2008), which emphasizes that teachers' ability to integrate content knowledge with pedagogical strategies influences how they design cognitively demanding tasks.

Moreover, interview data show that although participants recognized the importance of contextual tasks ("Context-based learning is important to help students understand mathematical problems related to everyday life"), they did not consistently translate this understanding into the design process. This gap suggests a surface-level understanding of context-based pedagogy—they value context as an illustration rather than as a tool for deep learning. These patterns reveal that pre-service teachers need scaffolded experiences in analyzing and designing context-based tasks that promote HOTS. They also highlight the importance of integrating reflective discussion and task analysis into teacher education, so that future teachers can move from familiar, concrete contexts toward more varied and abstract contexts that challenge students' reasoning.

To achieve effective mathematics learning, teachers need to engage students in challenging tasks teachers need to engage students in challenging and meaningful tasks, which not only require the application of procedures but also encourage critical thinking and problem-solving. Therefore, by working on mathematical tasks, teachers improve their mathematical knowledge and capacity for mathematical didactic design (Pepin, 2015). In this case, context plays an essential role because it is not limited to concrete real-world situations but rather more about creating relevant learning situations that can be experienced in real terms by students and are in line with their logic and common-sense understanding (Kohar et al., 2019). This approach makes mathematics learning more alive, meaningful, and connected to students' daily experiences.

In designing context-based tasks, pre-service mathematics teachers are not only required to create cognitively appropriate questions (LOTS, MOTS, and HOTS) but also consider various complex factors related to personal and institutional learning goals. This aligns with findings in other studies that emphasize the importance of aligning task design with the educator's values and beliefs (Chin et al., 2021; Chin et al., 2022; Huang & Chin, 2022). To investigate the characteristics of tasks designed by pre-service mathematics teachers, an analytical framework was used that included four dimensions: the type of context used in tasks, the purpose of context-based tasks, the type of information provided in tasks, and the type of cognitive demands of tasks (Wijaya et al., 2015).

Type of context used in tasks

The type of context used in the tasks dimension refers to the sources or settings of the situations used in mathematical tasks. Contexts can come from the real world, everyday life, a particular professional field (e.g. engineering or economics), social phenomena, or even fictional situations designed to resemble the real world (Canogullari & Radmehr, 2025; Umam et al., 2025). In this study, all subjects used the context of everyday life, such as shopping at the supermarket, buying clothes, fruit, soap, and other household products. This is in line with the results of previous studies that used the context of everyday life, such as traditional ceremonies (Irfan et al., 2019; Utami et al., 2022). In addition, this study's results align with other studies showing that designing context-based mathematics tasks is not a linear process but instead involves reflective thinking on various dimensions (Sullivan et al., 2015). These dimensions include designs such as context selection, language used, question structure, student interaction, and information distribution. In addition, some tensions need to be managed, such as cognitive, affective, epistemic, and ecological aspects of the designed task (Agustina et al., 2025; Marhaeni et al., 2025).

The Context-Based Tasks dimension aims to examine why context is used in tasks. The purposes for using context can vary, such as: as a conceptual hook to facilitate understanding of mathematical ideas (Bonghanoy et al., 2019), motivate students through relevant and interesting situations (Liu et al., 2025), introduction to mathematical modelling (Görgüt & Dede, 2023), used by students to interpret information and translate it into mathematical form (Jupri & Drijvers, 2016), developing mathematical literacy (Sulistyowati et al., 2023), and makes it easier for teachers to relate abstract mathematical material to everyday life so that mathematical material is easier for students to access (Nasrullah et al., 2025; Wijaya et al., 2015; Wijaya et al., 2018).

The type of Information Provided in the Tasks dimension refers to how information is structured and presented in a contextual mathematical task, directly influencing students' cognitive processes in understanding, interpreting, and solving problems (Wijaya et al., 2015; Wijaya et al., 2018). Information that is presented entirely and explicitly tends to encourage students to directly apply mathematical procedures without the need for in-depth interpretation (Amiyani & Widjajanti, 2018; Didis et al., 2016; van den Heuvel-Panhuizen & Drijvers, 2020). In contrast, partial, ambiguous, or unstructured information requires students to identify relevant data, formulate mathematical models independently, and develop reflective solution strategies. In addition, the form of information presentation, whether visual (graphs or diagrams), numerical (numbers or statistical data), or verbal (text narrative), has different effects on students' cognitive involvement. This variation in form can enrich the representation of the problem but also requires skills in translating information between representations.

Therefore, the type and format of information provided in an assignment not only functions as a context support but also as a determinant of the level of depth of critical thinking and students' problem-solving skills. This aligns with the steps of solving mathematical problems, which require students to understand, plan, and solve mathematical problems (Firdaus et al., 2023; Widodo, Pangesti, et al., 2020). In mathematical problems (especially context-based problems), students are required to understand the issues they face, then link all the information in the problem with the schemes that already exist in the student's brain until the connections between all the information obtained can lead to the stage of solving context-based problems.

The Type of Cognitive Demands of Tasks dimension refers to the level of cognitive complexity required of students in completing a mathematical task, which can generally be classified into three main categories: Lower, middle, and higher-order thinking skills (Mattis, 2015; Tekkumru-Kisa et al., 2015). Middle-order thinking skills and higher-order thinking skills. Tasks with lower-order thinking skills typically emphasize basic-level thinking processes such as remembering facts, recognizing procedures, and applying algorithms directly without requiring deep conceptual understanding. Meanwhile, Middle Order Thinking Skills involve more complex thinking processes, such as understanding the relationships between concepts, performing mathematical reasoning, and applying concepts in contexts that require interpretation and adjustment. Higher-order thinking Skills include high-level cognitive processes, such as in-depth analysis of problem situations, synthesis of information from various sources, evaluation of solution strategies, and generalization and resolution of non-routine open-ended problems. The level of cognitive demand in a task greatly determines the depth of student engagement in learning. It contributes to developing critical thinking skills and more meaningful conceptual understanding.

Context-based task design is an approach to designing learning tasks that emphasizes using real-world situations or everyday life contexts to teach mathematical concepts. The skills of pre-service mathematics teachers in designing context-based tasks can be a key element in preparing students to face real-world challenges and motivating them to learn mathematics better (Luque-Sánchez & Montejo-Gámez, 2023). The results of this study indicate that several skills that pre-service mathematics teacher students should have in designing context-based assignments include (1) Understanding Mathematical Concepts, (2) Understanding Context and Relatedness, (3) Creativity in Designing Assignments, (4) Understanding the Level of Difficulty of Assignments, (5) Considering Student Diversity, (6) Student Involvement, and (7) Reflection on Learning.

Deep conceptual understanding enables pre-service teachers to identify core ideas in mathematics and relate them to appropriate contextual situations so that the designed tasks assess procedural abilities and encourage students' conceptual thinking. This is in line with previous research showing that pre-service student teachers need to understand the mathematical concepts they want to teach through context-based tasks (Pincheira & Alsina, 2022). They must identify mathematical concepts appropriate to a given situation or context.

Understanding the context of everyday life or real-world situations relevant to the mathematical concepts taught. Pre-service mathematics teacher students need to have the ability to understand the context of everyday life or real-world situations that are relevant to the mathematical concepts being taught. This ability is vital to connect learning materials with students' real experiences to make the tasks designed more meaningful, engaging, and easy to understand. By linking mathematical concepts to situations close to students' lives, the learning process is theoretical and applicable, which can ultimately increase students' learning motivation and conceptual understanding in greater depth. This is in line with the results of previous research, which stated that students must have the skills to connect learning materials with their daily lives to make assignments more meaningful (Marco & Palatnik, 2024). Connecting learning materials to students' daily lives is one of the keys to creating meaningful and relevant learning. When mathematics materials are linked to real contexts close to students' experiences, they will more easily understand concepts, see the usefulness of mathematics in everyday life, and be motivated to learn. In addition, a contextual approach helps students build connections between knowledge learned in class and real situations, thus encouraging critical thinking, problem-solving, and flexible application of knowledge. For pre-service mathematics teachers, this skill also reflects their readiness to design learning that does not only focus on procedural aspects but also more profound and more applicable conceptual understanding.

Creativity is needed to design interesting and relevant tasks. Students must be able to think outside the box and create situations or problems that interest students. By thinking out of the box, students can develop situations or issues that follow mathematical concepts and attract their interest and curiosity. Creatively designed tasks allow students to be more actively involved in the learning process because they feel that what is being learned is related to real life and is presented non-monotonically. Therefore, creativity in designing tasks plays a significant role in building meaningful and enjoyable learning experiences.

Pre-service mathematics teacher students need to be able to adjust the level of difficulty of context-based tasks according to the grade level and students' understanding. This needs to be done so that the tasks designed are not too easy, less challenging, and not too complicated so that students are frustrated and lose motivation. This adjustment reflects the pedagogical sensitivity of pre-service mathematics teachers to students' learning needs and their ability to design differentiated learning. By considering students' cognitive development level and background, designed contextual tasks can be an effective means to encourage students' understanding, active involvement, and improvement of critical thinking skills. This is in line with the results of previous research, which stated that in compiling mathematics assessments, sensitivity is needed to the diversity of ability levels in the class so that the mathematics assessment used can accommodate all students (Rejeki et al., 2021). This sensitivity allows teachers to design questions that vary in difficulty and provide a fair opportunity for all students to demonstrate their understanding. In addition, assessments tailored to the diversity of abilities also help teachers identify individual learning needs and design more targeted learning follow-ups.

Students need to consider the diversity of students in the class, including learning styles, ability levels, and special needs. In designing context-based assignments, it must be ensured that the assignments are accessible to all students without exception while remaining challenging to encourage the development of their abilities and understanding. Considering this diversity, the prepared assignments become an evaluation tool, become inclusive learning facilities and support each student to learn optimally according to their potential and needs. By considering the diversity of students and ensuring that context-based assignments are accessible to all students, pre-service mathematics teachers also need to design assignments that encourage active student participation so that the learning process becomes more interactive and meaningful for all students. This aligns with previous research results, which stated that tasks should be designed to encourage active student participation (Hidayat et al., 2019). Context-based tasks should provide answers and encourage critical thinking, problem resolution, and discussion among students.

Student teachers need to be able to reflect on the effectiveness of the tasks they design as part of their professional development and learning improvement process. This reflection includes evaluating the extent to which the tasks they create can achieve learning objectives, engage students, are appropriate to the relevant context, and accommodate the diversity of abilities in the classroom. By reflecting on the strengths and weaknesses of the tasks they have used, students can identify areas for improvement and develop better strategies for designing future tasks. This reflective ability is vital so that student teachers become creative task designers and responsive and continuously developing educators. This is in line with the results of previous research, which stated that reflection on learning includes evaluating the extent to which tasks achieve learning objectives, the extent to which students are involved, and whether tasks facilitate understanding of mathematical concepts (Can & Yetkin Özdemir, 2020).

By compiling context-based assignments, teachers (including pre-service teachers) of mathematics can help students connect mathematics that is still abstract to be easier for students to reach. This is because mathematics learning uses a real-world context approach, and the context used is in the environment around the students, so appropriate context-based assignments can strengthen students' understanding. This is in line with the results of previous studies, which state that the use of familiar contexts in everyday life is expected to be material for teachers to design context-based assignments so that students feel that learning is fun and valuable.

4. CONCLUSION

This study revealed that prospective mathematics teachers possess the ability to design context-based tasks at various levels of cognitive demand—from low-, middle-, and high-level thinking skills, and across a variety of contexts. In the HOTS category, prospective teachers were able to create problems with relevant and essential contexts, where common-sense reasoning is required to understand and solve the problems, mathematical operations are not presented explicitly, and mathematical modeling is a crucial part of the solution. These tasks also reflect subcategories of cognitive demand, including connections, reproduction, non-routine problem solving, situation interpretation, and reflection, demonstrating early abilities in developing original mathematical approaches.

However, most of the tasks produced still focused on shopping contexts. This pattern suggests that prospective teachers are more comfortable using familiar, everyday situations. This, on the one hand, illustrates their ability to connect mathematics to real-life experiences, but on the other hand, demonstrates limitations in exploring more varied and meaningful contexts. This reliance on familiar contexts indicates that creativity in context selection still needs to be expanded to include more reflective and thematic approaches. Furthermore, there was variation in individual abilities: some participants were able to design tasks that required mathematical modeling and reflective thinking, while others remained at the level of reproducing routine problems with limited context integration. This difference underscores the need for more systematic provision in teacher education programs to strengthen Knowledge of Content and Teaching (KCT) skills, particularly in designing context-based tasks that foster higher-order thinking.

Overall, the results of this study indicate that prospective teachers have an initial foundation for integrating mathematical content with real-life contexts. However, these skills still need to be deepened through more diverse exploratory, reflective, and practice-based task design activities. Further research could explore broader thematic contexts—such as cultural practices, environmental issues, or digital technologies—and involve more participants to obtain a more comprehensive picture of the development of context-based task design skills in prospective mathematics teachers.

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