Prospective teachers' design of numeracy tasks using a physical distancing context

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Abstract

Physical distancing, which is widely practiced limiting the spread of COVID-19, is recognized to contain mathematical thoughts that can be harnessed as a context for prospective teachers' practices of mathematical problem posing. The goal of this study is to investigate the profile of mathematical tasks posed by prospective mathematics teachers using the context of physical distancing that meets the criteria of numeracy tasks. Data were collected from 66 mathematical tasks posed by thirty-three prospective teachers at a public university in Surabaya, Indonesia, attending an assessment course of numeracy based on a problem-posing task. To analyze, the posed tasks were first identified as solvable or unsolvable tasks and then further categorized into the domains of the level of context use and the level of cognitive processes. Results show that the level of context use embedded in the posed tasks varies from zero to first order, with only a few of the posed tasks being coded as having second-order context. Regarding the levels of cognitive processes, most of the posed tasks reach the level of understanding, with only a small number of reasoning tasks identified. Interestingly, all the tasks coded to contain second-order context are classified as reasoning tasks. Some implications regarding designing numeracy tasks using physical distancing and interventions in teacher education related to numeracy task design are discussed.

Keywords: COVID-19, Numeracy Task, Physical Distancing, Prospective Teacher

In recent years, many people around the world become familiar with concepts of physical distancing as individual and collective efforts to slow and limit the spread of COVID-19. Physical distancing, which is also referred to as social distancing, means creating a safe distance of at least two meters (six feet) between two individuals (Jones et al., 2020). This implies people are not allowed to gather in groups and are also required to stay away from crowded places and avoid mass gatherings. Some mathematical thoughts within the concept of physical distancing were discussed by scholars to give insights into how mathematics takes part in such efforts (see e.g., Murray, 2020; Park et al., 2021). Park et al. (2021), for example, applied the so-called spatial optimization techniques to arrange the largest number of seats that satisfies the 2-m physical distance in an indoor stadium, while Murray (2020) used such techniques to plan classroom seating. Two more recent studies by Bortolete et al. (2022) and Stoll (2022) respectively employ an online tool to optimize classroom seating by considering variables of fixed and non-fixed

position seat allocation and proposes solutions to the distance constrained cinema seating problem which suits the COVID-19 regulation.

In the context of education, physical distancing is not only used as a recommendation for the rule of organizing school learning and teaching activity (Murray, 2020) but also can be used in the context of learning mathematics (Nusantara & Putri, 2020; Nusantara et al., 2021; Sari et al., 2021; Zulkardi et al., 2020). Nusantara et al (2021), for instance, used the context of the regulation of personal transportation restrictions during large-scale social distancing (LSSR) as a special case of physical distancing context to develop PISA-like tasks, while this context is also used to foster students' numeracy on the task with the content of change and relationship (Nusantara & Putri, 2020). Also, this context was employed by Sari et al. (2021) in a qualitative study to encourage students' numeracy through a task dealing with isolation rooms for COVID-19 patients. Furthermore, the mathematical thoughts emerging from this context can also be investigated from issues such as mathematical modeling on COVID-19 spread patterns, graph interpretation related to the current trend of COVID-19 spread over a particular population, and geometrical shape of area implied by the 2-m distance rule (Murray, 2020; Park et al., 2021). Regarding the latter issue, this context implies that those responsible for public places such as shopping places, sidewalks, places of worship, traditional markets, queues at hospitals, and the like are urged to provide a special sign indicating where a person should sit/stand to stay within a safe distance. With the information contained in these issues, the context of physical distancing has the potential to be embedded in mathematical literacy/numeracy problems.

While it could be argued that there is a difference between mathematical literacy and numeracy, the fact is that the use of those two terms appears to be geographical, with some countries choosing to use the former while others prefer the latter (Liljedahl, 2015). Currently, in Indonesia, for example, the term numeracy is used to indicate the ability to think using concepts, procedures, facts, and mathematical tools to solve everyday problems in various kinds of contexts which are relevant for individuals as Indonesian citizens and citizens of the world (CAL, 2020). This is in line with the definition of mathematical literacy defined by OECD in the PISA framework (OECD, 2018), where the term "think" in numeracy of the Indonesian curriculum refers to the capacity to reason mathematically and to formulate, employ, and interpret mathematics to solve problems in a variety of real-world contexts. According to Goos et al. (2013), to be numerate, one needs to do more contextualization, instead of an abstraction. Thus, numeracy, as also highlighted by CAL (2020), means being willing and able to use mathematical tools, knowledge, and dispositions in various contextual (even real) situations. In this case, contextual situations play important roles to determine mathematical procedures and therefore performance (Boaler, 1993), where they can be indicated through aspects of personal life, workplace, and exercising civil responsibilities (Geiger et al., 2015), and even scientific issues (OECD, 2018; CAL, 2020).

Since the use of context is essential in numeracy problems/tasks (Geiger et al., 2014), attention to how the selected context such as physical distancing, which can be regarded as a scientific issue, is used in the mathematical task has the potential to improve students' numeracy. The challenges to designing such kind of task are around how to turn the context into a set of authentic tasks which meet the concept of numeracy (Ekawati et al., 2017; Paolucci & Wessels, 2017). This can be understood as a tool to evaluate how realistic a problem situation is (Bonotto, 2007), where the realistic level of a given problem in mathematics learning is in line with the actual task occurring in the community to be simulated (Palm, 2006). These requirements indicate the level of use of context in mathematical tasks, where the use of context indicates the extent to which problem-solving requires involvement with the context in cognitive processes when solving a problem, both when formulating a problem into mathematical form, solving it

mathematically, and when interpreting the mathematical results and validate the interpretation in the context of the given problem (OECD, 2018; Salgado, 2016). Thus, the context embedded in the numeracy task should lead to clear authenticity so that the task solver uses it to solve the problem, which is not the case with the solution process of the seemingly artificial task that is independent of the context presented (Tout & Spithill, 2015).

Concerning the design of numeracy tasks, harnessing physical distancing context can be identified from the extent to which the mathematical thoughts of such a context are investigated and then employed simultaneously with the actual situation relevant to COVID-19 to solve the problem contained in the designed task. In this sense, some aspects identified as essential in numeracy tasks according to Geiger et al (2014) can be assessed from the emergence of real-life contexts (e.g., the use of physical distancing context related to COVID-19), the use of mathematical knowledge in solving real-life problems (e.g., the 2-m rule and its relevant mathematical consequences), the use of physical, representational and digital tools to assist in problem-solving (e.g., calculator and drawing tool to illustrate geometrical shape derived from the 2-m rule of physical distancing), the improvement of positive attitude towards the use of mathematics (e.g., the improvement of mathematical disposition due to the engagement in mathematical activities from the mathematical thoughts of COVID-19), and the need of critical orientation to interpret mathematical results and make decisions based on evidence (e.g., implication of problem-solving experience related to physical distancing to the self-awareness of COVID-19 outbreak).

In this paper, the design of the numeracy task is mainly derived from the current Indonesian curriculum document about numeracy (MoE, 2017). It does not only cover tasks about the use of numbers, but also the use of a larger scope of traditional mathematical contents, such as algebra, geometry, probability, and statistics in real life. The document mentions three levels of the cognitive process showing the thought processes required to solve the numeracy problem (CAL, 2020). Referring to OECD (2018), the higher the level, the more complex one needs to activate the cognitive process of formulating problems mathematically, employing formal mathematical structure, and interpreting/evaluating mathematical results to the problem context. Sequentially, the level of this cognitive process is increasing from the category of "understanding" task, to "applying" task, to the "reasoning" task (CAL, 2020).

As prospective teachers, students who are studying in undergraduate mathematics education study programs are encouraged to be capable of posing numeracy tasks since the significance of such a task can help them prepare students to be numerate/mathematically literate (Blum & Niss, 1991; Stacey & Turner, 2015), emphasizes students to figure out the connection between real-world and mathematics (Felton, 2010), and enhances the transferability of mathematics to another context (Salgado, 2017). However, to meet the criteria of numeracy task which suits those significances, prospective teachers often experience difficulties in posing mathematical tasks such as only being able to pose simple and one-step-solution tasks, exercise, tasks with lower-level cognitive demands (procedures without connections), a limited domain of task such as arithmetic operations, or even pose non-mathematical or unsolvable tasks, which included bare or insufficient information (Fitriana et al., 2022; Kılıç, 2013; Kohar et al., 2019; Leavy & Hourigan, 2020; Zulkardi & Kohar, 2018). Concerning the design of numeracy tasks, they are also confronted with the challenge of creating authentic problems using real-world context (Tout & Spithill, 2015; Sevinc & Lesh, 2021; Siswono, Kohar, Rosyidi, & Hartono, 2018). To sum up, issues of task solvability, task promoting higher-level of cognitive demand, and task authenticity become crucial for prospective teachers' experiences in problem-posing.

In responding to the last-mentioned issues, we were interested in investigating the quality of

problem-posing products, namely prospective teachers' design of numeracy tasks. This can be undertaken by assessing the level of context use for mathematics problems as suggested in the PISA framework where only the contexts for mathematization are allowed to be embedded in the tasks created (de Lange, 1987), and the level of cognitive process indicating the cognitive demand of the task (CAL, 2020). In this regard, scrutinizing prospective teachers' design of numeracy tasks considering such a rule will be fruitful for teacher educators to evaluate the learning design or even curriculum for teacher education in an undergraduate program. Thus, this research aims to investigate the level of context use and the level of cognitive processes of the mathematical tasks posed by prospective teachers using physical distancing context for COVID-19.
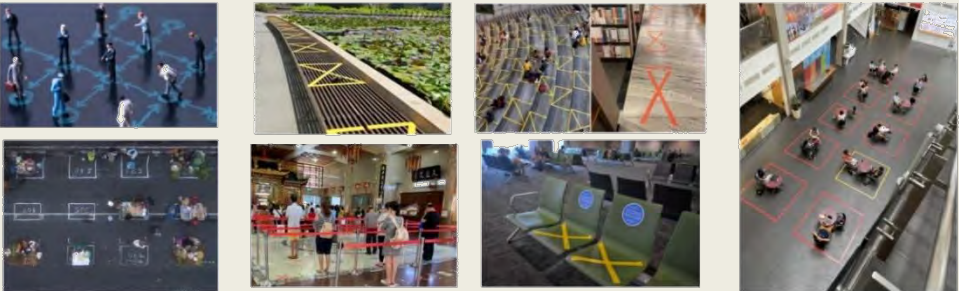
METHODS

Participants

This is descriptive explorative research that snapshots the profile of numeracy tasks posed by prospective teachers. As many as 66 mathematical tasks were created by 33 prospective teachers (7 males, 26 females) who were studying at a public university in Surabaya Indonesia, having completed the first half of their study time and finished some basic courses both in mathematics and pedagogy such as basic mathematics, learning design, and were taking an assessment course that discusses the concept of numeracy, particularly in Indonesian curriculum. Thus, the prospective teachers had gained some basic skills in creating mathematical tasks, such as the format of written tasks/questions (e.g., multiple-choice, closed-constructed task, and open-constructed task), validity and reliability of task, and scoring response. More specifically, they also already learned the topic of cognitive processes of revised bloom taxonomy (Anderson & Krathwohl, 2001) as the basis for designing any mathematical problems. However, they were not given explicit courses on how to design numeracy tasks.

Instruments

The instrument is in the form of a problem-posing task in which the participants were asked to pose two numeracy tasks (one multiple-choice, one closed or open constructed item) using a physical distancing context. The participants took about 20 minutes to complete the task. The task was validated by an expert in assessment from the same university as the first author by asking her to review the initial draft of the instrument regarding the aspects of content, construct, and language issues qualitatively. The revision was done based on the results of the review, which were around the redundancy of information, by removing some irrelevant information and adding some pictures representing the concept of physical distancing to make the task more illustrative. Figure 1 indicates the revised version of the problem-posing task.

Physical Distancing

The concept of Physical Distancing has been applied by many countries to limit the spread of COVID-19 in recent years. According to experts, the safe distance between people in a crowd is at least 2 meters. This concept implies that the people in charge of public places such as shopping areas, sidewalks, places of worship, traditional markets, waiting areas at hospitals, and the like are urged to give special signs indicating where a person must sit/stand to stay within the safe distance recommended.

Sumber gambar: google.com

By using the concept of physical distancing, create two numeracy tasks (one multiple choice and one essay). You need not write the solutions corresponding to each of the tasks.

Figure 1. Physical distancing task

Data Analysis

Data were analyzed by categorizing the frequency of tasks created by prospective teachers regarding two domains: level of context use and level of cognitive processes for each domain. Before labeling each task into those two domains, each of the tasks was first identified as to whether it is solvable or unsolvable. An unsolvable problem (task) contains unclear wording, unstated important assumptions, or overmuch complex algebraic expressions (Kwek, 2015). Additionally, the authors also considered a task item containing incomplete contextual, numerical, figural, tabular, or graphical information about COVID-19 that makes such a task impossible to solve is also labeled as an unsolvable task. The analysis did not consider the correctness of spelling or grammatical structure if the meaning of the sentences or other information of the task item can be understood. After this step, the tasks labeled as solvable tasks were then categorized into two domains whose analytical descriptions of each categorization are described in Table 1.

While the level of context use for each task item is labeled from the extent to which the context is used in the mathematization process as indicated in Table 1, the level of cognitive processes draws on the extent to which mathematical facts, concepts, and procedures are employed during problem-solving processes. An 'understanding' task demands a solver to recall facts, processes, concepts, and procedures, assess fluency with mathematical concepts and skills, while an 'applying' task demands a solver to apply knowledge and conceptual understanding of facts, relations, processes, concepts, procedures, and methods in real-life contexts to solve problems. Furthermore, a 'reasoning' task demands a solver to analyze data and information, make inferences, and expand understanding in new situations, including previously unknown situations or more complex contexts. Thus, this task can cover more than one approach or strategy.

Table 1. Domains of analytical tool

Level of context use (Salgado, 2016)	Level of cognitive processes in numeracy task (CAL, 2020; MoE, 2017)
Zero-order: Context provides the opportunity to take direct actions or make direct inferences from the instructions given in a mathematics problem. Hence, the context of a problem is not used to interpret mathematical results or arguments. *First-order:* Context is used to either identify or select relevant information, variables, or relationships for the mathematical formulation of a problem. Also, context is used to determine the adequateness of the mathematical results. *Second-order:* Context is the source to either define or retrieve relevant variables, assumptions, or relationships, for the mathematical formulation of a problem. Besides, context is used to judge the adequacy of the mathematical results/arguments in terms of the initial problem.	*Understanding:* Task assessing students' understanding of facts, procedures, and mathematical tools. *Applying:* Task assessing students' ability to apply mathematical concepts in real situations that are routine. *Reasoning:* Task assessing students' reasoning on non-routine problems.

To examine the reliability of the coding, the authors applied Cohen's Kappa for each of the codings from the coders, which are the first and the third author. Cohen's Kappa (κ) resulted from analyzing the coding by using SPSS 26. As indicated in Table 2, the resulted κ score is respectively 0.874 (n=66), 0.867 (n=50), and 0.642 (n=50) for the solvability of the task, level of context use, and level of cognitive processes. According to Landis and Koch (1977), this result indicates that the coding is almost perfect for both domains of solvability of task and level of context between the two raters, while that is substantial for the domain of level of cognitive processes. Hence, the authors negotiated the coding primarily on the domain of the level of cognitive processes to increase the agreement. To report, the codings of the third author were then selected to be further analyzed.

RESULTS AND DISCUSSION

Distribution of Posed Tasks

Of 66 task items, there were 50 items (75.7%) that are solvable, while the remaining 16 items (24.3%) are unsolvable. Since we were only interested in the solvable tasks, we did not consider the unsolvable tasks for further analysis.

Table 2. Distribution of Posed Tasks

	Zero-order	First-order	Second-order	Cognitive process level
Understanding	4 (8%)	20 (40%)	0 (0%)	24 (48%)
Applying	5 (10%)	5 (10%)	0 (0%)	10 (20%)
Reasoning	1 (2%)	0 (0%)	15 (30%)	16 (32%)
Context level	10 (20%)	25 (50%)	15 (30%)	50 (100%)

Table 2 indicates the distribution of solvable tasks regarding the level of context use and level of cognitive processes. Regarding the level of context use, Table 2 points out that most task items are first-order use of context (50%) and 'understanding' problem (48%).

Unsolvability of Tasks

Despite the number of unsolvable tasks being relatively few (24.3%), the findings related to the feature of tasks created by prospective teachers need attention. Some findings which lead the tasks unsolvable are indicated in Figure 2 and Figure 3.

Translation: A traditional market in Surabaya carries out selling-buying activities by complying with the regulations set out related to the COVID-19 health protocol, one of which is the obligation to maintain distance among visitors. This market has a long rectangular land with a size of 40 m x 60 m. If sellers must keep 2 meters, how many sellers are selling in the market during this pandemic?

Figure 2. Unsolvable task 1

Figure 2 is coded as an unsolvable task since it does not state important assumptions such as the size room of every seller and the size of a path that the visitor may occupy, which causes such a task to not be solved. In addition, the issue of unclear wording is also found in the stated question of the task. The question, "how many sellers are selling in the market", is unclear since it might be interpreted as the number of sellers at a particular time or the maximum number of sellers that can occupy the market.

Translation: A supermarket in Gresik city will apply the physical standing concept. For the queue at the cashier, there is a distance of ± 2 m between buyers. What is the maximum number of buyers when the place to queue is full if the size of the queue is 0.5 m x 0.5 m?

Figure 3. Unsolvable task 2

Another similar issue related to unstated assumptions is also found in unsolvable task 2 (Figure 3). Some important things are not known in task 2 that cause it unsolvable, such as the number of cashiers in supermarkets, the size of the cashiers' working table, and the length of the room used in queuing. Additionally, some insufficient information is also found in several created tasks such as indicated in Figure 4. It not only contains unclear and inappropriate wording, e.g., 'perimeter of a seat

box' (instead of the perimeter of the top surface of the seat box) and 'the distance to the wall' (which distance?) but also contains incomplete contextual information such as indicated by the sentence 'the area of the floor is 35 m²' which leads no single size of the floor, which of course causes more than one solution processes so that the format of multiple-choice in this case is not appropriate.

> Diketahui keliling sebuah kotak tempat duduk orang adalah 4 m. Jika luas lantai tempat yang memuat semua kotak tempat duduk tersebut adalah 35 m², dan jarak masing-masing kotak adalah 1 m, termasuk juga jarak dengan temboknya. Berapa banyaknya kotak tempat duduk yang dapat dibuat bila kotak tempat duduk tersebut berbentuk persegi yang identik?
>
> (a) 5   (c) 3
> (b) 6.   (d) 4

Translation: Given that the perimeter of a seat box is 4 m. If the area of floor loading all the seat boxes is 35 m², and the distance between every two-seat box is 1 m, including the distance to the wall, how many seat boxes can be made if the shape of all the seat boxes is identical (congruent) in a square?

Figure 4. Unsolvable task 3

Level of Context Use of Numeracy Tasks

Some examples of tasks created by prospective teachers regarding their level of context use are provided respectively in Figure 5 until Figure 10. The task in Figure 5 is coded as zero-order use of context task due to irrelevant context with the problem of the task.

> Pasar Suko di Sidoarjo menerapkan aturan physical distancing bagi penjualnya untuk menghindari pembeli berdesakan. Jarak antara 1 penjual dengan penjual lainnya adalah 2 meter. Caca dan cici belanja di salah satu penjual pasar suko, kemudian cici berjalan ke penjual sayur melewati 2 penjual lainnya. Berapa jarak cici dan caca?
>
> a. 2 m   c) 6 m
> b. 4 m   d. 8 m

Translation: Sooko Market applies physical distancing for every seller to prevent COVID-19 transmission. Given that the distance between two sellers is at least 2 meters. Caca and Cici are shopping in a seller at Sooko Market, then Cici walks past two other sellers (which are on the same side as the first seller). What is the distance between Cici and Caca?

Figure 5. Zero-order use of context task 1

The context of physical distancing is not used to find the distance between Caca and Cici. In other words, whether the rule of 2-m distance is applied or not, the rule does not affect the way a solver of such a task finds the distance requested. A similar finding is also indicated in Figure 6.
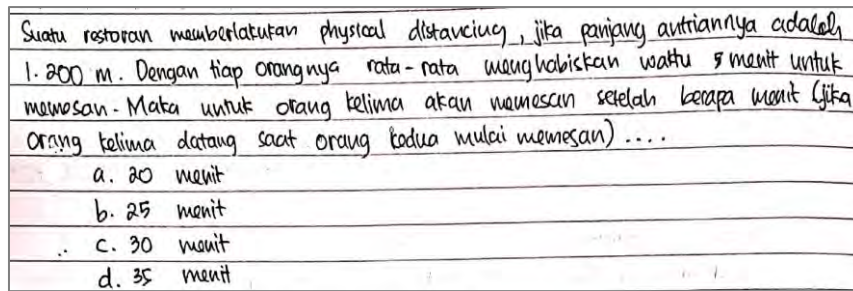
Translation: A restaurant enforces physical distancing. (Given that) the queue length at the restaurant is 1200 m with each person spending about 5 minutes ordering (a meal). After how many minutes will the 5th person start ordering if he arrives when the 2nd person starts ordering? A. 20 minutes, B. 25 minutes, C. 30 minutes, D. 35 minutes.

Figure 6. Zero-order use of context task 2

While the task shown in Figure 6 is mathematically solvable, it does not open any opportunities for a solver to use the context of physical distancing, which is the rule of 2-m distance, to find the time spent to order a meal. Thus, none of the stages of problem formulation or interpretation of mathematical results into the real world require the physical distancing context mentioned in the problem. Another type of task indicated to use zero-order context is the task that requires relatively high cognitive demand but lacks mathematization, such as the task that asks a solver to find the number of ways of seating a particular number of people with additional constraints such as the rule of where they should sit. Although a physical distancing context, which is every two people should keep a 2-m distance, is included as part of the information within the task, a solver does not require such pieces of information to obtain the solution.

Next, two examples of first-order use of context tasks are provided in Figure 7 and Figure 8. The context of the waiting chair size in Figure 7 is required, i.e., only the length (5 m), and not the width (0.5 m), which is considered important to making any calculations to find the maximum number of people who can sit on the chair.
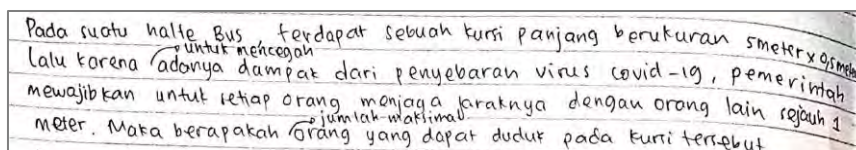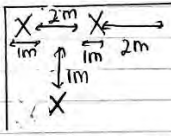

Translation: At a bus stop, there is a rectangular waiting chair measuring 5 meters x 0.5 meters. Because there are efforts to prevent the impact of the spread of the COVID-19 virus, the government requires everyone (who sits in the waiting chair) to maintain a distance of 1 meter. What is the maximum number of people that can sit on the chair?

Figure 7. First-order use of context task 1

Furthermore, the context of the physical distancing rule of 2-m distance is used to construct any representations for formulating strategy as well as check the adequateness of the mathematical results from the executed strategy. Thus, both the two contexts provide clear cues to mathematize the situation of the task.

The task in Figure 8 asks a solver to find the maximum number of prayers according to the physical distancing rule. While the context of 2-m rules is relevant to the solution process, this task provides explicit information that a solver may extract explicitly from the given information.

Translation: To suppress the spread of the Coronavirus, the administrator of the Al Karim Mosque arranged the floor of the mosque so that it complied with the rules of physical distancing. For this reason, the administrator puts a cross sign on the place that should not be occupied during congregational prayers as shown in the following picture (see the figure beside).
If the mosque is 10 m x 6 m, what is the maximum number of prayers that can be accommodated?

Figure 8. First-order use of context task 2

The sketch, the size of the mosque, the relevant size of prayers needs to pray, and the cross sign indicating an unoccupied place is important to find the number of prayers. The rule of 2-m distance in physical distancing is used relevantly in the context of the task in Figure 9. This is indicated using information about the seating rule which optimizes the distance. However, such a rule does not come to a particular strategy that leads a solver to find the solution.

Translation: In a hospital, there is a waiting room containing 10 rows of seats with 12 seats in each row. However, due to the COVID-19 pandemic, the seating rules are based on the physical distancing rule, i.e., people must be separated by two chairs, and no one in front and behind can sit. The maximum number of visitors in the waiting room who can occupy the seats provided is...
a. 40 people   c. 60 people
b. 50 people   d. 70 people

Figure 9. Second-order use of context task 1

To find the maximum number of visitors in the waiting room, a solver needs to identify a possible seating map that covers all the possibilities of seating patterns, which is not directly given in the information. Thus, the solver needs to extract some extraneous information regarding the seating rule. Hence, this task is coded as the task with second-order use of context.

The task in Figure 10 indicates problem contexts that need to be mathematized, namely congregational prayers, prayer room, health protocol, and social distancing. The first two contexts indicate how Muslims do praying in a mosque, while the last two contexts affect changes in the first two

contexts. In these contexts, Muslims who pray in the congregation will line up neatly in several rows where each row will contain worshipers who are close to each other, usually with their heels close together so that there is no significant distance between each worshiper in a row. However, because the social distancing context requires a distance of 2 meters for every two worshipers in a row, the congregation in one row can no longer be tight.

Translation: A prayer room will hold congregational prayers by implementing the health protocol (COVID-19) to prevent the transmission of COVID-19, namely by social distancing, i.e., each congregation must be 2 meters apart. What is the maximum number of people who can attend the prayer room (the size of the prayer room is 5 m x 10 m)

Figure 10. Second-order use of context task 2

In addition, in practice, each line of worshipers requires space with a width of about 1 meter (which can vary depending on the conditions of the place) to realize one prayer movement. The latter can be considered as an assumption that a problem solver needs to apply. Therefore, this task is coded in a second-order task of context use because contexts do not provide enough cues for mathematization. This is also the main difference with the task in Figure 8, where this assumption is presented explicitly in the cross-sign design information, especially to show how wide the space required, which is 1 meter, by the congregation praying in each row. Thus, the contexts in Figure 8 provide explicit cues.

Level of Cognitive Processes of Numeracy Tasks

Some examples of tasks created by prospective teachers regarding their level of cognitive processes are provided respectively in Figure 11, Figure 12, Figure 13, and Figure 14. The task in Figure 11 assesses students' understanding of procedural skills, i.e., counting simple integer operations for finding the maximum number of people loaded in the room.
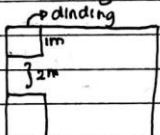
Translation: In a waiting room at a hospital, each sitting visitor is spaced two stools apart. There are 6 seats in each row. If there are 5 rows of seats, what is the maximum number of people in the waiting room?

Figure 11. 'Understanding' task 1

It is clear that no matter which seats are allowed and are not allowed to be used, each row will have a maximum of 2 seats available for seating so that a simple multiplication operation of 5 rows x 2 seats can be used. Thus, this task is labeled as an 'understanding' task. Another typical 'understanding' task can be seen in Figure 7. By representing the situation of the task into a sketch of a chair with a length of 5 meters, for example, a solver of this task immediately knows how many people can sit.

Translation: An office applies physical distancing of the 2-m rule for working activities. Hence, the office, which measures 13 m x 13 m, will redesign the space of the office area with every worker space being 1 m x 1 m (as indicated in the picture). Using this model, how many spaces can be created?

Figure 12. 'Applying' task 1

The task in Figure 12 indicates a simple problem that examines solvers to use the multiplication rule to find the maximum spaces that can be created in the room provided. Thus, a solver needs to find the maximum number of spaces in one row and then multiply it by the possible number of rows within the room. Another example of 'Applying' task is shown in Figure 8, where one needs to only apply a routine mathematical operation in real situations by first determining how many rows there are and how many people in each row that can be loaded based on the given sketch design.


Translation: A mosque applies a physical distancing rule for its praying activity, which is a 2-m distance rule for each prayer to another (within one row). If the number of prayers that will pray in such a mosque is 100 prayers, is it possible for the mosque to apply the physical distancing rule for those prayers?
Given that the size of the mosque (area for praying) is 50 m x 30 m.

Figure 13. 'Reasoning' task 1

While the task in Figure 13 can also be regarded as the task with the second-order context use, this task is also labeled as a reasoning task. This is because the task examines a solver to first identify the context of praying activity in a mosque, investigate the relationship between the size of space a prayer needs to pray, consider the distance of every two prayers which is separated by at least 2 meters, identify the number of the row containing prayers that can be occupied with such a mosque size, and finally find

the possible number of prayers by using multiplication rule (number of prayers in a row times number of possible row). These things make the solution of the problem non-routine. Therefore, a solver needs to finally answer whether all the 100 prayers can occupy the mosque with a physical distancing rule.
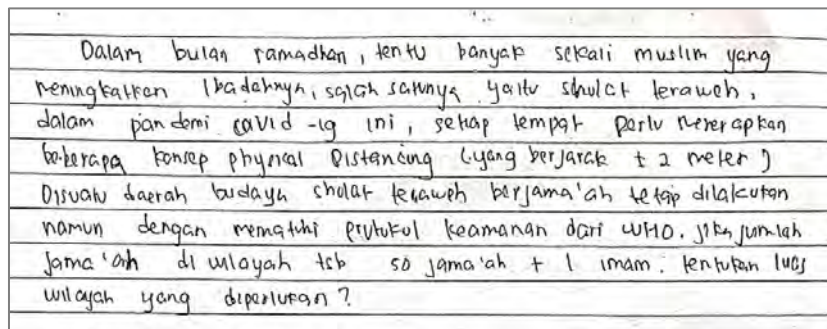
Translation: In the month of Ramadan, many Muslims want to perform tarawih prayers despite the current COVID-19 pandemic situation. Every gathering place (including prayer congregations) needs to implement physical distancing (with a distance of 2 meters). In an area with a congregation of 50 people + 1 priest, determine the area required to contain the congregation.

Figure 14. 'Reasoning' task 2

Another example of a 'reasoning' task is given in Figure 14 which shows a more open-ended task leading to more than one solution. This task requires a degree of cognitive effort by employing multiple ways to put all the 51 people such that they occupy an area constrained by the rule of 2-m distance. For example, if a solver decides to select a rectangular area for the prayer congregations, the size of the area could be 5x10 (people) or 7x13 (people) which leads to different areas.

Results of this study indicate that creating numeracy tasks using a physical distancing context is quite challenging. This is shown by the findings that show a relatively low number of tasks that meet the highest level of context use and cognitive process in numeracy tasks which proceed with students' mathematization and promote reasoning skills. Some possible issue related to this finding and the potential effect of the context is discussed as follows.

At the time this context was assigned to students, the information that developed about the 2-m distance rule for physical distancing had not been much reviewed by researchers, especially in the context of the virus in COVID-19. Therefore, it is very possible that even if they pay attention to the authenticity of the context in the design of the task, this distance rule seems only understood for all kinds of conditions. Recently several researchers reviewed the 2-m physical distance rule by constructing an infection risk-based model in which the transmission rate of COVID-19 is also influenced by where the distance is applied (Liu et al., 2021; Stoll, 2022). According to this research, the 2-m one-size-fits-all physical distancing rule derived from a pure droplet-based model does not apply under some realistic indoor settings and may further increase the likelihood of disease transmission. The authenticity of the designed task can be identified from the extent to which current information about the factors that affect the transmission rate of COVID-19 is embedded in the information contained in the task. For example, scientific factors related to the 2-m distance rule such as the use of face cover, virus exposure time, the thermal stratification of the indoor environment (Liu et al., 2021), the specific pattern of airflow containing the droplets of viruses, room ventilation, and susceptibility of an individual to infection (Jones et al., 2020) can be used as a steppingstone as scientific contexts for the mathematization process which is indispensable in designing numeracy tasks (OECD, 2018; Stillman et al., 2015). In the case of spatial optimization constrained by physical distancing, Stoll (2022), for instance, offers an idea of seating groups

of various sizes in a limited seating space such as in a cinema, while ensuring sufficient empty seats between each group to optimize the number of cinema visitors to minimize the possibility of spreading the virus between groups. Meanwhile, Islam et al. (2021) implemented physical distance in a simulation model by considering the dynamic changes in the diameter of a person's location during interaction with the diameter of another one's location. Hence, to create numeracy tasks with a physical distancing context, prospective teachers can also consider scientific aspects behind this context which complement the geometrical aspects directly derived from this context, which are mostly found in the posed tasks in this study.

Regarding the distribution of posed tasks, Table 2 indicates an interesting finding, namely all the second-order context tasks are recognized as reasoning problems, although it is only 32% out of the created tasks. While this type of task is expected to arise from the more tasks that the prospective teachers pose, this encourages the hypothesis that the higher the level of use of context, the higher the level of cognitive processing demand of the numeracy tasks created. This argument can be supported by the theoretical statement that an individual who successfully engages in mathematization in various contexts, both extra and intra-mathematical contexts, needs to activate mathematical competencies (Niss, 2015; Niss & Højgaard, 2019; OECD, 2018; Pettersen & Nortvedt, 2018). It can be understood that context-based problem-solving that requires the ability to identify extraneous information, such as the type of questions with second-order contexts where assumptions are needed but not given in the task, have an impact on the need for activating higher degrees of mathematical competencies underpinning mathematical literacy, including more complex chains of reasoning (Turner et al., 2015). In this regard, a positive correlation is also reported by OECD (2010) asserting that the highest levels of mathematical literacy (numeracy) involve the ability to effectively handle tasks with second-order contexts while solving the highest levels of mathematical literacy problems needs advanced mathematical thinking and reasoning (OECD, 2013). This finding raises the question of whether the skills of posing tasks with a high level of cognitive processing are positively correlated with the skills of those with a high level of context use.

The fact that there are still unsolvable tasks (24.3%) and the relatively high use of zero-order context tasks (20%), whose use should be avoided in the design of numeracy tasks (OECD, 2010), found in the created tasks shows lack of problem-posing skills of prospective teachers. The findings of some unclear wordings and unstated assumptions in the created tasks in Figure 2 and Figure 3 show that the prospective teachers show limited exposure to real-world mathematical modeling experiences (Kwek, 2015). For example, when they considered using the term 'distance between two people is 2 m' within their posed tasks, they often interpreted this by putting the objects having such a distance in a rectangular model, instead of an equilateral triangle model which accommodates equal distance between any two objects. Moreover, some of them also include incomplete contextual information such as only providing the area of a particular space without any information about the size which makes them unsolvable. This finding, according to Guo et al. (2020), is related to the less consideration of the accuracy of posed problems which encompasses insufficient questions (questions without the required information, e.g., "What is the maximum number of people attending the concert in the stadium?" that does not provide information on the size and shape of the stadium (only the total area is given) and other relevant contexts such as whether the stadium is full of people or not, whether they sit or stand, or whether any specific rule such as physical distancing is applied) and impossible questions (questions with unreasonable information, e.g., "The length of the fences of a triangular city park is 10 cm, 20 cm, and 30 cm, respectively, please find the area enclosed by the fences of the park"). The latter example indicates that

it is not only contextually invalid (it is unusual to find a city park whose fences are only 10 cm, 20 cm, and 30 cm long) but also mathematically invalid (the size of fences of the triangle does not meet Triangle Inequality Theorem). Regarding the level of context use, the fact that only limited tasks indicated to use of second-order context (30%) shows that the majority of the prospective teachers neglected the openness of the task where assumptions and predictions allow for unique solutions are required (Ferri, 2018; Maaß, 2010), meaning that not every task requiring complex mathematical operation such as exemplified by some prospective teachers in this study can always be recognized to satisfy the criteria of task openness (Dogan, 2020).

Findings in this study, therefore, lead to an important alarm for teacher education so that prospective teachers studying numeracy could improve their skills in posing mathematical tasks which meet the criteria of numeracy tasks. Since problem-posing is known as a multifaceted and complicated task (Crespo & Sinclair, 2008), issues around this phenomenon should be tackled by providing interventions that can improve prospective teachers' use of authentic context, i.e., context used for mathematization (Siswono, Kohar, Rosyidi, & Hartono, 2018), reduce their tendency to use too much information provided in the tasks, unfamiliar terms, unspecific units of contexts, and unacceptable use of mathematical symbols (Zulkardi & Kohar, 2018), and engaged prospective teachers in collaborative problem posing (Crespo, 2020; Utami & Hwang, 2021). More particularly, to increase the level of context use, Tout and Spithill (2015) argue that a designer of mathematical literacy (numeracy) task needs to simplify the complex real-world context and related stimuli, and include mathematical information to make the task accessible to students while still maintaining the authentic aspect. This can be undertaken in two ways, i.e., starting from a new context and then showing suitable content for that context or vice versa, i.e., starting with a particular mathematical concept or content area and then trying to find the appropriate context based on an authentic real-world task. In addition, many research finds a positive correlation between problem-posing and problem-solving (e.g. Baumanns & Rott, 2021; Limin et al., 2013), as well as problem-posing and mathematical content knowledge (e.g. Lee et al., 2018; Van Harpen & Presmeg, 2013). Thus, the interventions could provide learning activities that not only enhance prospective teachers' concept of numeracy tasks but also problem-solving activities particularly using numeracy tasks. Responding to such recommendations, professional developments could be undertaken by engaging numeracy problem posers in identifying the nature of numeracy/mathematical literacy tasks and solving numeracy tasks collaboratively and individually preceding problem-posing activities (Siswono, Kohar, & Hartono, 2018; Ulger et al., 2022). Such ways can be extended with various methods of posing numeracy tasks that may be found in future research.

While this research may bring another insight into the knowledge about the extent to which mathematical tasks designed by prospective teachers meet the criteria of numeracy tasks, limitations regarding methodology and data sampling need to be improved. Thus, more research is needed, for example by applying more sophisticated statistical procedures to investigate the correlation between the level of context use and the level of the cognitive process from tasks created by prospective teachers inferentially and involving a bigger number of participants to add the degree of external validity.

CONCLUSION

Most of the posed tasks investigated in this study are solvable, which are free from invalid assumptions, insufficient information, error wording, and insufficient information. Meanwhile, prospective teachers tend to create numeracy tasks without incorporating extra information important in the mathematization

process. Regarding the level of context use, most created tasks are in the first-order use of context, indicating that context is used relevant to solve the task although it is stated explicitly. Regarding the level of cognitive processes, most of the posed tasks are identified as 'understanding' tasks.

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Declarations

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