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Problem-based task in teacher training program: Mathematics teachers' beliefs and practices

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Abstract

Research on mathematics teacher professional development has emphasized primarily teaching quality enhancement. Mathematics task as one of the vital components in mathematics teacher education has been sparsely investigated. The purpose of this research is to explore mathematics teachers' beliefs and practices in applying a problem-based task after attending one-semester online teacher professional training funded by the Ministry of Education. This is a mixed-method research design with data collected by distributing questionnaires to 105 mathematics teachers from 24 provinces in Indonesia after accomplishing an online professional training program to determine their self-reported beliefs about mathematical problem-based tasks. Data were also collected by conducting focus group interviews with 15 mathematics teachers with different teaching experiences. Teachers' relevant documents, such as course contents, task forms, and notes, were analyzed and used to enrich the qualitative interpretation. The quantitative result indicated that mathematics teachers' beliefs on the problem-based task were low. Meanwhile, the qualitative findings indicated this category of teachers constructed their problem-based tasks with no theoretical framework. Three misconceptions in designing problem-based tasks were also reported. Therefore, future research is recommended for a more acceptable and applicable problem-based tasks framework and design a specific teacher professional development training to promote teachers' competencies.

Keywords: Misconceptions Task-Practice, Problem-Based Tasks, Professional Development, Teaching Experiences

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The ability to solve problem-based tasks has become one of the primary concerns of mathematics education (NCTM, 2000). Learning activities are expected to develop students' 21st-century skills and competencies (Bell, 2010). However, some previous research reported that students have low abilities in terms of solving problem-based tasks (Napitupulu et al., 2016; Haruehansawasin & Kiattikomol, 2018; Hendriana et al., 2018). Napitupulu et al. (2016) further stated that they lacked the ability to translate problem representations into mathematical equations, while Haruehansawasin and Kiattikomol (2018) reported that it is difficult for them to solve questions that are not properly structured. Hendriana et al. (2018) stated that initially, students had low abilities before adopting innovative teaching. More specifically, several research proved that the majority were unable to solve mathematical problems that required complex strategies (Nelson & Powell, 2018; Bardy et al., 2021) rather they find routine problems easier to solve (Yeo, 2017; Prendergast et al., 2018; Lavie et al., 2019; Verschaffel et al., 2020). PISA test results showed similar outcomes regarding students' low mathematical problem-solving abilities. For example, the 2018 PISA evaluation, which was launched on December 3, 2019, reported that approximately 76% of the test samples obtained from 65 different countries were categorized in level two. Ironically, the analysis results in 24 countries proved that more than 50% of students scored below the standard average (Schleicher, 2019). The 2018 PISA test results showed that most Indonesian students have low abilities in solving problem-based tasks. This depicts that 80% of them failed to reach level two. The outcome of this research led to the need to ascertain whether these students have been familiarized with problem-based task-solving activities. One of the possible causes of low achievement is the type of assignments given by teachers, which is far from the international mathematics standards, such as in the PISA tests (Andrews et al., 2014).

At all levels of education in Indonesia, the use of problem-based assignments, has been recommended as in other countries (Kemendikbud, 2016). It promotes and motivates students to develop 21st-century competencies and skills (Capraro & Slough, 2013; Lee & Blanchard, 2019). Previous research stated that adopting problem-based tasks positively affected students' academic achievement and conceptual development (Karaçalli & Korur, 2014; Trinter et al., 2015). Karaçalli and Korur (2014) specifically reported that they tend to build their knowledge during this process. Trinter et al. (2015) designed a model that provided students with the opportunity to be able to express their mathematical ideas. This caused the government to make significant efforts to motivate teachers to design problem-based learning through professional development programs (Lee & Blanchard, 2019). However, the type of assignments given during the initiative is yet to be studied. Most professional development programs usually focus on learning innovation, strategies, and materials, as well as Technology Pedagogy Content Knowledge (TPACK) (Egert et al., 2018; Sims & Fletcher-Wood, 2021). Bosica et al. (2021) stated that the quality of these tasks perceived as an essential part of learning is often neglected in implementing teacher professional development programs.

Consequently, the implementation of the task design during the professional development programs needs to be investigated to be adequately understood. This can be explored in depth if an exploratory investigation is carried out on teachers' perceptions of these practices. CrossFrancis et al. (2015) stated that their beliefs shape the importance of achieving student learning goals. This research aims to ascertain teachers' perceptions of designing problem-based tasks after participating in the professional development program. The next goal is to identify factors that explain the suitability or discrepancy between their beliefs and approaches applied in the classroom.

Problem-Based Tasks in Mathematics

Problem-based assignments are an aspect of problem-based learning, but they have a different focus on providing students with certain academic experiences. It is important to note that not all tasks are problem-based (van Barneveld & Strobel, 2009; Bosica et al., 2021). It is one of the mathematical instructional forms that aims not only to solve certain arithmetic questions (Uden, 2003; Takahashi, 2008). This also entails the reconstruction or representation of similar problems related to students' lives. The designed model also emphasizes the importance of relevant issues encountered daily, and in the future, it tends to help them resolve real challenges. In the context of this research, problem-based assignments are designed based on the activities of mathematics teachers who have participated in professional development programs. These aim to ensure that students can solve complex and contextual or real-world tasks (Hmelo-Silver, 2004).

Several previous research on similar topics reported positive and negative results. The positive results indicate the optimistic influence of assignments on students independence, motivation, creativity, and learning outcomes (Nicol & Krykorka, 2016; Günter & Alpat, 2017; Wijnen et al., 2017). Meanwhile, despite its successful implementation (van Barneveld & Strobel, 2009; Bosica et al., 2021), the shortcomings of problem-based tasks are also criticized. It was highlighted that there were no firm theoretical frameworks in the available research on problem-based tasks that potentially influenced students' learning processes and outcomes. Based on these voids, it is evident that there are still several gaps in problem-based tasks that previous research and teachers failed to investigate. Previous research models that concerning problem-based tasks, were rarely investigated at the primary and secondary education levels (Westwood, 2011; Merritt et al., 2017). Although the analysis results on PBL and task-based learning have been widely acknowledged, its successful implementation, failures, and challenges have not been widely investigated. This research aims to discern the mathematics teachers' perception and implementation of problem-based tasks in the context of professional development.

The proposed frameworks involve two crucial components, namely mathematical problems, and tasks. Delisle (1997) first initiated a mathematical problem, its design, and how teachers' role in implementing problem-based learning has been properly explained. This research adopted the framework designed by Delisle (1997), which mandated that: a) the designed problem-based task needs to consider students' previous experiences, b) the given problems relate to their daily activities, c) problems are developed by connecting students' real-life activities and the curriculum, d) they are ill-structured, and e) instructions or questions should promote their engagement.

This section elaborates on mathematical tasks, a central aspect of the teaching and learning activities. In this context, it denotes what is expected of students. Meanwhile, this activity affects their learning outcomes, including students' interaction and involvement (Sullivan et al., 2012). The nature of the chosen or designed task is also another determinant factor that enhances students' learning engagement (Grevholm et al., 2005). Swan (2011) designed five types of mathematical tasks, namely classification of objects (asking students to make certain designs, and classify them), interpreting multiple representations (being able to determine the relationships between these representations), evaluating mathematical statements (the ability to determine their validity), creating problems for others to solve (Students create problems for their classmates), as well as analytical reasoning and solutions (Students can identify errors and compare solutions).

Problem:

$$\frac{x-3}{x+2} = \frac{x-3}{x+3}$$
$$(x-3)(x+3) = (x-3)(x+2)$$
$$x+3 = x+2$$
$$3 = 2$$

Tasks:

a. Narrate the steps for solving the given problems
b. Investigate the validity of the steps
c. What are the possible causes of the different results?

Figure 1. Task 1 (problem-based tasks)

Furthermore, the problem-based task model is based on the following criteria: 1) ill-structured problems, 2) issues related to students' real-life contexts and curriculum, and 3) the instructions fulfill one or more of the five criteria of math assignments (designing classifications, interpreting multiple representations, evaluating the validity of mathematical statements, creating problems, or identifying errors and comparing solutions). These are compared in Figures 1 and 2.

Solve the quadratic equation $x^2 + 2x - 3 = 0$

Figure 2. Task 2 (straightforward tasks)

Considering the two examples, Figure 1 is a problem-based task where students interpret several representations, decide the validity of the mathematical statements, and identify the cause of the error. Meanwhile, in Figure 2, they routinely practice procedural skills previously learned in class. This is completely different in terms of the learning experiences and thinking processes. According to Sullivan et al. (2012), these are portrayed when they work on a series of problem-based tasks, not on those completed and used as an example by teachers.

Mathematics Teacher Professional Development

In the past 20 years, discussions regarding the issue of mathematics teachers' professional development in various traditional, hybrid, and online approaches heavily relied on learning innovation and media, teaching strategies, and materials, including syllabus design. The majority usually ignore task design which is a core aspect, and rather focus on pedagogy, content, and knowledge (PCK). Hiemstra and Brockett (1994) initially investigated traditional teachers' professional development programs and focused on how they get credit for certification requirements. Subsequently, Gabriel (2004) reported similar results and further asserted that this program is mainly based on government initiatives. It focuses more on learning administration than content knowledge.

In the next phase, the programs were applied using mixed offline and online platforms, known as blended teachers' professional development. This initiative focuses on technological, pedagogic, and content, knowledge (TPACK) and tends to ignore task content. Desimone (2009), Glava and Glava (2010), Salmon (2012), and Chikasanda et al. (2013) reported that the focus of blended professional development is to design learning instructional activities for both perspectives. Previous research (Borko, 2004; Sims & Fletcher-Wood, 2021) highlighted five effective criteria, namely content, active learning, coherence, duration of program implementation, and learning content. Mathematics content was taught in a general manner within a limited time. Meanwhile, task design was neglected during hybrid professional development.

In this digital era, professional development program has completely evolved into an online platform which focus is centered on equipping teachers to adapt to this new learning environment, how to design it (Tschida et al., 2016), and highlight its impact on learning (Elliott, 2017; Parsons et al., 2019; Powell & Bodur, 2019). Elliott (2017) specifically reported how teachers were able to overcome the challenges encountered during the transformation of traditional learning to online and how it was designed to manage distance and time constraints. Parsons et al. (2019) further stated that professional development is focused on equipping teachers with technological skills to adapt to the online learning environment. Powell and Bodur (2019) reported similar results that emphasized teaching strategies, media, motivation, and lesson plan design, although task quality was excluded because it was not evaluated. This is not in accordance with Ratnayake et al. (2020), that investigated how to improve the use of digital technology for learning mathematical concepts in the classroom. Ratnayake et al. (2020) focused on designing these tasks by drawing graphs of quadratic functions using Geogebra. This research provided teachers with an idea of how to design quality assignments, which optimize students' thinking processes by leveraging digital technology. The professional development program lasted for a relatively short period, only four days. Therefore, the significant impact on teachers' ability to design quality assignments could not be revealed.

METHODS

Participant

The subjects of this research involved 105 secondary school mathematics teachers who participated in the online professional development program for three months in East Java Province, Indonesia. It was implemented in the Mathematics Education Department of one of the private universities, which has been accredited with an "excellent" rating by the National Accreditation Board. This online professional development program was designed for five sessions over three months. Teachers independently learned mathematical content for two weeks in the first session using five modules. Meanwhile, in the second session, which lasted for 30 days, the participants learned the module tasks and analyzed possible misconceptions. They were also taught the theory of innovative learning models, including problem-based tasks.

In the third session, teachers were instructed to design lesson plans supervised by the senior lecturers and tutors for 14 days. The designed learning activities started with problem identification. These participants were able to prepare their lesson plans, teaching media, content, and evaluation instruments or tasks, based on the formulated problems. This learning set was designed using a problem-based approach.

Afterward, the participants conducted two-day peer-teaching practices using their prepared lesson plans. During this session, one of them acted as a teacher, while two others were the observers, and ten participants acted as learners. In the fifth session, the participants underwent a comprehensive test to determine their eligibility for participating in the online classroom teaching practice for 31 days. The next session involves a final review, reflection, and discussion of their previous teaching practices performed using video conferencing before they took a competency test involving mastery of math content and their performances. Teaching practice videos and portfolios were used to determine whether they deserved to hold a professional certificate.

Instrument

Three instruments were used to obtain valid data on teachers' beliefs and practices of problem-based math tasks. First, a questionnaire consisting of 10 statement items was developed to measure their beliefs. Based on this instrument, item numbers 1 to 4 explain the teachers' perception of problem-based math assignments, procedures, and their opinions regarding the adequacy of the problem-based tasks in the handbooks used. In addition, items 5 to 10 were designed to investigate the practices regarding problem-based math tasks. The question items were designed based on frequency ranges, such as how often teachers designed and modified problem-based tasks from the textbooks when they felt that some were unsuitable.

Second, a semi-structured interview protocol was used to support the quantitative data acquired from the questionnaire. Its objectives were achieved by carefully designing it based on the research. Four sets of questions were developed based on the task structures, information type, relevance to the students, and the availability of problem-based tasks in the teacher's Handbook. Furthermore, three experts evaluated the checklist of the semi-structured interview guide. Their assessments, notes, and suggestions were used to determine the content validity and appropriateness of the questions. This semi-structured interview was given to the teacher at the end of the professional development program. Third, related documents were analyzed to support its qualitative findings, namely the assignments designed by teachers during the program.

Data Collection

First, it was ensured that all the subjects had completed a five-month professional development program. They were given a questionnaire consisting of 10 statements related to teachers' beliefs and practice of problem-based tasks. Second, semi-structured interviews were held with nine teachers selected based on the results of the questionnaire and by considering the distribution of demographics and their teaching experiences. Third, as long as they participated in the professional development programs, their products, including problem-based task designs and teaching materials, were collected and analyzed.

Data Analysis

This research involved three types of information, namely, first, quantitative data derived from teachers' frequency in applying problem-based tasks and their beliefs. These were descriptively analyzed using SPSS 22.0 to determine how often it was promoted in front of students. The highest score indicated frequent implementation. Furthermore, the data concerning teachers' beliefs were then compared with their frequency reports of problem-based tasks to determine whether the information matched. Second, qualitative data acquired from semi-structured interviews were used to support the information obtained from the questionnaires. Nine teachers were purposely selected and interviewed based on the demographic distribution of different provinces and their experiences which ranged from ≤ 5 years, $5<PM\leq 10$ years, $PM>10$ years. Third, data acquired from problem-based tasks and teaching materials used during the professional development programs were collected to support the qualitative obtained from the semi-structured interviews. Those who attended the program produced three cycles and 105 problem-based tasks. The data from teachers' practices in designing these tasks were evaluated using the analytical framework developed by the authors, as shown in Table 1.

Table 1. Problem-based tasks analytical framework

Component	Category	Indicator
The nature of the problem	Ill-structured or non-routine problems	The task comprises two or three components: 1. Not all solutions to the problems were provided 2. The available data were interrelated. 3. It was provided in different order to be solved. 4. All acceptable solutions need to be made available.
	Routine problem	The tasks could be directly calculated or offered after an explanation or series of examples.
Task instructions	Reconstruction or decomposition, or giving similar problem	The tasks should lead the students to decompose the problem or create a similar representation, identify errors and compare solutions.

Straightforward tasks	The tasks could be directly calculated or offered after an explanation.

RESULTS AND DISCUSSION

Teachers' Beliefs about Problem-Based Tasks, the Nature of Problems, Clarity, and Completeness of Information to Find Solutions and Task Instructions

Regarding teachers' beliefs, the majority reported that their practices did not support students' abilities to solve tasks, their tasks indicating did not reflect the concept of problem-based tasks. Figure 3, related to the provision of completion steps (fifth statement), shows that 86% or 90 out of 105 teachers, consisting 24 agree and 66 strongly agreed, agreed to provide transparent information regarding the adopted mathematical procedures. Based on the information type acquired (first statement), approximately 64% (67 of 105) agreed to support students in solving problem-based tasks only when the required data were included in the assignment. In accordance with task instruction, 92% of teachers (97 of 105) significantly agreed that the task instruction was provided to help students solve the problem. This is possible because teachers lack a proper understanding of the task, which is in line with the research conducted by de Araujo and Singletary (2011), despite participating in the professional development. The tasks designed just to get the job done tend to provide opportunities and meaningful learning experiences for students (Schoenfeld, 2022).

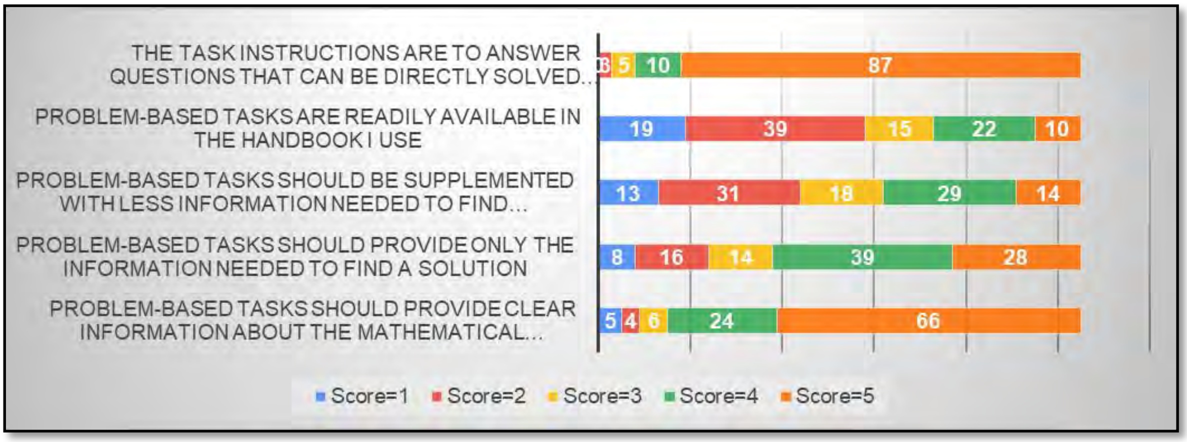

Figure 3. Teachers' beliefs about problem-based tasks

Teachers' Reported Teaching Practice

Figure 4 describes teachers' reported teaching practices. According to them, they rarely give problem-based tasks to students. Only 19% stated that they gave such assignments weekly. A few designed their problem-based task, while the rest adopted it from Handbook (19 of 105 or 18%). Furthermore, some teachers also tried to modify those obtained from the textbooks. It was reported that 21 teachers engaged in this activity weekly, while 24 of them assigned it to the learners every semester. This is possible because teachers' adopted practices are highly influenced by their beliefs (CrossFrancis et al., 2015).

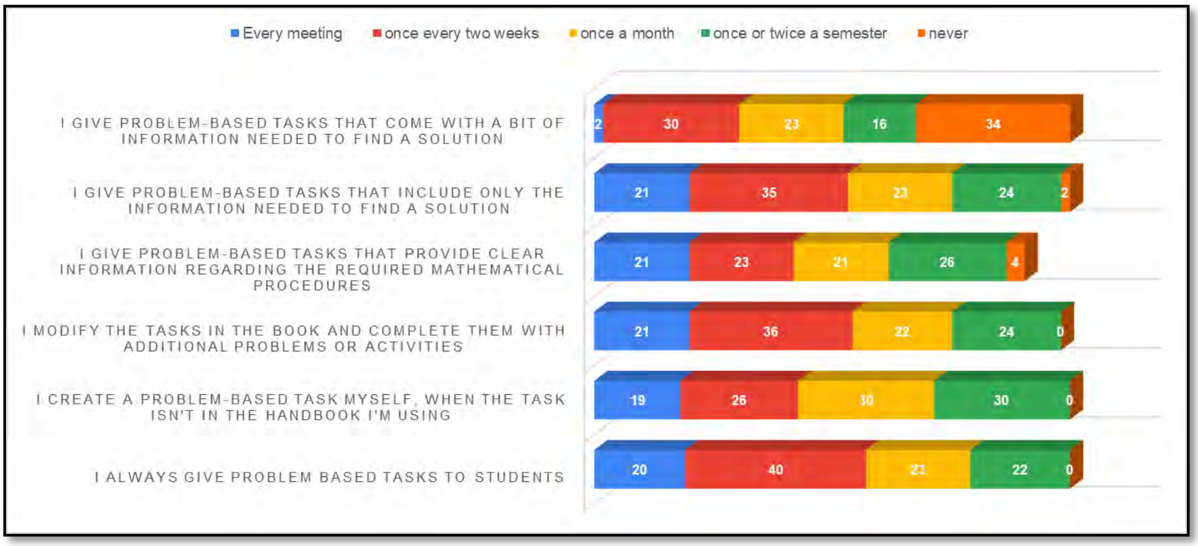

Figure 4. Teachers' reported teaching practice

Teachers' Beliefs of Reported Teaching Practices in Designing Problem-Based Tasks

The extraction of teachers' beliefs through questionnaires indicated that most teaching practices did not support students' abilities to solve problem-based tasks and did not align with the mandated framework. Approximately 86% agreed to provide relevant information regarding the required mathematical procedures. The results of interviews with nine selected teachers regarding problem-based task designs during their enrolment in the professional development program are shown in Table 2.

Table 2. Demographic information of the interviewed teachers

Initial name	The school (code)	Province	Gender	Age (years)	Teaching experience (years)	Background of Education
SN	A	Jawa Timur	Female	29	4	S1 Mathematics Education
LZS	B	Nusa Tenggara Barat	Female	30	4,5	S1 Mathematics Education
AH	C	Nusa Tenggara Timur	Male	32	4,5	S1 Mathematics Education
NH	D	Kalimantan Selatan	Female	34	7,5	S1 Mathematics Education
GH	E	Sumatra Utara	Male	38	9	S1 Mathematics Education
DA	F	DKI Jakarta	Female	33	8	S1 Mathematics Education
AM	G	Jawa Timur	Male	40	15	S1 Mathematics Education
TM	H	Jawa Timur	Male	35	10	S1 Mathematics Education
RA	I	DKI Jakarta	Female	38	12	S1 Mathematics Education

A Group of Teachers with Less than Five Years of Teaching Experience

This section describes three task designs produced by SN, LZS, and AH. These participants had less than five years of teaching experience. The results of the developed tasks are presented in Figures 5, 6, and 7, respectively.

Mr. Idris has three children, namely Faisal, Alu, and Riski. Meanwhile, Mr. Sugandar has two Sunaida and Firman, and Mr. Adhim has a child named Wafi. Determine a possible mathematical relation and state it in the form of an arrow diagram.

Figure 5. Mathematical relation task by SN

SN designed the task in Figure 5, however, it does not contextually reflect a problem-based assignment. It is similar to the result of SN's questionnaire, where SN scored 3 in the first item questions regarding unclear information in designing problem-based tasks. This simply implied that SN did not understand the context.

Consequently, SN was unable to apply a relevant and acceptable approach to the developed task. Based on the nature of the problem, its contents regarding Mr. Idris, Mr. Sugandar, and Mr. Adhim lacked a clear directive. Second, the instruction "…find the possible mathematical relations…" was not well-defined in discerning whether the connections were between parents or among children in a family. This practice was considered inappropriate for task openness, as proposed by Yeo (2017). It was further stated that its limitations had to be well-defined to determine a possible solution. The task instructions need not make students focus on the context of the problem.

Meanwhile, during the interview held with SN concerning 'Mathematical relation task', two misconceptions were discovered in the developed task, namely that of 'problem' and instruction or questions. First, SN did not understand the concept of an ill-structured task and failed to follow the stipulated rules. Not all information in terms of guiding students on how to solve these problems was provided, and the available data are not interrelated. Previous research on the ill-structured characteristics of problem-based tasks was properly described by Delisle (1997). It was the first to characterize problem-based learning. Delisle further stated that most teachers made mistakes while defining ill-structured tasks at the conceptual level but not in practical design. The findings of this research provide empirical evidence that the designed assignments are still far from the ill-structured concept. The following is an excerpt from the interview held with the subject SN.

Researcher : From the "Mathematical relation" task you designed, what would you like students to do? and what information do they need to be able to execute the assignment?

SN : I want students to find as many relations as possible, besides the information provide is the number of members in each set, for example I = {Faisal, Alu, Riski}; S = {Sunaida, Firman}; A = {wafi}

Researcher : Was adequate information provided?

SN : Hmmm…yes, because for this assignment the information is usually incomplete, students need to be creative

The following results were obtained from the second subject, named LZS, who had problems related to 'context' as part of a problem-based task. The context was literally interpreted. Based on her understanding, it was perceived as an object easily encountered by students in their daily activities. Therefore, it was interpreted as a type of fruit, although she failed to explain the acceptable focus of the task. When they have completed the assigned task, the context seems to disappear because its focus relies only on the calculated process, causing the problem to disappear. Based on this finding, Clarke and Roche (2018); and Wijaya et al., (2015) asserted that 'context' should help students solve the problem, and not only see it as an object related to their lives.

Nani goes to the market to buy apples and rambutans. The price of 1 kg of apple is three times that of 1 kg of rambutan at the Murah Meriah store. Nani bought 2 kg apples and 3 kg rambutan for Rp. 90.000,00. If Noni also buys 6 kg of rambutan at the same shop, is there a possibility of Noni bringing back Rp. 50,000.00?

Figure 6. SPLDV task by LZS

In contrast to the two misconceptions from subjects 1 and 2, the third also experienced it at the routine tasks levels. She was also unable to understand the concept of a problem-based task because her task was easily solved using direct calculations. This is a straightforward task because it had no impact and did not motivate students to engage in such problems.

A cylinder has a radius of 10 cm. If the height is 30 cm and π = 3.14, what is the width and surface area of the cylinder?

Figure 7. A Geometry task by AH

A Group of Teachers' Teaching Experience between Five to Ten Years

The following findings are derived from the subjects with teaching experience between five to ten years. The results indicated they had problems related to context design and the completeness of the information provided to find solutions. This is because teachers understood the task with the aim that students can complete it, not on how they develop their thinking processes (de Araujo & Singletary, 2011). The SPLDV task designed by GH, as shown in Figure 8, had two misconceptions.

One day, Ama and Ina bought stationery at the school shop. Ama bought two notebooks and a pencil, while Ina bought three notebooks and two pencils. The price of a notebook is Rp. 3,000, and the price of one pencil is Rp. 4,000. How much money do Ama and Ina have to pay?

Figure 8. SPLDV task by GH

The first was about the context, and it was similar to LZS. Surprisingly, both subjects were unable to identify the context accurately. The second was concerned with task data or information required to find a solution to GH's assignment that every variable with "The price of a book is Rp. 3.000, and one pencil is Rp. 4.000".

Class XI students of Agribusiness are collecting eggs from chicken and quail. Today, they sold 2 kg of broiler eggs and 1 kg of quail eggs to Mr. Hasan for Rp. 90.000,00, and 1 kg of purebred chicken eggs and 3 kg of quail eggs to Mr. Ardi for Rp. 145,000.00. Can you provide information on the selling price of 1 kg of purebred chicken eggs or 1 kg of quail eggs?

Figure 9. SPLDV task by NH

It was easy to predict the answer, and 100% could guess the answer correctly through a short process without involving any form of comprehension in this context. Similarly, Subjects NH and DA also developed their tasks, as shown in Figures 9 and 10.

Write a PLSV with the following equation $-\frac{3}{2}$

Figure 10. SPLDV task by DA

A Group of Teachers with More than Ten Years of Teaching Experience

The following findings were obtained from senior mathematics teachers with longer teaching experiences who tended to apply straightforward tasks. This is due to the complexity of the problems and their experiences in terms of participating in professional development that was not equipped with characteristic tasks, specifically when the focus is on how to design good learning in general and not on the content (Clarke et al., 2009; Zaslavsky & Sullivan, 2011). In addition, senior teachers who are used to the application of direct tasks reluctantly find it difficult to change to more complex ones (Schoenfeld, 2022). The task in Figures 11, 12, and 13 could be solved directly or in a straightforward manner.

If $\vec{a} = (6, -2), and\ \vec{b} = (-12, 4)$, Determine the orthogonal scalar projection and the orthogonal vector projection from $\vec{a}n\ on\ \vec{b}\ and\ \vec{b}\ on\ \vec{a}$?

Figure 11. Vector task by AM

These findings align with their belief in problem-based tasks. The three subjects, AM, TM, and RA, provided a score of 5 to the first item questionnaire (Problem-based tasks should provide clear information about the mathematical procedures needed to solve them). Similar results were obtained from the interviews and teaching practices, and item 8 reported the frequency of giving problem-based tasks and their procedures.

In the cube ABCD.EFGH with the side length being 6 cm, the distance from point B to the diagonal of space AG is...

Figure 12. Geometry task by TM

The subjects gave clear and specific information because they feared students were unable to solve the tasks. Jackson et al. (2013) reported that most teachers often instruct students to help them understand and find the solution to the problem.

Determine the sum of $(3x - 17x + 35z)\ and\ (4x + 23y - 9)$

Figure 13: Algebra task by RA

Disharmony of Teachers' Beliefs and Practices

Regarding all the questionnaire items, teachers' beliefs about problem-based tasks had the highest agreement in statement 1. These questions have to provide clear information about the mathematical procedures needed to find possible solutions, of 105 teachers, 90 stated that they significantly agreed with the statement. This was compared to item 8. The results showed that only 4 of 105 teachers reported not designing a problem-based task using clear information regarding the mathematical procedures needed to find a solution. This was due to several reasons, first, the short duration of the training and teachers' workload during the program, and this tends to cause a less optimum understanding. Second, the concept of problem-based tasks was introduced a long time by Delisle (1997), but its frameworks were not explicitly written. The participants were unable to properly interpret them and practice the designed problems according to the right frameworks.

Meanwhile, the highest unsuitability of tasks was found in questionnaire item 4 regarding problem based-tasks in the textbook. 73 out of 105 teachers stated that these assignments were not sufficiently available in their handbooks. This was followed by teachers' unwillingness to design or modify tasks already in their Handbooks (Ruthven & Hennessy, 2002). Pepin et al. (2013) stated that they tend to adopt tasks in the textbook. Even and Olsher (2014) also stated that teachers presume it is easier to give assignments using textbooks. It is in accordance with Casa et al. (2019), which stated that the majority designed their tasks based on the textbook without further adaptations. This finding emphasizes that teachers' beliefs about problem-based tasks are less available in the textbooks they use in class, but it has no clear procedures and contexts. They are unwilling to modify the tasks as it is time-consuming and challenging for them. Further, Glasnovic Gracin (2018) and van Zanten and van den Heuvel-Panhuizen (2018) stated the importance of mathematics books in fostering students learning through the tasks .

CONCLUSION

There are two significant findings, first, it was revealed that teachers' beliefs about problem-based math tasks were low, indicating their lack of understanding. These also gave insightful recommendations for professional development programs by the Indonesian government and similar initiatives to involve problem-based tasks as one of the crucial learning elements. At the initial stage, the government needs to map and analyze teachers' abilities to design a problem based-task. Second, those with relatively minor teaching experience (less than five years) have more complex problems. There is a misconception in the practice of developing problem-based tasks. This is similar to the problem structure, its context, and the design of instructions or questions.

The group of teachers with moderate teaching experience (between five to ten years) had the main problem, which is related to 'context'. Similarly, those in the senior group tend to apply straightforward tasks. Teachers need intensive and sustainable training to develop problem-based tasks, environment, and culture can be formed. Their common understanding of this conception may be due to a lack of appropriate designs. It is recommended that future research need to develop a more acceptable and applicable problem-based tasks framework and organize specific professional development training to promote teachers' competencies in designing problem-based tasks.

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Declarations

Author Contribution : SS: Conceptualization, Methodology, Writing - Original Draft, Editing, and Visualization.

TN: Writing - Review, Editing, and Investigation.

INP: Validation and Supervision.

SI: Formal analysis and Data Curation.

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REFERENCES

Andrews, P., Ryve, A., Hemmi, K., & Sayers, J. (2014). PISA, TIMSS and Finnish mathematics teaching: An enigma in search of an explanation. *Educational Studies in Mathematics*, *87*(1), 7–26. https://doi.org/10.1007/s10649-014-9545-3

Bardy, T., Holzäpfel, L., & Leuders, T. (2021). Adaptive tasks as a differentiation strategy in the mathematics classroom: Features from research and teachers' views. *Mathematics Teacher Education and Development*, *23*(3), 25–53. https://files.eric.ed.gov/fulltext/EJ1320725.pdf

Bell, S. (2010). Project-based learning for the 21st century: Skills for the future. *The Clearing House*, *83*(2), 39–43. https://doi.org/10.1080/00098650903505415

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher*, *33*(8), 3–15. https://doi.org/10.3102/0013189X033008003

Bosica, J., Pyper, J. S., & MacGregor, S. (2021). Incorporating problem-based learning in a secondary school mathematics pre-service teacher education course. *Teaching and Teacher Education*, *102*(103335), 1–10. https://doi.org/10.1016/j.tate.2021.103335

Capraro, R. M., & Slough, S. (2013). Why PBL? Why STEM? Why now? An introduction to STEM project-based learning: An integrated science, technology, engineering, and mathematics (STEM) approach. In *R. M. Capraro, M. M. Capraro, and J. Morgan (Eds.), Project-based learning: An integrated science, technology, engineering, and mathematics (STEM) approach, 2nd ed* (pp. 1–6). Sense. http://stemcentre.ru/uploads/media/documents/doc5b98abd338a755.73991485.pdf

Casa, T. M., MacSwan, J. R., LaMonica, K. E., Colonnese, M. W., & Firmender, J. M. (2019). An analysis of the amount and characteristics of writing prompts in Grade 3 mathematics student books. *School Science and Mathematics*, *119*(4), 176–189. https://doi.org/10.1111/ssm.12333

Chikasanda, V. K. M., Otrel-Cass, K., Williams, J., & Jones, A. (2013). Enhancing teachers' technological pedagogical knowledge and practices: A professional development model for technology teachers in Malawi. *International Journal of Technology and Design Education*, *23*(3), 597–622. https://doi.org/10.1007/s10798-012-9206-8

Clarke, B., Grevholm, B., & Millman, R. (2009). *Tasks in primary mathematics teacher education*.

Springer. https://doi.org/10.1007/978-0-387-09669-8

Clarke, D., & Roche, A. (2018). Using contextualized tasks to engage students in meaningful and worthwhile mathematics learning. *The Journal of Mathematical Behavior*, *51*, 95–108. https://doi.org/10.1016/j.jmathb.2017.11.006

CrossFrancis, D., Rapacki, L., & Eker, A. (2015). The individual, the context, and practice: A review of the research on teachers' beliefs related to mathematics. In *H. Fives & M. G. Gill (Eds.), International handbook of research on teachers' beliefs* (pp. 336–352). Routledge.

de Araujo, Z., & Singletary, L. M. (2011). Secondary mathematics teachers' conceptions of worthwhile tasks. In *L. R. Wiest & T. Lamberg (Eds.), Proceedings of the 33rd annual meeting of the North American chapter of the international group for the psychology of mathematics education* (pp. 1207–1215). University of Nevada, Reno. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.688.797&rep=rep1&type=pdf#page=1215

Delisle, R. (1997). *How to use problem-based learning in the classroom*. Ascd.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher*, *38*(3), 181–199. https://doi.org/10.3102/0013189X08331140

Egert, F., Fukkink, R. G., & Eckhardt, A. G. (2018). Impact of in-service professional development programs for early childhood teachers on quality ratings and child outcomes: A meta-analysis. *Review of Educational Research*, *88*(3), 401–433. https://doi.org/10.3102/0034654317751918

Elliott, J. C. (2017). The evolution from traditional to online professional development: A review. *Journal of Digital Learning in Teacher Education*, *33*(3), 114–125. https://doi.org/10.1080/21532974.2017.1305304

Even, R., & Olsher, S. (2014). Teachers as participants in textbook development: The integrated mathematics wiki-book project. In *Y. Li & G. Lappan (Eds.), Mathematics curriculum in school education* (pp. 333–350). Springer. https://doi.org/10.1007/978-94-007-7560-2

Gabriel, D. M. (2004). *Teacher-centered professional development association for supervision & curriculum development*. Association for Supervision, VA. http://62.182.86.140/main/510000/aa1b64731a59c0c92a46a709d19bce54/Gabriel%20Diaz-Maggioli%20-%20Teacher-Centered%20Professional%20Development%20%282004%29.pdf

Glasnovic Gracin, D. (2018). Requirements in mathematics textbooks: A five-dimensional analysis of textbook exercises and examples. *International Journal of Mathematical Education in Science and Technology*, *49*(7), 1003–1024. https://doi.org/10.1080/0020739X.2018.1431849

Glava, C. C., & Glava, A. E. (2010). Teaching skills training through e-learning. *Procedia-Social and Behavioral Sciences*, *2*(2), 1752–1756. https://doi.org/10.1016/j.sbspro.2010.03.978

Grevholm, B., Millman, R., & Clarke, B. (2005). Function, form and focus: The role of tasks in elementary mathematics teacher education. In *Tasks in primary mathematics teacher education* (pp. 1–5). Springer, Boston, MA. https://doi.org/10.1007/978-0-387-09669-8

Günter, T., & Alpat, S. K. (2017). The effects of problem-based learning (PBL) on the academic achievement of students studying "Electrochemistry." *Chemistry Education Research and Practice*, *18*(1), 78–98. https://doi.org/10.1039/C6RP00176A

Haruehansawasin, S., & Kiattikomol, P. (2018). Scaffolding in problem-based learning for low achieving learners. *The Journal of Educational Research*, *111*(3), 363–370. https://doi.org/10.1080/00220671.2017.1287045

Hendriana, H., Johanto, T., & Sumarmo, U. (2018). The role of problem-based learning to improve students' mathematical problem-solving ability and self confidence. *Journal on Mathematics Education*, *9*(2), 291–300. https://files.eric.ed.gov/fulltext/EJ1194294.pdf

Hiemstra, R., & Brockett, R. G. (1994). Resistance to self-direction in learning can be overcome. *New Directions for Adult and Continuing Education*, *1994*(64), 89–92. https://www.academia.edu/download/51620040/ace.3671994641320170203-6565-1a8gm14.pdf

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review*, *16*(3), 235–266. https://doi.org/1040-726X/04/0900-0235/0

Jackson, K., Garrison, A., Wilson, J., Gibbons, L., & Shahan, E. (2013). Exploring relationships between setting up complex tasks and opportunities to learn in concluding whole-class discussions in middle-grades mathematics instruction. *Journal for Research in Mathematics Education*, *44*(4), 646–682. http://mathedseminar.pbworks.com/w/file/fetch/69060017/JReseMathEduc.44.4.0646.pdf

Karaçalli, S., & Korur, F. (2014). The effects of project-based learning on students' academic achievement, attitude, and retention of knowledge: The subject of "electricity in our lives." *School Science and Mathematics*, *114*(5), 224–235. https://doi.org/https://doi.org/10.1111/ssm.12071

Kemendikbud. (2016). *Permendikbud Nomor 22 Tahun 2016 Tentang Standar Proses Pendidikan Dan Menengah [Minister of Education and Culture Regulation Number 22 of 2016 concerning Standards for Middle and Educational Processes]*. Kemendikbud.

Lavie, I., Steiner, A., & Sfard, A. (2019). Routines we live by: From ritual to exploration. *Educational Studies in Mathematics*, *101*(2), 153–176. https://doi.org/https://doi.org/10.1007/s10649-018-9817-4

Lee, H. C., & Blanchard, M. R. (2019). Why teach with PBL? Motivational factors underlying middle and high school teachers' use of problem-based learning. *Interdisciplinary Journal of Problem-Based Learning*, *13*(1), 2. https://doi.org/10.7771/1541-5015.1719

Merritt, J., Lee, M. Y., Rillero, P., & Kinach, B. M. (2017). Problem-based learning in K–8 mathematics and science education: A literature review. *Interdisciplinary Journal of Problem-Based Learning*, *11*(2), 3. https://doi.org/10.7771/1541-5015.1674

Napitupulu, E. E., Suryadi, D., & Kusumah, Y. S. (2016). Cultivating upper secondary students' mathematical reasoning-ability and attitude towards mathematics through problem-based learning. *Journal on Mathematics Education*, *7*(2), 117–128. https://ejournal.unsri.ac.id/index.php/jme/article/download/3542/1882

NCTM. (2000). *Nasional Council of principles and standards for school mathematics*. NCTM. https://www.nctm.org/uploadedFiles/Standards_and_Positions/PSSM_ExecutiveSummary.pdf

Nelson, G., & Powell, S. R. (2018). A systematic review of longitudinal studies of mathematics difficulty. *Journal of Learning Disabilities*, *51*(6), 523–539. https://doi.org/10.1177/0022219417714773

Nicol, C., & Krykorka, F. (2016). The place of problems in problem based learning: A case of mathematics and teacher education. In *Problem-based learning in teacher education* (pp. 173–186). Springer, Cham. https://doi.org/10.1007/978-3-319-02003-7

Parsons, S. A., Hutchison, A. C., Hall, L. A., Parsons, A. W., Ives, S. T., & Leggett, A. B. (2019). U.S. teachers' perceptions of online professional development. *Teaching and Teacher Education*, *82*, 33–42. https://doi.org/10.1016/j.tate.2019.03.006

Pepin, B., Gueudet, G., & Trouche, L. (2013). Re-sourcing teacher work and interaction: New perspectives on resource design, use and teacher collaboration. *ZDM: The International Journal of Mathematics Education*, *45*(7), 929–943. https://doi.org/10.1007/s11858-013-0534-2

Powell, C. G., & Bodur, Y. (2019). Teachers' perceptions of an online professional development experience: Implications for a design and implementation framework. *Teaching and Teacher Education*, *77*, 19–30. https://doi.org/10.1016/j.tate.2018.09.004

Prendergast, M., Breen, C., Bray, A., Faulkner, F., Carroll, B., Quinn, D., & Carr, M. (2018). Investigating secondary students beliefs about mathematical problem-solving. *International Journal of Mathematical Education in Science and Technology*, *49*(8), 1203–1218. https://doi.org/10.1080/0020739X.2018.1440325

Ratnayake, I., Thomas, M., & Kensington-Miller, B. (2020). Professional development for digital technology task design by secondary mathematics teachers. *ZDM*, *52*(7), 1423–1437. https://doi.org/10.1007/s11858-020-01180-8

Ruthven, K., & Hennessy, S. (2002). A practitioner model of the use of computer-based tools and resources to support mathematics teaching and learning. *Educational Studies in Mathematics*, *49*(1), 47–88. https://files.eric.ed.gov/fulltext/ED463748.pdf

Salmon, G. (2012). *E-moderating: The key to teaching and learning online*. Routledge. https://doi.org/10.4324/9780203816684

Schleicher, A. (2019). *PISA 2018: Insights and interpretations.* OECD Publishing. https://www.oecd.org/pisa/PISA%202018%20Insights%20and%20Interpretations%20FINAL%20PDF.pdf

Schoenfeld, A. H. (2022). Why are learning and teaching mathematics so difficult? In *Handbook of cognitive mathematics* (pp. 1–35). Springer. https://doi.org/10.1007/978-3-030-44982-7

Sims, S., & Fletcher-Wood, H. (2021). Identifying the characteristics of effective teacher professional development: A critical review. *School Effectiveness and School Improvement*, *32*(1), 47–63. https://doi.org/10.1080/09243453.2020.1772841

Sullivan, P., Clarke, D., & Clarke, B. (2012). *Teaching with tasks for effective mathematics learning*. Springer. https://doi.org/10.1007/978-1-4614-4681-1

Swan, M. (2011). Designing tasks that challenge values, beliefs and practices: A model for the professional development of practicing teachers. In *Constructing knowledge for teaching secondary mathematics* (pp. 57–71). Springer, Boston, MA. https://doi.org/10.1007/978-0-387-09812-8

Takahashi, Y. (2008). Problem-based learning and task-based learning: A practical synthesis. *The Kaohsiung Journal of Medical Sciences*, *24*(3), S31–S33. https://doi.org/10.1016/S1607-551X%2808%2970091-3

Trinter, C. P., Moon, T. R., & Brighton, C. M. (2015). Characteristics of students' mathematical promise when engaging with problem-based learning units in primary classrooms. *Journal of Advanced Academics*, *26*(1), 24–58. https://doi.org/10.1177/1932202X14562394

Tschida, C. M., Hodge, E. M., & Schmidt, S. W. (2016). Learning to teach online: Negotiating issues of platform, pedagogy, and professional development. In *Handbook of research on learning outcomes and opportunities in the digital age* (pp. 664–684). IG.

Uden, L. (2003). Problem-based task knowledge structures in projects. *4th Annual Conference of the LTNS Centre for Information and Computer Science*. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.500.5522&rep=rep1&type=pdf

van Barneveld, A., & Strobel, J. (2009). Problem-based learning: Effectiveness, drivers, and implementation challenges. In *Research on PBL practice in engineering education* (pp. 35–44). Brill Sense.

van Zanten, M., & van den Heuvel-Panhuizen, M. (2018). Opportunity to learn problem solving in Dutch primary school mathematics textbooks. *ZDM Mathematics Education, 50*, 827–838. https://doi.org/10.1007/s11858-018-0973-x

Verschaffel, L., Schukajlow, S., Star, J., & Van Dooren, W. (2020). Word problems in mathematics education: A survey. *ZDM*, *52*(1), 1–16. https://doi.org/10.1007/s11858-020-01130-4

Westwood, P. (2011). The problem with problems: Potential difficulties in implementing problem-based learning as the core method in primary school mathematics. *Australian Journal of Learning Difficulties*, *16*(1), 5–18. https://doi.org/10.1080/19404158.2011.563475

Wijaya, A., van den Heuvel-Panhuizen, M., & Doorman, M. (2015). Teachers' teaching practices and beliefs regarding context-based tasks and their relation with students' difficulties in solving these tasks. *Mathematics Education Research Journal*, *27*(4), 637–662. https://doi.org/10.1007/s13394-015-0157-8

Wijnen, M., Loyens, S., Smeets, G., Kroeze, M., & van der Molen, H. (2017). Students' and teachers' experiences with the implementation of problem-based learning at a university law school. *Interdisciplinary Journal of Problem-Based Learning*, *11*(2). https://doi.org/10.7771/1541-5015.1681

Yeo, J. B. (2017). Development of a framework to characterise the openness of mathematical tasks. *International Journal of Science and Mathematics Education*, *15*(1), 175–191. https://doi.org/10.1007/s10763-015-9675-9

Zaslavsky, O., & Sullivan, P. (2011). *Constructing knowledge for teaching secondary mathematics: Tasks to enhance prospective and practicing teacher learning*. Springer. https://doi.org/10.1007/978-0-387-09812-8