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Research Article

Skill-based problems from the perspective of pre-service mathematics teachers: A lesson study practice

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The aim of the study is to present the views of pre-service mathematics teachers about skill-based problems and the use of such problems in the learning environment. The sample of the research consisted of 31 pre-service mathematics teachers studying in the elementary mathematics teaching programme of a state university, attending the problem solving course in mathematics and participating in the lesson study practice focused on skill-based problem solving. Interviews were also conducted with 10 pre-service teachers who were selected on a voluntary basis from the pre-service teachers who participated in the lesson study practices. The data in the study were obtained through interviews with pre-service teachers, meeting minutes of the lesson study groups in which pre-service teachers participated, and documents. The data obtained were subjected to inductive content analysis. In the study, it was observed that pre-service teachers mostly used internet sources, written sources and rarely used external experts as sources for accessing skill-based problems. In addition, it was seen that the features that shaped the definitions of skills-based problems of pre-service teachers were related to the statement of the problem, the setting-context of the problem, the problem solving process, mathematical skills, valuing mathematics, the relationship of the problem with the outcomes and the difficulty level of the problem. Moreover, all of the interviewed pre-service teachers stated that the use of skill-based problems in mathematics classes is important and necessary. It is suggested that teachers should be included in such skill-based problem solving-oriented lesson study practices by referring to the opportunities offered to pre-service teachers by the lesson study process experienced by pre-service teachers during the research process.

Keywords: Teacher training, skill-based problem, lesson study

1. Introduction

In addition to the centralised national exams for transition to secondary education, students in Turkey also take PISA and TIMSS exams, which are international assessment tools, and rank in the lower ranks by failing to show the expected performance (Ministry of National Education [MoNE], 2015). One of the reasons for this situation is that the questions of international exams differ from the questions of national exams. The questions asked in international exams are mostly based on mathematical literacy and mathematical skills (Gürbüz, 2019). In this context, when the 2018 mathematics curriculum is examined, it is seen that arrangements have been made to provide students with mathematical literacy, problem solving and reasoning skills (MoNE, 2018). Turkey's first encounter with skill-based problems occurred with the 2018 High School Entrance Examination. Skill-based problems are problems that measure students' ability to use mathematics functionally rather than knowing it well. Through these problems, it is aimed to measure students' high-level skills such as reading comprehension, interpretation, inference, problem solving, analysis, critical thinking, and scientific process skills (MoNE, 2018). However, the results of the exams conducted since 2018 show that students are not used to such problems and have difficulty in solving them (Çepni, 2020; Karadağ, 2023; Tortop at al., 2022). Another group trying to get used to skill-based problems is teachers. The meaning that teachers attribute to skill-based problems is extremely important because it is thought that the perspective of teachers will be directly reflected to their students. There are many studies focusing on how teachers define skill-based problems

(Çolak, 2022; Güler et al., 2019; Erden, 2020; Kablan & Bozkuş, 2021; Karakeçe, 2021; Kertil at al., 2021; Tortop at al., 2022; Uzun, 2021; Ünsal & Kaba, 2022). These studies generally state that teachers need resources and in-service training support for skill-based problems (Çolak, 2022; Güler at al., 2019; Hançer, 2023).

In this context, the current research covers a part of a large-scale research carried out in cooperation with the national education directorate-university, which was initiated with the question of whether lesson study can be a functional tool in the process of incorporating skill-based problems into mathematics classes, which have been used since 2018. In his research, Çolak (2022) states that prospective teachers, who are the teachers of the future, should be involved in courses or practices related to skill-based problems. From this point of view, in this study, pre-service mathematics teachers participated in lesson study practices focused on skill-based problem solving. Thanks to the lesson study, pre-service mathematics teachers had the opportunity to work on skill-based problems for a long time. It is thought that it will be possible to describe pre-service mathematics teachers' views on skill-based problems and the learning environment in more detail by utilising the data obtained through the lesson study process.

1.1. From Mathematical Skills to Skill-based Problems

The necessity of developing higher-order mathematical skills including critical, creative thinking, reasoning, decision-making, communication and problem-solving skills in learning environments has been expressed by many studies (Jerome et al., 2019; Kolovou et al., 2009). For this reason, exams such as PISA and TIMSS are important international exams that are applied to measure students' high-level mathematical skills (Demir, 2010; OECD, 2015; Parcerisa et al., 2020). Countries make changes in their national exams, curricula and learning environments by taking into account the results of exams such as PISA and TIMSS (Breakspear, 2012; Erden, 2020; Hopkins et al., 2008). It can be stated that the questions asked to measure students' high-level mathematical skills are based on being able to use mathematics rather than knowing mathematics. With the mathematical literacy dimension defined in this context, PISA aims to measure students' ability to use and interpret mathematics and to relate it to daily life (OECD, 2019). In Turkey, among the specific objectives of the secondary school mathematics curriculum, which was renewed in 2018, qualities such as students' mathematical literacy skills, the ability to use mathematical concepts in daily life, the ability to express their thoughts and reasoning in the problem solving process, the ability to conduct research, produce and use information, and the ability to make predictions come to the fore (MoNE, 2018). In parallel with this revision made in the curriculum, it is seen that the mathematics questions in the 2018 High School Entrance Examination are questions that contain more than one outcome, are related to current life, are based on interpretation, have distractors and require processing skills, and therefore aim to measure higher-order thinking skills (Düzgün, 2022). With the 2018 LGS exam, it is aimed to measure students' high-level skills such as reading comprehension, interpretation, inference, problem solving, analysis, critical thinking, and scientific process skills (MoNE, 2018).

1.2. Skill-based Problems in Turkey

Focusing on the research conducted since the first day when the concept of skill-based problems emerged in Turkey, it is seen that the researches were conducted on students' views on skill-based problems (Çaylar, 2020; Dadandı, 2022; Ergün, 2021; Kablan & Bozkuş, 2021) and teachers' views on these problems (Arslan, 2022; Atay, 2021; Ceylan, 2022; Çolak, 2022; Güler et al., 2019; Erden, 2020; Kablan & Bozkuş, 2021; Karakeçe, 2021; Kertil at al., 2021; Tortop et al. , 2022; Uzun, 2021; Ünsal & Kaba, 2022) the examination of mathematics skill-based problems developed and published by MoNE (Ergün, 2021; Erkoç et al., 2020; Sanca et al., 2021) and student attitudes towards skill-based problems (Kılcan, 2021). It is thought that defining skill-based problems and determining their characteristics are important for teachers, students and mathematics learning environments (Ceylan & Orhan, 2022; Çolak, 2022; Hançer, 2023; Karakeçe, 2021). Studies examining teachers' perceptions of skill-based problems revealed that teachers do not fully

understand the concept of skill-based problems (Çolak, 2022; Hançer, 2023; Karakeçe, 2021). This result is important because the perceptions of teachers who present and apply such questions to students will of course be reflected in learning environments. This situation brings to mind the question "What are the opinions of pre-service teachers, who are the teachers of the future, about skill-based problems and the use of such problems in the learning environment?".

1.3. Purpose of the Study

Çolak (2022) states in his study that pre-service mathematics teachers, who are the teachers of the future, should be involved in courses or practices related to skill-based problems. Because it is extremely important to ensure the awareness of pre-service teachers, who will use skill-based problems in mathematics classrooms in the future, about such problems during pre-service education. In this context, the first step to be taken is to describe pre-service teachers' views on skill-based problems. However, when the literature is analysed, no research reflecting the views of pre-service mathematics teachers in Turkey on skill-based problems and the use of such problems in learning environments has been found. In this context, in order to meet the need in the literature, it was preferred to work with pre-service mathematics teachers in this study. The aim of the study is to present the views of pre-service mathematics teachers on skill-based problems and the use of such problems in learning environments. In the study, pre-service mathematics teachers participated in a lesson study practice focused on skill-based problem solving. In this way, pre-service teachers had the opportunity to work on skill-based problems in a collaborative manner for a long period of time. It is also thought that it will be possible to describe pre-service teachers' views on skill-based problems in more detail by utilising the data obtained from the lesson study process. Therefore, the research problems of the study are as follows:

RQ 1) How is the process of determining the skill-based problems that the pre-service teachers will focus on in the lesson study process?

RQ 2) What are the opinions of pre-service teachers about skill-based problems and their use in learning environments?

2. Method

In the study, pre-service mathematics teachers' views on skill-based problems will be described. In addition, while obtaining pre-service mathematics teachers' views on skill-based problems, various data collection tools such as interviews, meeting minutes and documents will be used. Therefore, case study design of qualitative research approach was employed in the research (Creswell, 2007).

2.1. Participants

Participants of the study consisted of 31 pre-service teachers who were studying in the elementary mathematics teaching programme of a state university, taking the problem solving course in mathematics and participating in the skill-based problem solving-oriented lesson study practice. Interviews were also conducted with 10 pre-service teachers who were selected on a voluntary basis from the pre-service teachers who participated in the lesson study practices. The study group was determined through convenience sampling to ensure that the pre-service teachers participated in every stage of the research process completely voluntarily. In the research, the representation of the lesson study groups in which the pre-service teachers are involved will be shown as G1, G2, G3, ..., G10, and the representation of the pre-service teachers will be shown as T1, T2, T3, ..., T10 in parallel with the names of the groups they are involved in. For example, while the 1st group will be shown as G1, the teacher candidate in the 1st group will be shown as T1.

2.2. Process

The research reflects a part of a large-scale research conducted in co-operation with the provincial directorate of national education and the university. The research process can be considered in three dimensions. In the first stage of the research, pre-service teachers received a comprehensive

training on teaching problem solving in mathematics for six weeks. Then, the pre-service teachers received a one-week training on the lesson study professional development model, and in the third stage, they carried out skill-based problem solving-oriented lesson study processes with the lesson study groups they formed on a voluntary basis.

In the lesson study process, the pre-service teachers first formed ten different lesson study groups of three or four people on a voluntary basis. The lesson study groups held meetings every week for a period of two hours to carry out the lesson study process. Some groups held additional meetings when necessary. The lesson study process carried out by the pre-service teachers within the scope of the research was designed by taking Fujii (2014) lesson study process as a guide. The lesson study process experienced by the pre-service teachers consisted of determining the skill-based problem to be focused on, designing the learning environment for solving the skill-based problem, implementing and observing skill-based problem solving, evaluating the skill-based problem solving practice, and preparing the lesson study bulletin and sharing it with other lesson study groups.

In this study, it is aimed to describe how pre-service teachers' views on the concept of skill-based problem are as a result of this process they experienced. For this reason, in addition to the meeting minutes and documents in the pre-service teachers' bulletins, interviews were conducted with the pre- service teachers at the end of the process.

2.3. Data Collection Tools

Since the research aimed to describe the views of pre-service teachers on skill-based problems in detail, the data were obtained through interviews with pre-service teachers, meeting minutes of the lesson study groups in which pre-service teachers were involved, and documents.

2.3.1. Interview

The interviews were conducted in order to obtain the opinions of the pre-service teachers about such problems after the skill-based problem solving-focused lesson study process they participated in. The 10 pre-service teachers who voluntarily participated in the interviews were asked questions about the definitions of skill-based problems and the characteristics of skill-based problems.

2.3.2. Meeting minutes

It consists of the minutes kept by the Lesson Study groups in which the pre-service teachers participated regarding the step of selecting the skill-based problem to be focussed on. The minutes were obtained from the bulletins prepared by the lesson study groups.

Documents: Documents such as resources used in the process of selecting skill-based problems, texts or visuals related to skill-based problem situations, and worksheets were used to support the findings obtained in the study. The documents were obtained from the bulletins prepared by the lesson study groups.

2.4. Data Analysis

The data obtained in the study were subjected to inductive content analysis (Patton, 2002). The tables and direct quotations created in response to the first research question were obtained as a result of the analysis of the meeting minutes. In response to the second research question, an answer was found by content analysis of the interviews. The data obtained were coded simultaneously by an expert in the field of teacher training and qualitative research. In order to increase the reliability of the research, simultaneous coding method was used and consensus was reached on the categories where there was no consensus.

3. Results

3.1. Pre-service Teachers' Processes of Determining the Skill-based Problems that They will Focus on in the Lesson Study Process

In the meeting held to determine the skill-based problem to be focused on by the lesson study groups formed by pre-service mathematics teachers, each pre-service teacher participated in the meeting with at least one example of a skill-based problem situation. Lesson study group members exchanged ideas in the first meeting in order to select one of the existing problem situations and jointly selected a single problem to focus on in the lesson study process. In order to present this process experienced by the lesson study groups, this step will be discussed under three subheadings: the sources that the pre-service teachers used while selecting the problem, the reasons of the lesson study groups for selecting the problem to focus on, and the reasons for eliminating the problems they did not select.

3.1.1. Sources used by the lesson study groups when selecting the problem

Information about the sources that the lesson study groups used when selecting the problem to focus on is presented in Table 1.

Table 1
Sources that lesson study groups used when selecting a problem

TS	*Sources Used While Selecting the Problem*	*f*	*Groups*
Internet Sources	Skill-based questions at 5th, 6th, and 7th grade levels of MoNE	6	G4, G5, G6, G7, G9, G10
	Maths related web pages	4	G2, G7, G9, G10
	Maths related applications	1	G7
	PISA questions	1	G9
	Total	12	G2, G4, G5, G6, G7, G9, G10
Written Sources	Supplementary textbooks	5	G1, G3, G4, G8, G10
	Textbooks of MoNE	2	G2, G3
	Maths study fascicle of MoNE	2	G1, G3
	LGS study books	1	G8
	Problems solved in problem solving course in maths	1	G2
	Teacher's Book of MoNE	1	G3
	Total	*12*	*G1, G2, G3, G4, G8, G10*
External Experts	Researcher	2	G1, G7
	Teacher of research lesson	2	G1, G10
	Other lesson study groups	1	G7
	Total	*5*	*G1, G7, G10*

Note. TS: Type of source

Since one group used more than one type of source, the frequency values obtained in Table 1 are more than the number of groups (10). As can be seen from Table 1, the groups mostly and equally used internet sources and written sources and rarely consulted external experts. According to the order of preference, the most preferred *internet sources were skill-based questions at the 5th, 6th, and 7th grade levels of MoNE, maths-related web pages, maths-related applications and PISA questions.* The explanation of the group coded G9 about the internet sources they used in the selection of skill-based problems is as follow: "Firstly, we analysed the skill-based questions of MoNE. We found a problem related to footprint, then we searched for similar problems on the internet. We found a footprint question from PISA." [Meeting minutes of the group coded G9].

Additionally, when Table 1 is analysed in terms of the groups preferring internet sources, it can be said that more than half of the groups (groups coded G2, G4, G5, G6, G7, G9 and G10) used internet sources.

Another source mostly used is written sources. According to the order of preference, these sources are as follows: *supplementary textbooks, textbooks of MoNE, mathematics study fascicle of MoNE, LGS study books, problems solved in the problem solving course in mathematics and teacher's books of MoNE*. Following are the explanations of the groups coded G1, G8 and G2 regarding the written sources they used in skill-based problem selection. "We examined MoNE's 4th grade 2nd Unit 2 Study Fascicle, On Burda publications and Ata publications math max book." [Meeting minutes of the group coded G1]. "The problem was taken from the LGS MoNE Sample Questions Workbook." [Meeting minutes of the group coded G8].

> In the process of selecting the skill-based problem, we first started to search for resources. When we examined the resources in the Ministry of National Education and on the internet, we thought that the problems did not lead to thinking and reasoning. So, we decided to select our problem from the problems we also used in the problem solving course in mathematics. [Meeting minutes of the group coded G2]

When Table 1 is analysed in terms of the groups who preferred written sources, it is seen that more than half of these groups (groups coded G1, G2, G3, G4, G8 and G10) used written sources when selecting skill-based problems.

Another resource that Lesson Study groups rarely use is *external experts.* The groups also consulted the researcher, who also took part in the research as an external expert, the teachers of the classes in which the research lesson would be carried out, and other lesson study groups. The statements of the group coded G1 that they consulted the researcher and the teacher as external experts are given below.

> We started the process of selecting the skill-based problem firstly by searching for resources. In order to reach the necessary resources, we received help from the researcher and the teacher of the class in which we would carry out the application. . […] [Meeting minutes of the group coded G1]

The group coded G7 stated that they consulted with other groups in skill-based problem selection.

> [...] we could not find a skill-based question exactly as we wanted. [...] We asked our friends to share the questions they found with us. They shared links. The shared questions were good. [...] [Minutes of the meeting of the group coded G7]

The statements of the group coded G10 regarding the use of the internet, written sources and the teacher as an external expert in skill-based problem selection are presented below.

> While selecting the problem, we tried to benefit from the Skill-Based Questions published by the Ministry of National Education, the Ata Publications Math Max book used by the classroom teacher in the lesson, and many publications on the internet. At the problem selection stage, we tried to select the problem suitable for the level of the class by learning from the classroom teacher whether the problem was suitable for the class. [Meeting minutes of the group coded G10]

Moreover, when Table 1 is analysed in terms of the groups preferring external experts, it is seen that these groups are G1, G7 and G10 coded groups.

3.1.2. The reasons of the lesson study groups for selecting the problem to focus on

After the groups identified the sources related to the problem, each group member individually analysed the sources and each group member proposed at least one problem in the meeting. One of the problems brought by the group members to the meeting was selected and the others were eliminated. In this section, the reasons for the selection of the selected problems will be explained with the help of Table 2.

Since one group presented more than one reason, the frequency values obtained in Table 2 are more than the number of groups (10). As seen in Table 2, in the process of selecting the skill-based problem to be focussed on, *problem solving teaching* was at the top

of the reasons for the selection of the selected problems, followed by *mathematical skills and affective factors*, respectively.

Table 2
Pre-service teachers' reasons for selecting the problems to focus on

	Reasons for Selecting the Problem	*f*	*Groups*
Problem Solving Teaching	Being suitable for students	7	G2, G3, G4, G5, G6, G7, G10
	Using different strategies in its solution	7	*G1, G2, G4, G5, G7, G8, G9*
	Relating to real life, daily life or different disciplines	5	G1, G2, G4, G7, G10
	Fiction based on a game, story or puzzle	3	G1, G2, G5
	Addressing more than one outcome	2	G5, G7
	Difficult to solve	2	G3, G4
	Containing visuals	2	G2, G5
	Difficult to understand	2	G4, G5
	The solution requires no formula	2	G2, G6
	Generating new problems from the problem	2	G5, G8
	Enabling the use of old and new information	1	G8
	Generating many antecedent questions for the solution process	1	G5
	Having no unnecessary and missing information	1	G5
	Easy to solve	1	G4
	Easy to understand	1	G3
	Rich in content	1	G6
	Total	40	G1, G2, G3, G4, G5, G6, G7, G8, G9, G10
Mathematical Skills	Reasoning	6	G2, G3, G5, G6, G7, G10
	Relation, recognising and establishing the relationship	4	G1, G2, G4, G5
	Critical thinking	3	G6, G7, G9
	Mental skills	3	G6, G7, G9
	Analytical thinking	3	G6, G7, G9
	Interpreting	3	G6, G7, G9
	Metacognition	3	G5, G6, G8
	Using mathematical language	3	G2, G3,G10
	Mathematical thinking	2	G2, G3
	Attributing	1	G10
	Visual spatial thinking	1	G5
	Cognitive skills	1	G8
	Proving	1	G2
	Mathematical literacy	1	G1
	Making predictions	1	G1
	Total	36	G1, G2, G3, G4, G5, G6, G7, G8, G9, G10
Affective Factors	Being associated with core values	2	G1, G5
	Showing the fun aspect of mathematics	2	G5, G6
	Supporting positive attitude towards mathematics	2	G1, G2
	Total	6	G1, G2, G5, G6

The first feature that makes the skill-based problem expressed by the Lesson Study groups selected is related to the teaching of problem solving. In this dimension, they expressed many features related to the problem solving process and teaching, such as the problem being suitable for the student's grade level, prior learning experiences or readiness, using different strategies such as making tables, finding relations or reasoning in the solution, *being difficult to understand, not*

requiring formulas to solve, and being able to generate new problems from the problem. Below are the statements of the group coded G10 about the problem being suitable for the student.

> In the selection stage of the problem, we tried to select the problem suitable for the level of the class by learning from the class teacher whether the problem is suitable for the class. The problem is capable of mobilising the readiness levels of the students." [Meeting minutes of the group coded G10]

The group coded G4 stated that they took into account the feature related to the use of different strategies in solving the problem in the selection of skill-based problems: "The main reason for selecting this problem is the use of multiple strategies such as making tables, finding relations, making systematic lists in the solution of the problem." The group coded G5 stated the fact that new problems could be generated from the problem as the reason for selection.

> We selected this problem because, from the root of the problem, a lot of new problems could be reached from Polya's problem solving steps that would fulfil the evaluation stage of the problem." [Meeting minutes of the group coded G5]

While selecting the problem that the lesson study groups would focus on, they considered the content of the problem. In this context, they considered variables such as the skill-based problem being related to real life, daily life or other disciplines, addressing more than one outcome, being based on a game, story or puzzle, or containing visuals. In this context, the statements of the groups coded G1 and G4 are presented below.

> We preferred to use the 'musical chairs game' problem in our application. The fact that the problem is a game was the biggest factor in our choice of this problem. Because the grade level we did our application was the 4th grade and we thought that the game would attract the attention of that age group the most. [...] [Meeting minutes of the group coded G1]

> Problem posing should be related to real life or other fields and should be appropriate to the level of the student. In other words, a fiction related to real life situation or other fields should be prepared for the problem. Or the problem should be related to other fields and while doing this, whatever the student needs to know about that field for that problem should be explained in the problem and that information should be given to the student. [Meeting minutes of the group coded G4]

It is noteworthy that all groups showed the features related to problem solving teaching as a reason for selection in the skill-based problem selection process. In this dimension, in addition to considering the problem solving process and teaching, the groups also emphasised the suitability of the problem for the student, its fiction or context.

Lesson study groups mentioned many mathematical process skills such as reasoning, recognising and establishing relations, critical thinking, mental thinking, analytical thinking, interpretation, metacognition and using mathematical language as mathematical skills that made them select skill-based problems. All groups considered one or more of the mathematical skills when selecting the skill-based problems to focus on. In this context, an excerpt from the meeting minutes of the group coded G2 is shared below.

> Skill-based problems enable students to reason, enable students to think critically, prevent unnecessary formula memorisation and extra effort. They develop students' mental skills and interpretation ability, and provide students with analytical thinking skills. When selecting the Frog Jumping problem, we decided to select this problem based on this definition of skill-based problems. [Meeting minutes of the group coded G2]

On the other hand, it is noteworthy that all groups showed the features related to mathematical skills as a reason for selecting skill-based problems.

Finally, the reasons put forward by the lesson study groups for selecting skill-based problems are related to affective factors. The fact that the problem can be associated with the core values of the curriculum, that it shows the fun aspect of mathematics and that it positively supports the student's attitude towards mathematics are important criteria in the selection of skill-based problems. In this context, the statements of the groups coded G1 and G2 are presented as an example.

> We liked this problem very much because the concepts such as "environmental awareness, recycling" in the statement of the problem can be associated with the core values in our curriculum such as patriotism and responsibility. [Meeting minutes of the group coded G1]
>
> [...] the fact that there was a game used for the solution of the musical chairs game problem attracted our attention, so we thought that students could learn by having fun and we selected this problem. [Meeting minutes of the group coded G2]

In addition, it is seen that the groups coded G1, G2, G5 and G6 presented the features related to affective factors as a reason for skill-based problem selection.

3.1.3. Pre-service teachers' reasons for eliminating problems they did not choose

After the groups identified the sources related to the problem, each group member individually analysed the sources and each group member proposed at least one problem in the meeting. While one of the problems brought by the group members to the meeting was selected, the others were eliminated. In this section, the reasons for the elimination of the eliminated problems will be explained with the help of Table 3.

Table 3
Pre-service teachers' reasons for eliminating problems they did not choose

	Reasons for Eliminating Problem	*f*	*Groups*
Problem solving teaching	Not being suitable for the students	3	G1, G3, G4
	Direct to the solution	2	G4, G5
	Ensuring only one outcome	2	G5, G7
	Containing missing data	1	G4
	Failure to adapt Polya's problem solving steps	1	G5
	Being mathematical operation-oriented	1	G7
	Solving is based on using formula	1	G9
	Using a single strategy to solve the problem	1	G5
	A lot of verbal expression	1	G6
	Not addressing any outcome	1	G7
	Being visually inadequate	1	G6
	Total	17	G1, G3, G4, G5, G6, G7, G9
Mathematical skills	Mathematical thinking	4	G2, G3, G4, G5
	Reasoning	3	G3, G7, G9
	Critical thinking	2	G7, G9
	Mental skills	2	G7, G9
	Interpreting	2	G7, G9
	Analytical thinking	2	G7, G9
	Reading tables	1	G1
	Attributing	1	G1
	Ratiocination	1	G2
	Total	15	G2, G3, G4, G5, G7, G9
Degree of difficulty	Being difficult	2	G4, G6
	Being easy	2	G1, G3
	Total	*4*	*G1, G3, G4, G6*

Since one group presented more than one reason, the frequency values obtained in Table 3 are more than the number of groups (10). As can be seen in Table 3, the reasons for the elimination of the problems eliminated in the problem selection process were primarily the reasons related to problem solving teaching, followed by the reasons related to mathematical skills and the degree of difficulty the problem.

The reasons related to problem solving teaching include statements related to the problem statement or problem solving process such as the problem is not suitable for the students, directing the student directly to the solution or the problem enables only one outcome. The pre-service teachers eliminated the problems by taking into consideration the verbal part of the problem being too much or containing missing data, the problem being visually inadequate, the context or content of the problem not being suitable for the students or the relationship with the outcome. The statements of the group coded G1 about the problem not being suitable for the student are presented below.

> One of the problems we liked in the book we thought we could use in our application since it would measure students' mathematical literacy skills. However, when we analysed it in detail, we decided that the concept of car in this question would not be appropriate due to the gender difference and that the Motor Vehicles Tax would not be very interesting for the students." [Meeting minutes of the group coded G1]

The reasons for the elimination of the group coded G6 related to the appearance and verbal expression of the problem are as "The problem was eliminated because it was inadequate in terms of visuality and verbal expressions took place more" [Meeting minutes of the group coded G6].

In the context of teaching problem solving, pre-service teachers also provided reasons about the problem solving process. For example, the statement of the group coded G4 is remarkable.

> [...] since the problem clearly stated what it wanted and the step of understanding the problem was within the problem, it did not push the children to think and understand the problem but focused on the solution. Therefore, we eliminated this problem. [Meeting minutes of the group coded G4]

The reason offered by the group coded G5 regarding the relationship of the problem with the outcome and the problem's unsuitability for using different strategies is as follows: "The solution of the problem directly addressed a specific outcome, therefore, it constituted a single strategy in its solution, we did not select it. [...]" [Meeting minutes of the group coded G5].

Another dimension that emerged in terms of reasons for elimination was based on the relationship between the problems and mathematical skills. In this dimension, pre-service teachers referred to skills such as reasoning, critical thinking, mental skills, interpretation, analytical thinking, reading tables, attributing or ratiocination. The statements of the group coded G5 about mathematical thinking are as follows: "[...] we thought that this problem did not fit the skill-based problem mould we wanted. Because its solution was not based on mathematical thinking." [Meeting minutes of the group coded G5].

In addition, the inclusive statement of the group coded G7 in the context of mathematical skills is presented below.

> "[...] Other problems do not enable children to reason. They do not provide students with a critical thinking structure. It does not improve their mental skills. It does not develop interpretation skills. It does not develop analytical thinking skills. [...] Therefore, we eliminated them." [Meeting minutes of the group coded G7]

The last reason for elimination was related to the degree of difficulty of the problem. The statement of the group coded G6 that they eliminated the skill-based problem because it was difficult is presented: "We eliminated some problems because they were more difficult and we thought that students would have difficulty in understanding the problem."[Meeting minutes of the group coded G6].

The reasons for the elimination of the group coded G3 regarding the relationship of the problem with the reasoning skill and its being easy are given below.

> "We thought that it would be easy for the students to realise that the rhombus numbers in the first 3 steps are multiples of each other while solving the problem and that this problem would be weak in terms of developing students' reasoning skills, so we eliminated it." [Meeting minutes of the group coded G3]

An interesting finding noticed in the research is that for some groups, the problem being difficult was presented as a reason for elimination, while for others, on the contrary, the problem being easy was presented as a reason for elimination.

3.2. Pre-service teachers' views on skill-based problems

Interviews were conducted with the volunteer pre-service teachers in order to find out how their views on skill-based problems were after the lesson study focused on skill-based problem solving. The findings obtained as a result of the analysis of the interviews are presented under the titles of *pre- service teachers' views on the characteristics of skill-based problems* and *their views on the use of skill-based problems in learning environments.*

3.2.1. Pre-service teachers' views on the characteristics of skill-based problems

Table 4, which describes the views of pre-service teachers on the characteristics of the skill-based problems, is presented below.

Table 4
Pre-service teachers' views on the characteristics of skill-based problems

	Characteristics of Skill-Based Problems	*f*	*Code of Pre-service teacher*
Problem Solving teaching	Not being operation-orientated	8	T1, T2, T3, T4, T5, T6, T7, T10
	Being suitable for the students	7	T1, T2, T3, T4, T5, T9, T10
	The solution is not based on using a formula	5	T1, T3, T4, T6, T8
	Using different strategies in the solution	4	T2, T4, T7, T9
	Relevance to contexts other than mathematics	4	T2, T3, T4, T5
	No unnecessary information	4	T1, T4, T5, T6
	The solution is not obvious at first glance	3	T5, T6, T8
	Containing visuals	3	T2, T4, T5
	The importance of the step of understanding the problem	2	T1, T3
	Generating new problems from the problem	2	T2, T9
	Enabling at least one outcome	1	T7
	Total	43	T1, T2, T3, T4, T5, T6, T7, T8, T9, T10
Mathematical skills	Reasoning	7	T2, T3, T5, T6, T8, T9, T10
	Mathematical thinking	3	T5, T6, T9
	Creative thinking	1	T1
	Critical thinking	1	T8
	Analytical thinking	1	T8
	Total	13	T1, T2, T3, T5, T6, T8, T9, T10
Degree of difficulty	Being difficult	1	T1
	Being easy	1	T3
	Total	2	T1, T3

Since one pre-service teacher presented more than one feature, the frequency values obtained in Table 4 are more than the number of pre-service teachers (10). As can be seen from Table 4, pre-service teachers' views on the characteristics of skill-based problems can be expressed under three main headings: problem solving teaching, mathematical skills and degree of difficulty.

It is seen that the pre-service teachers mostly used expressions related to problem solving teaching when talking about the characteristics of skill-based problems. The main features of skill-based problems are that they are not *operation-oriented, they are suitable for students, their solution is not based on using formulas, different strategies are used in the solution, they are related to contexts other*

than mathematics, they do not contain unnecessary information, the solution path is not obvious at first glance and they contain visuals. The statements of T3 coded pre-service teachers regarding the distinctive features of skill-based problems in terms of solution process are presented below.

> Skill-based problem should be solved without requiring a formula [...]. If a formula is necessary for the solution of the problem, that formula should be given in the problem. In other words, the problem should not measure the student's knowledge of formulae. (T3)

In a similar manner, T7 asserted that, ""Skill-based problems should not be based on operations and students should not be overwhelmed in the crowd of operations.". The fact that skill-based problems are related to contexts other than mathematics and that they are suitable for students are among the features frequently expressed in the context of problem solving teaching.

> The construction of the problem should be related to real life or other fields and should be appropriate to the level of the student. In other words, a fiction related to the real life situation or other fields should be prepared for the problem. Or the problem should be associated with other fields and while doing this, whatever the student needs to know about that field for that problem should be explained in the problem and that information should be given to the student. (T3)

The statement of the pre-service teacher coded T1 about the suitability of skill-based problems for students is also noteworthy.

> Skill-based problem should be interesting. The given problem situation should be adjusted according to the class levels and adjusted according to the interest and knowledge levels of that age group. Because they do not want to solve a problem that they are not interested in and do not have enough knowledge. (T1)

It is seen that pre-service teachers think that it is an important feature that skill-based problems attract students' attention and arouse curiosity in them or that they are suitable for students' readiness level.

In addition to this, pre-service teachers rarely expressed that the problem is difficult to understand, that new problems can be generated from the problem, or that it addresses one or more learning outcomes in the dimension of problem solving teaching.

The fact that skill-based problems support skills such as *reasoning, mathematical thinking, creative thinking, critical thinking and analytical thinking* is another important feature under the mathematical skills dimension. In particular, reasoning skill is among the skills frequently mentioned by pre-service teachers. T10 stated that "The purpose of using skill-based problems in the classroom is to enable students to approach the problems they encounter from different perspectives by developing their reasoning skills. Reasoning is extremely important for skill-based problems." In this context, the statement of the pre-service teacher coded T5 is also significant: "Skill-based problems should not only aim to measure mathematical operation skills. Rather, they should encourage students to think mathematically, establish relationships and reason."

Finally, it is highlighted that only T1 and T3 coded pre-service teachers used expressions about the degree of difficulty of skill-based problems and these expressions were contradictory. The pre-service teacher coded T1 emphasised that the skill-based problem should not be easy by stating "Skill-based problem should not be easy at the same time. The student should feel uncomfortable when he/she first encounters the problem situation. In this way, the student will force his/her mind for the solution." On the other hand, the pre-service teacher coded T3 expressed ease as a characteristic of the skill-based problem.

> The students were able to solve the skill-based problem, which was difficult for them at first glance, easily with our questions on the worksheet and our activity in our solution. Therefore, I think that skill-based problems are actually easy problems. (T3)

3.2.2. Pre-service teachers' views on the use of skill-based problems in learning environments

All of the pre-service teachers stated that they realised the necessity of using skill-based problems in mathematics classrooms after the lesson study practices focused on skill-based problem solving. Below are the experiences of some pre-service teachers and their views on the use of skill-based problems in learning environments. For example, the pre-service teacher coded T2 expressed

his/her opinion that skill-based problems should be included more in mathematics classes as follows.

> Doing this practice gave me a much clearer mindset about the position of classrooms and mathematics. In this practice, I realised how far away even good schools are from skill-based questions and that solving skill-based questions is seen as a waste of time. I heard not only from me but also from my friends who did this practice that students do not want to deal with the questions and see them as unnecessary. This made me realise that we need to familiarise students with skill-based questions, and if necessary, we need to break students' misconceptions about this subject by devoting only one mathematics lesson to a skill-based question. Students should not be asked too many questions, but questions that will be useful for them and improve their way of thinking, but there is a mindset that the more questions solved in the lessons, the better. This mindset seems wrong to me. Therefore, I think that more time should be allocated to skill-based questions. (T2)

Pre-service teachers coded T3 and T9 referred to the lesson study process they experienced and stated that such problems should be solved in the classroom using Polya's problem solving steps.

> The lesson study process I carried out enabled me to learn Polya's problem solving steps in depth, to learn what a skill-based problem is, and to learn the necessity of solving skill-based problems with Polya's problem solving steps. Skill-based problems support students' reasoning skills and therefore should be used in mathematics classrooms. This study also increased my knowledge about the characteristics that a skill-based problem should have, so that I can now make correct comments about whether the problems presented under the title of skill-based problem are skill-based or not. It taught me how the worksheet prepared to have my students solve a skill-based problem according to Polya's problem solving steps should be. It even helped me to learn which questions I use in this worksheet and how I ask those questions would be more appropriate for that step. [...]" (T3)

> Through skill-based problems, students gain analytical thinking skills and learn strategic thinking. Skill- based questions also enable children to gain the ability to understand questions and easily follow each stage of the problem. This makes it easier to overcome problems in all areas of life. The student should not reach the solution immediately. I mean this, the student should think about the problem. In line with the work I did with my friends, I realised that I knew these things on behalf of skill-based problems, but I did not even adapt them to a problem situation myself. I observed the same situation in the students. In this process, the students were doing fast operations in order to give an answer as soon as possible and they did not stop and think. As they made processing errors, they claimed that the answer to the problem was not found and that there was a mistake in the question. However, if they went step by step in a calm manner, they could easily reach the solution steps of the problem. It was at this point that Polya's problem solving steps came into play. [...] In the school where we went to practice, many students did these steps very well. But they were not aware of the steps they did. We made them realise that they did these steps [...](T9)

The pre-service teachers coded T4, T7 and T8 mentioned the opportunities offered by skill-based problems to students in mathematics classes.

> Skill-based problems are a problem type that has recently entered our lives and students have prejudices. I think that with the adoption of skill-based problems by the learners, their logical thinking will increase and they will incorporate more gains suitable for problem solving. First of all, we discovered what a skill-based problem reminds the student and how to think from the student's perspective. I had an idea about how to break the negative prejudices that skill-based problems create in students and why they occur. I find it necessary for the teachers of elective mathematics courses, which should be in every school, to participate in such a study. [...] (T4)

> For students to understand what they read in the exams of the courses they study, to gain a critical thinking structure, and to become very good literates depends on the quality of the questions. Thanks to these questions, analytical thinking skills are gained and strategic thinking is learnt. Skill-based questions also enable children to gain the ability to understand questions and easily follow each stage of the question. This makes it easier to overcome problems in all areas of life. Skill-based questions contribute to the development of students' problem solving skills and high-level thinking skills, making information meaningful, increasing their interpretation skills, and reading graphics. Therefore, it is essential to use them in mathematics classes. (T7)

> Firstly, I tried to understand what a skill-based problem is. Skill-based problem system is one of the most important parts of the renewed education system. Thanks to these questions, students' minds are not filled with unnecessary memorised information, they can receive education by thinking completely and through skills. [...] (T8).

4. Conclusion, Discussion and Suggestions

While determining the skill-based problems to be worked on in the lesson study practices focused on skill-based problem solving, pre-service teachers mostly referred to internet resources such as skill-based problems published by the Ministry of National Education, web pages or applications related to mathematics, and published PISA questions. Kertil et al. (2021) stated in their study that mathematics teachers mostly used the skills-based problems published by the Ministry of National Education in their classes. Güler et al. (2019) stated that teachers had difficulty in finding resources for skill-based questions and tried to overcome this deficiency by using question samples of exams such as PISA and TIMSS. By making use of these statements, it can be stated that pre-service teachers and teachers mostly choose internet resources, and pre-service teachers' internet resources vary. The other source mostly used by pre-service teachers is written sources such as MoNE publications and books of private publishing houses. Contrary to the research finding, some studies reported that teachers stated that the content of MoNE textbooks related to skill-based problems is insufficient and that there is a need for an arrangement in this regard (Çolak, 2022; Hançer, 2023; Karakeçe, 2021; Kertil et al., 2021). Similarly, it is seen in the studies that teachers refer to the books published by private publishers, but they state that the quality of the skill-based problems in these resources is insufficient (Çolak, 2022; Karadağ, 2023). Considering the results obtained in the research and the literature, it can be said that teachers, pre-service teachers and even students experience resource shortage and even resource pollution related to skill-based problems. In this regard, it is important that the definition and characteristics of the skill-based problem should be determined precisely and sample skill-based problem resources should be enriched by MoNE.

The other source that pre-service teachers rarely used while reaching skill-based problems was external experts. As external experts, the researcher or the mathematics teacher of the class in which the research course was carried out supported the groups in the process of determining the problems they would focus on, both with their field knowledge, experience and resource supply. The role of the teacher as an external expert in the process can be associated with Kanbolat's (2015) study. In his study, Kanbolat (2015) stated that the teacher, as an external expert, took part in the lesson study process carried out with pre-service teachers with the role of providing information and criticising in problem-solving sharing. In addition, it can be stated that the interaction of the groups with teachers enriches the process in a different dimension due to the school-based nature of the lesson study. In the study, the fact that more than one course study group working on problem solving instruction also communicated with each other shows that the study was also continued between the groups. In this context, it is predicted and recommended that such practices in the courses carried out in the context of mathematics teaching at the undergraduate level will enable pre-service teachers to interact among themselves on mathematics and its teaching. Based on the result that pre-service teachers apply to other pre-service teachers at the stage of finding skill-based problems, it is suggested that teachers should be encouraged to benefit from their colleagues in finding skill-based problems. In this context, the lesson study model used in the research can be a functional tool. Thanks to the lesson study practices focused on skill-based problem solving supported by the Ministry of National Education, it can be ensured that pre-service teachers can reach skill-based problems and even produce such problems.

Based on the reasons for selecting the problem or eliminating other problems expressed by the pre-service teachers while determining the skill-based problem to focus on and the interviews conducted with the pre-service teachers, the features that shape the skill-based problem definitions of the pre-service teachers are related to problem solving teaching, mathematical skills, degree of difficulty of the problem and affective factors.

Çolak (2022) stated that mathematics teachers mostly mentioned the formal features of skill-based problems while defining them. Within the scope of the research, in the dimension of problem solving teaching, the comments of pre-service teachers on the problem statement are related to the formal feature of the skill-based problem. The pre-service teachers think that the expression of the skill-based problem should *be clear, concise and understandable* by the student and should be supported by visuals if appropriate. Similarly, Hançer (2023) stated in his study that simplicity and clarity were expressed as one of the distinguishing features for skill-based problems. The pre-service teachers stated that the dose of the visuals or figures used in the problem should be determined well, and they also stated that the use of more visuals than necessary may cause students to approach the problem situation with prejudice. Çolak (2022), in his thesis study in which he analysed the expectations of mathematics teachers for skill-based problems, stated that they mostly emphasised the necessity of including visual elements or figures in the questions and that these visual elements should be clear, free from confusion and understandable. In another study, Uzun (2021) stated that mathematics teachers stated that skill-based problems are questions in the form of long paragraphs and visually rich. Studies show that teachers state that these problems have very long texts as one of the distinguishing features of skill-based problems (Angay, 2022; Bayat, 2023; Çepni, 2020; Çolak, 2022; Erden, 2020; Karakeçe, 2021; Uzun, 2021). In addition, pre-service teachers emphasised that problem statements should not contain incomplete information. Based on these facts, it is recommended to carry out research to evaluate the existing skill-based problems in terms of these formal features. In addition, it is suggested that teachers should include activities in which students meet different representations of mathematics such as verbal or visual representations.

In the study, it is seen that pre-service teachers mostly commented on the content of the skill-based problem. As a matter of fact, in the studies conducted by Kertil et al. (2021) and Hançer (2023), teachers gave answers that took into account the content structure of skill-based problems rather than their form.

The first of the features mentioned by the pre-service teachers about the construction of the problem is related to the *context of the problem*. The pre-service teachers who thought that the context of the skill-based problems should be related to mathematics itself or its areas of use (such as daily life, other disciplines, etc.) emphasised that these contexts should be remarkable, intriguing and suitable for the interests of each student. As a matter of fact, in many studies on the views of mathematics teachers on skill-based problems, it is similarly seen that teachers think that skill-based problems should be questions related to real/daily life problems (Çolak, 2022; Hançer, 2023; Karakeçe, 2021; Uzun, 2021). Pre-service teachers also stated that it is important to construct problems using games, puzzles or stories. Similarly, Çolak (2022) stated that teachers stated that skill-based problems start with a story and differ from other problems with this feature. For this reason, it is thought that teachers' sharing of mathematics and its usage areas in their classrooms is important in students' approach to skill-

Some pre-service teachers thought that skill-based problems should not be outcome-oriented. Some pre-service teachers also criticised the fact that skill-based problems enable only one outcome. Moreover, Erden (2020) stated in his study that teachers stated that the current skill-based problems are not related to the outcomes. On the contrary, Hançer (2023) stated in his study that being outcome-oriented is among the distinguishing features of skill-based problems. At this point, it is thought that it is necessary to evaluate the association of skill-based problems used especially in national exams with achievements. Then, naturally, depending on the decision taken as a result of the evaluation, it is thought that studies should be carried out to ensure an integrity between the teaching and measurement and evaluation dimensions of the curricula.

The actions performed in the *problem solving process* are also one of the situations that pre-service teachers take into consideration when selecting, eliminating or defining skill-based problems. It can be said that pre-service teachers consider the whole process from understanding the problem to the evaluation of the solution. For example, some pre-service teachers think that skill-based problems are difficult to understand. This explanation of pre-service teachers about the

step of understanding the problem can be associated with Karadağ's (2023) research. The pre-service teachers generally stated that the skill-based problems presented with long texts and visuals are naturally difficult to be understood by the students. In Karadağ's (2023) study, it was generally determined that students who successfully performed the comprehension step were able to perform the other steps and solve the questions correctly. In addition, pre-service teachers think that skill-based problems should not direct the student directly to the solution, and their solution should not be based on formulas, hard mathematical operations or pure mathematical knowledge. Ekinci and Bal (2018), in their study examining skill-based problems, stated that the problems are rarely related to operation skills. Pre-service teachers think that skill-based problems are easy to solve and can be solved by applying more than one strategy. In addition, there are pre-service teachers who emphasised that new problems should be generated from skill-based problems. Pre-service teachers' comments on problem solving can be related to Karadağ's (2023) research. Karadağ (2023) found that students who implemented Polya's problem solving process in mathematics were more successful in skill-based problem solving and suggested the use of Polya's problem solving process in teaching skill-based problem solving. In this context, in this study, it is recommended that teachers organise skill-based problem solving activities according to Polya's problem solving steps and especially give the necessary importance to the step of understanding the problem.

Another dimension that pre-service teachers mentioned while defining skill-based problems is related to *mathematical skills.* The pre-service teachers especially stated that skill-based problems should support students' *mathematical thinking* skills such as reasoning, recognising and establishing relations, critical thinking, analytical thinking, interpreting events, and creative thinking. Pre-service teachers' statements about mathematical skills can be related to the purpose of MoNE (2018) in implementing skill-based questions. MoNE (2018) states that it is not aimed to measure students' high-level skills such as reading comprehension, interpretation, inference, analysis, critical thinking, problem solving, prediction, and scientific process skills with skills-based problems. In addition, the studies in the literature also indicate that skill-based problems are used to measure reasoning skills (Angay, 2022; Ekinci & Bal, 2018; Kolovou et al., 2011), metacognition (Ergün, 2021; Kolovou, et al., 2011; Uzun, 2021), analytical thinking (Erden, 2020; Güler et al, 2019), creative thinking (Hançer, 2023), critical thinking (Hançer, 2023; Karakeçe, 2021; Uzun, 2021), prediction (Türk, 2022), and association (Uzun, 2021).

According to pre-service teachers, skill-based problems also affect students affective. Thanks to skill-based problems, students should be introduced to the fun and functional aspects of mathematics and thus they can develop positive attitudes towards mathematics. In his study, Uzun (2021) stated that teachers expressed the necessity of using skill-based problems to develop positive attitudes towards mathematics. Similarly, Tortop et al. (2022) stated that students with high academic achievement level in mathematics course were more interested in mathematics, made sense of it, and their attitudes towards mathematics increased positively thanks to skill-based problems. In the same study, teachers stated that students with low academic achievement and negative attitudes towards mathematics lost their hopes for mathematics with skill-based problems, had difficulty in understanding the questions and were pessimistic. At this stage, teachers who use skill-based problems in the learning environment have a great role. It is suggested that teachers should be directed to trainings to design learning environments that make skill-based problems solvable by all students or to collaborative practices such as the lesson study model.

The pre-service teachers commented on *the degree of difficulty* of the skill-based problems. As an interesting result in the study, it is seen that pre-service teachers agree with both of the opinions about the difficulty or ease of skill-based problems. When the literature is analysed, it is seen that teachers also express the opinion that skill-based problems are difficult or unnecessarily challenging (Hançer, 2023). The reason for the contradictory interpretation of the difficulty of skill-based problems from pre-service teachers, unlike teachers, may lie in the fact that pre-service teachers have limited experience with skill-based problems. It is suggested to investigate the

perceptions of pre-service teachers, teachers and even students with the degree of difficulty of skill-based problems and to investigate the variables underlying their views. In this way, valid and functional measures can be taken to prevent the perception that skill-based problems are 'difficult problems'.

All of the pre-service teachers with whom the interviews were conducted stated that the use of skill-based problems in mathematics classes is important and necessary. Research suggests that teachers have a positive approach towards using skill-based problems (Çolak, 2022; Güler et al., 2019; Hançer, 2023; Kertil et al., 2021). In addition, some pre-service teachers stated that students are not interested in skill-based problem solving activities and that teachers rarely use such problems in classroom environments. Studies indicate that teachers have a common view that due to the time constraints caused by the intensity of the curricula, raising the subject matter is at the forefront and this situation makes it difficult to use skill-based problems in the lesson (Çolak, 2022; Uzun, 2021). In this context, it is suggested that necessary changes should be made in the curricula to enable teachers to use skill-based problems in their classes. One pre-service teacher pointed to the lesson study experience she participated in and suggested the inclusion of skill-based problems in the classroom environment through lesson study practices with teachers. It is thought and suggested that the lesson study model can be a functional tool in the process of integrating skill-based problems into mathematics classrooms by exemplifying the lesson study practice focused on skill-based problem solving carried out within the scope of the research.

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