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MATHEMATICAL COMPETENCIES REQUIRED BY MATHEMATICAL LITERACY PROBLEMS

***Hatice Kübra Güler**

Çiğdem Arslan

ABSTRACT

Mathematical literacy problems used in PISA consists of real life context. In order to solve the problems of these contexts, there are various mathematical processes that students have to pass through. These problems are intended to measure the various competencies that are intended to be taught to students. It is also important that the teachers who will use such real context problems should be aware of the skills and competencies required by the problem. The aim of this research is to determine the awareness of prospective mathematics teachers about the mathematical processes and competencies required by mathematical literacy problems. This study is a case study carried out with 63 high school prospective mathematics teachers. Five mathematical literacy problems were directed to participants in written form. They are asked to solve these problems and then asked to determine mathematical processes and the competencies to be met for the solution of problems. The data collected were analyzed by using descriptive analysis method. As a result of the research, it has been determined that the prospective mathematics teachers cannot fully understand the difference between competency and process, and it has been determined that they have difficulty in making a distinction between these two concepts.

Keywords: *Mathematical Process, Mathematical Competency, PISA, Mathematical Literacy*

INTRODUCTION

The purpose of education is not only for teaching knowledge to individuals but also transferring real life experiences to new situations by using the knowledge learned. Mathematics is more than just an algorithmic rule; it is perceived as a problem-solving activity based on the modeling of real life (De Corte, 2004). Moving from these thoughts, solving real life problems can be regarded as a sign of learning mathematics. PISA (Program for International Student Assessment) is an international exam that measures students' ability to solve real life problems. In this exam, real life problems are confronted as contextual problems. PISA conducted by the OECD is an exam applied to 15 year olds in areas of science literacy, mathematical literacy and reading skills.

In 2015 PISA, the concept of mathematical literacy is defined as follows (OECD, 2016):

> "Mathematical literacy is an individual's capacity to formulate, employ and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using

> mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to recognize the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged and reflective citizens."

This definition points to the ability of the individual to formulate, use and interpret mathematics. These three concepts consist of three mathematical processes: "Formulating situations mathematically", "Employing mathematical concepts, facts, procedures and reasoning" and "Interpreting, applying and evaluating mathematical outcomes" the antagonism emerges (OECD, 2016). The cycle of such mathematical processes is shown in Figure 1.

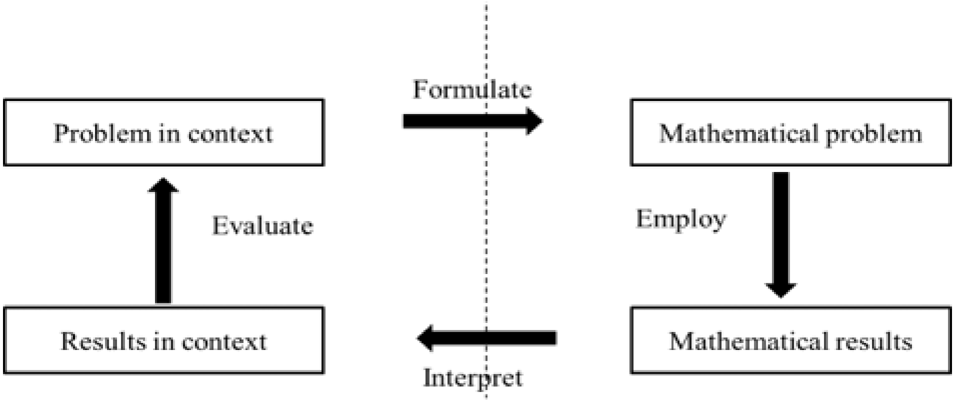

Figure 1. Mathematical Process Cycle (OECD, 2016).

As seen in Figure 1, the process of expressing a problem as mathematical problem needs formulating situations while to solve a mathematical problem and to take mathematical results indicate the process of using mathematics. Using the mathematical results obtained to adapt the daily life or solving these results to solve a new problem requires processes of interpreting and evaluating the results.

PISA 2015 also has the competencies that students should have to solve problems outside of mathematical context. These competencies are including communication; mathematisation; representation; reasoning and argument; devising strategies; using symbolic, formal and technical language and operations; and using mathematical tools (OECD, 2016). The solution of mathematical literacy problems is possible by having one or more of these competencies. When choosing a question to use, a mathematics teacher should prefer the questions appropriate to the competency and skill they wish to develop in their students' teaching process. When looking at the studies carried out about the competencies; Guler (2013) stated that students mostly had difficulty in solving the PISA questions because of lack of reasoning, lack of proof and communication skills. Sáenz (2009) stated in his work that teacher candidates lack the competencies in using discussion, communication, reasoning, symbolism and symbolic, formal and technical language and operations. Sáenz's (2009) study showed that teacher candidates had serious deficiencies in mathematical literacy competencies. Despite the lack of interest in solving problems in the field of mathematical literacy, Demir and Altun (2018) stated that as a result of their work with mathematics teacher candidates, the teacher candidates had no awareness of the basis on which they solved the questions.

Prospective teachers' deficiencies in these competencies also raise the question whether they know what these competencies mean or not. It is important that the teachers and prospective teachers should be aware of the competencies and mathematical process that these problems require. However, the work focused on this subject was not found in the literature. There were researches which investigated the low scores of the students in PISA and the reasons of this situation in the literature (Altun & Akkaya, 2014; Guler, 2013; Gursakal, 2012). Altun and Akkaya (2014) examined teachers' views in order to investigate the cause of the low success of Turkey in the international exams in recent years. For this purpose, firstly the questions of the PISA research were asked in written form to the teachers and their opinions on these questions were taken. Gursakal (2012) examined the factors affecting the success of Turkish students attending PISA 2009. As a result of his study, he determined that mathematical literacy levels of the students depend on the variables such as gender, school start age and education level of the parents. In addition, there are also studies in the literature about the mathematical literacy of the teachers and teacher candidates (Kabael & Barak, 2016; Sáenz, 2009; Suharta & Suarjana, 2018; Widjaja, 2011). Kabael and Barak (2016) investigated middle school pre-service mathematics teachers' mathematical literacy via PISA items in their research. They found that participants had difficulties in mathematization, and their mathematical literacy was not at a desirable level. Suharta and Suarjana (2018) investigated elementary school mathematics teachers' mathematical literacy in terms of mathematical skills and gender. They found that participants who had strong mathematical skills were better in mathematical literacy and also the females were better than the males in mathematical literacy. Widjaja (2011) asked two PISA questions and pointed out that it would be important to teach pre-service teachers how to explain this issue. Teacher candidates cannot fully utilize mathematical expressions and experiences in the process, but if they are educated, they become qualified teachers. However, there is no analysis on the degree to which teachers are aware of the competencies and processes. For this reason, it is aimed to determine not only prospective teachers' solving PISA questions correctly, but also their knowledge about mathematical processes and competencies.

Today's students are expected to benefit from mathematics in everyday life. The mathematical process and competencies measured in PISA exams are the focus of this research because one of them is to raise their mathematical literacy levels. An, Kulm, and Wu (2004) found that teachers had a great impact on student achievement in international examinations. Similarly, the PISA director, Schleicher (2017) stated that the overall success of education can never be more than the success of teachers. In this case, it is even more important for teachers to be able to solve PISA questions and be aware of competence and mathematical processes. In this context, the aim of this research is to determine the awareness of prospective mathematics teachers about the skills required by the PISA problems. For this purpose, an answer was sought in the question "Do high school prospective mathematics teachers can determine the mathematical process and competencies required by mathematical literacy problems?"

METHODOLOGY

The aim of this study is not only to determine the accuracy of the answers of the prospective teachers to the problems, but also to determine whether they are aware of the necessary mathematical processes and competences required by the problems. Therefore, participants' answers require an in-depth analysis. The case study model based on "why" and "how" questions gives opportunity to analyse facts and events in depth, which is a kind of qualitative research methods (Yildirim & Simsek, 2006). Because of this reason, the model of the current study is a case study.

The study was carried out during the spring term of 2017-2018 academic year, which included 63 high school prospective mathematics teachers. Participants were individuals who have completed their studies at a mathematics department at different universities and applied for a certificate program to become a teacher of 15-18 years old students. They have no prior knowledge of PISA and mathematical literacy.

Participants were given a general introduction about mathematics literacy and PISA during 6 hours, and asked to solve given sample problems. Then, in the classroom environment, analysis was made in terms of the mathematical process to be taken for the solution of these sample problems and the competencies to be possessed.

Following the mathematics literacy training five problems asked to prospective teachers, one of them were used in the PISA pilot application in 2012 (Oil Spill) and main applications in 2000 (Carpenter), 2003 (Exports) and 2012 (Apartment Purchase) (Appendix-1). The researchers worked on Oil Spill and

Apartment Purchase problems because of that they were analysed by Turner and Adams (2012) in terms of mathematical processes and competencies. The other two problems were analysed by the help of Turner and Adams (2012)'s classification. They were asked the mathematical process for solving each problem and which competencies a student should have in order to solve these problems. At the same time, they were also required to justify their answers. The frequencies of the collected data are tabulated. On the basis of the numerical values obtained, answer sheets of prospective teachers were subjected to descriptive analysis. The results of the analysis were also supported by direct quotations from explanations made by prospective teachers.

The mathematical processes and competencies required by the Apartment Purchase and Oil Spill problems from the contexts used in this study were determined in a study conducted by Turner and Adams (2012). The competencies and processes required by the two issues of the Carpenter problem and the Exports context were analysed by the researchers in line with the framework drawn by Turner and Adams (2012). The process and competencies of these problems are given in Table 1.

Table 1
Processes and Competencies Required by the Problems

Problem	Mathematical process	Competency
Apartment Purchase	Formulating situations mathematically	High level devising strategies; Moderate level communication, representation and mathematization; Low level reasoning and argument
Carpenter	Interpreting, applying and evaluating mathematical outcomes	High level reasoning and argument;
Oil Spill	Employing mathematical concepts, facts, procedures and reasoning	High level devising strategy, mathematization, using symbolic, formal and technical language and operations; Moderate reasoning and argument; Low level representation; Very low communication
Export 1	Employing mathematical concepts, facts, procedures and reasoning	High level communication and representation
Export 2	Employing mathematical concepts, facts, procedures and reasoning	High level communication and representation; Low level devising strategies, reasoning and argument

FINDINGS

Since the aim of this study is to reveal the mathematical processes and competencies required by the mathematics literacy problems of the prospective teachers, the findings are presented for each question in the context of mathematical processes and then the competences. The frequencies for the responses of the prospective teachers to the process of the solution of the apartment purchase problem are presented in Table 2.

Table 2

Responses to the Process for the Apartment Purchase Problem

		Mathematical Process				
		Formulate	Employ	Interpret and Evaluate	No answer	Total
Answers	Right	11	20	6	5	42
	Wrong	1	6	1	2	10
	No answer	2	6	1	2	11
	Total	14	32	8	9	63

The Apartment Purchase question requires "Formulating situations mathematically" as a process. As seen in Table 2, 42 participants answered the apartment purchase problem correctly, 10 of them made this question wrong and 11 gave no answer. Eleven of those who gave the right answer said that they need "Formulating situations mathematically", 20 of them said "Employing mathematical concepts, facts, procedures and reasoning", and six of them said "Interpreting, applying and evaluating mathematical outcomes".

However, half of the participants stated that this problem employing mathematical concepts, facts, procedures and reasoning. When the answers of prospective teachers were examined, it was understood that they confused the notion of reasoning. They used "Using mathematical concepts, facts, methods and reasoning" which is a process instead of reasoning and argument which is a competency. A prospective teacher used the following expression:

> "When we are finding four lengths, we must form a strategy by reasoning."

Another participant stated that:

> "... I showed the equilibrium of the opposite edges from a mathematical point of view by determining the edges needed for the base area. I did this somehow using reasoning. So, the process of this question is the use of mathematical concepts, facts, methods, and reasoning. "

The frequencies of the responses of the prospective teachers to the competencies required by the apartment purchase problem are presented in Table 3.

Table 3

Responses to the Competencies Required by the Apartment Purchase Problem

Competencies	The answers of the problem			Total
	Right	Wrong	Empty	
Communication	4	2	1	7
Reasoning and argument	31	8	5	44
Mathematization	24	4	5	33
Representation	7	2	3	13
Devising strategies	20	5	5	30
Using symbolic, formal and technical language and operations	17	3	1	21
Using mathematical tools	9	1	2	12

The Apartment Purchase problem requires a high level of devising strategies, moderate level of communication, representation and mathematising, and low level of reasoning and argument for solving problems as mathematical competence. While the prospective teachers who expressed right on their need for the competencies listed above, they also emphasized the merit of using the symbolic language and the two competencies, which were indispensable for this question. When the participants' answer sheets were examined with emphasis on the ability to use symbolic language, it was seen that they have expressed that these competencies should be used when making calculations. In the present problem, it is desirable to determine only the lengths required to calculate the area. Similarly, those who emphasized the use of mathematical means have been shown to focus not only on determining lengths but also on measuring lengths and finding areas.

The frequencies for the responses of the prospective teachers to the processes that should be passed for the solution of the carpenter problem are presented in Table 4.

Table 4
Responses to the Processes Required by the Carpenter Problem

		Mathematical Process				
		Formulate	Employ	Interpret and Evaluate	No answer	Total
Answers	Right	7	16	6	3	32
	Wrong	5	9	7	5	26
	No answer	1	-	3	1	5
	Total	13	25	16	9	63

The carpenter problem is aimed at interpreting and evaluating mathematical outcomes as a process when it is necessary to draw conclusions for the context of everyday life. As seen in Table 4, 32 participants answered the carpenter problem correctly, 26 of them answered wrongly and 5 gave no answer. Seven of the prospective teachers stated that this problem was appropriate for the process of "Formulating situations mathematically", 16 of them said that "Employing mathematical concepts, facts, procedures and reasoning" and 6 of them said that "Interpreting, applying and evaluating mathematical outcomes". However, only four of the prospective teachers stated that this process is required. When the papers of the prospective teachers were examined, it was seen that they were confused with reasoning adequacy and the process of employing as they were in the question of the apartment house. An answer which supports this finding:

> "As mathematical concepts, facts, methods and reasoning as a process skill ... The lengths of non-planar edges in shapes A and C can be determined visually and reasonably without calculation."

The above statement showed that prospective teachers used the process statement instead of competency. The frequencies of the responses of the prospective teachers to the competencies required by the carpenter problem are presented in Table 5.

Table 5
Responses to the Competencies Required by the Carpenter Problem

Competencies	The answers of the problem			Total
	Right	Wrong	Empty	
Communication	3	1	2	6
Reasoning and argument	17	16	3	36
Mathematization	13	1	2	16
Representation	3	5	1	9
Devising strategies	8	9	-	17
Using symbolic, formal and technical language and operations	11	4	3	18
Using mathematical tools	3	9	1	13

The carpenter question requires a high level of mathematical reasoning and argument. The participants also emphasized mathematization and using symbolic, formal and technical language and operations in addition to reasoning. When the answer sheets were examined, the ones who emphasized the mathematization competency didn't explain their answers. One participant who emphasized using symbolic, formal and technical language and operations explained her answer as follows:

> "In order to answer this question, students should calculate the circumference of the figure. They should see the circumference of rectangle, parallelogram and other figures by calculating."

Although carpenter problem requires reasoning and argument at high level; it can be said that it also needs the use of symbolic, formal and technical language and operations at low level from the participants' explanations.

The frequency for responses of prospective teachers to the processes to be solved for the oil spill problem is presented in Table 6.

Table 6
Responses to the Processes Required by the Oil Spill Problem

		Mathematical Process				
		Formulate	Employ	Interpret and Evaluate	No answer	Total
Answers	Right	5	5	-	1	11
	Wrong	18	9	7	4	38
	No answer	1	6	1	6	14
	Total	24	20	8	11	63

The Oil Spill question requires "Employing mathematical concepts, facts, procedures and reasoning" as a process. As shown in Table 6, 11 prospective teachers answered correctly for the oil spill problem, 38 answered this question wrong and 14 gave no answer. When the prospective teachers' papers were examined, it was seen that they made errors when calculating the areas of the squares or circles which they made or when measuring the edge lengths. Five of the participants who answered right have stated that this problem required "Formulating situations mathematically" as a process, while 5 says "Employing mathematical concepts, facts, procedures and reasoning". Half of those who answered the question correctly stated that it required the process of employing and the other half stated that it required the process of formulating. When the papers of prospective teachers were examined, it was seen that they confused competencies and processes as well as other questions. It is understood that participants are emphasizing reasoning as a competence from their expressions, and a participant's statement about this situation is as follows:

> "Employing mathematical concepts, facts, procedures and reasoning. Because student will make a comment using the distance of the tanker to the ground, but he will not use any ready-made formula to obtain this interpretation. "

The frequencies for the responses of the prospective teachers to the competencies required by the oil spill problem are presented in Table 7.

Table 7
Responses to the Competencies Required by the Oil Spill Problem

Competencies	The answers of the problem			Total
	Right	Wrong	Empty	
Communication	-	7	1	8
Reasoning and argument	8	22	4	34
Mathematisation	7	20	7	34
Representation	4	9	1	14
Devising strategies	6	21	2	29
Using symbolic, formal and technical language and operations	3	10	5	18
Using mathematical tools	3	6	4	13

The Oil Spill problem requires competence to produce a high level of devising strategies, mathematization, using symbolic, formal and technical language and operations, moderate reasoning and argument, and low level of communication and representation. As expected, prospective teachers have generally focused on reasoning and argument, mathematising and devising strategies. The reason why those who made the wrong decisions could correctly determine the necessary competences might be that they made this question wrong because they made a mistake in the measurement. Prospective teachers who were mistaken were also aware that the problem required competence to devising strategies and reasoning.

The frequencies for the responses of prospective teachers to the processes to be solved for the solution of the first question of the exports-1 problem are presented in Table 8.

Export-1 question requires "Employing mathematical concepts, facts, procedures and reasoning" as a process. As seen in Table 8, 57 participants responded correctly to the export-1 question. 8 of them said that the question requires "Employing mathematical concepts, facts, procedures and reasoning", while 38 of them said "Interpreting, applying and evaluating mathematical outcomes".

Table 8
Responses to the Processes Required by the Exports-1 Question

		Mathematical Process				
		Formulate	Employ	Interpret and Evaluate	No answer	Total
Answers	Right	5	8	38	6	57
	Wrong	-	-	2	1	3
	No answer	-	2	1	-	3
	Total	5	10	41	7	63

The frequency of the responses of the prospective teachers to the processes to be passed for the solution of the second question of the Exports-2 problem is presented in Table 9.

In Table 9, it is seen that 58 participants responded correctly to the Export-2 question. While 5 of them expressed that this question was appropriate to the process of "Formulating situations mathematically", 9 of them stated "Employing mathematical concepts, facts, procedures and reasoning" and 38 of them stated "Interpreting, applying and evaluating mathematical outcomes".

Table 9
Responses to the Processes Required by the Exports-2 Question

		Mathematical Process				
		Formulate	Employ	Interpret and Evaluate	No answer	Total
Answers	Right	5	9	38	6	58
	Wrong	-	1	2	1	4
	No answer	-	-	1	-	1
	Total	5	10	41	7	63

Since both questions of the exports problem include the processes of extracting mathematical results from a mathematical problem, it requires "Employing mathematical concepts, facts, procedures and reasoning" as process skills. But more than half of the participants stated that the question was suitable for "Interpreting, applying and evaluating mathematical outcomes" process. While the participants' answers were examined, it was seen that they have explained what they had done. A prospective teacher justified the answer "Interpreting, applying and evaluating mathematical outcomes" as follows:

> "Based on the graphs given in the table, we use mathematical interpretation and evaluation as the process for which we use the data."

This statement emphasized the adequacy of representation competency. Thus, it could be said that it was difficult for the prospective teachers to distinguish between process and competency, and they did not fully understand the mathematical process cycle.

The frequencies of responses of prospective teachers to the competencies required by the first question of the Export-1 problem are presented in Table 10.

Table 10
Responses to the Competencies Required by the Export-1 Problem

Competencies	The answers of the problem			Total
	Right	Wrong	Empty	
Communication	8	-	1	9
Reasoning and argument	20	-	-	20
Mathematisation	24	-	3	27
Representation	14	1	1	16
Devising strategies	8	-	-	8
Using symbolic, formal and technical language and operations	28	2	-	30
Using mathematical tools	7	-	-	7

Export-1 problem requires high level of communication and representation as mathematical competency. Export-2 problem requires high level representation, low level of devising strategies and reasoning and argument. If Table 10 and Table 11 were taken into considerations together, it can be seen that participants have stated that they required reasoning, mathematization and symbolic language and operations. When examining the papers of prospective teachers for this finding, one of them explained the reason for expressing symbolic language competency as follows:

> "Using symbolic, formal and technical language and operations is necessary because the graphics need to be read correctly and rate-proportions established."

The expression of this participant pointed out to be merely representative of the symbolic background, but the symbolic language and the operations were sufficient because the participant thought that it was necessary to establish the rate-proportions. Another participant also used the following expression, emphasizing the need for further action:

> "It is necessary to specify that the total value of the table corresponds to 100% and to find the percentage that the fruit juice corresponds to."

Both prospective teachers emphasized mathematical processes. From this point of view, it can be said that this problem requires a very low level of symbolic language and operations. For mathematization, it was observed that they did not make any justification. The frequencies of the answers to the competencies required for the second question of Export-2 problem are presented in Table 11.

Table 11
Responses to the Competencies Required by the Export-2 Problem

Competencies	The answers of the problem			Total
	Right	Wrong	Empty	
Communication	8	-	1	9
Reasoning and argument	19	1	-	20
Mathematization	26	-	1	27
Representation	15	1	-	16
Devising strategies	7	1	-	8
Using symbolic, formal and technical language and operations	29	1	-	30
Using mathematical tools	7	-	-	7

Export-2 questions require high level of devising strategy as mathematical competence, moderate communication, representation and mathematization, and low-level reasoning and argument. While the participants who gave the right answer expressed their need for the competencies listed above, they also emphasized the merit of using the symbolic language and the two competencies, which were indispensable for this question. When the papers of the prospective teachers related to this finding were examined, it was seen that they made the same explanations as the Exports-1 question for the symbolic language and the competencies were sufficient. It was determined that they accepted the graph as a mathematical tool for the competency of "using mathematical tools".

DISCUSSION

In this study it was found that the prospective mathematics teachers were successful in solving the problems addressed to them. It has been observed that the correct answers of prospective teachers vary widely in terms of contexts. While only 11 out of 63 prospective teachers answered the Oil Spill question correctly, 57 of them answered Export 1 and 58 of them answered Export 2 question correctly. In the literature, there are studies which indicate that the context of a problem is effective in problem solving process and success (Almuna, 2017; Huang, 2004; Van Den Heuvel-Panhuizen, 2005; Wijaya, Van den Heuvel-Panhuizen, Doorman, & Robitzsch, 2014). In the present study, the success difference between the problems may be due to the differences in the context of the questions in parallel with the literature.

Only 10 of the prospective teachers who responded to the Export questions correctly were able to determine the mathematical processes of the same questions correctly. Similarly, the number of prospective teachers who could determine the mathematical processes correctly in other questions was not more than 20 participants with Oil Spill question. According to these results, it can be said that the prospective teachers' awareness on mathematical processes is low.

Although prospective teachers had a very high level of correct answer to the Export questions; they have difficulty in determining competences as in mathematical processes. Only 9 prospective teachers stated that the questions required communication competency and 16 of them stated that the questions required representation competence. Similarly, for the Export questions, the prospective teachers had difficulty in determining competencies in other questions. They wrote many competencies for each question, although they weren't required. This situation may be an indication that they were unable to differentiate competences. Kabael and Barak (2016) stated that the middle school mathematics teacher candidates had difficulties in solving PISA problems which included mathematization and especially making relations between variables in the problem and interpreting graphics. Despite of this result, high school prospective mathematics teachers in the current study could solve the problems which required the mentioned competencies but they couldn't determine which ones were required for solution as seen Export questions.

When competencies and mathematical processes were evaluated as a whole, it was determined that the prospective teachers' awareness was low. This result might be due to the fact that teacher candidates had a low awareness of the nature of the questions and the underlying philosophy, as Demir and Altun (2018) stated.

Prospective mathematics teachers took the theoretical knowledge related to competencies and mathematical processes in the course of special teaching methods. In this study, it was concluded that they did not fully understand the difference between competency and mathematical process. The difference between reasoning in "Employing mathematical concepts, facts, procedures and reasoning" as a mathematical processes and reasoning in "reasoning and argument", which is a competence, was not clear for prospective teachers. Guler (2013) stated that students had difficulty in solving questions when they needed reasoning. The inability of prospective teachers to make the distinction between reasoning as a mathematical process and reasoning which is a competence can be considered as a result of Guler (2013) 's study. Prospective teachers have also difficulty in making the distinctions within the competencies. From the findings, it was determined that some of the prospective teachers accepted the graph as a mathematical tool. The graph, on the other hand, is a mathematical representation. Sáenz (2009) stated that prospective teachers had difficulty in demonstrating the competencies they needed to answer PISA questions. It is possible to say that when this study combined the results of Sáenz (2009), the inability to exhibit such competencies aroused from the lack of information on competences.

Ozcan and Arik (2018) found that the majority of the middle school teachers had inadequate knowledge about the content of PISA researches and they did not state the purpose of PISA researches accurately. Teachers cannot be expected to be aware of the competences and skills they require when they do not have enough information about PISA. Sahin and Basgul (2018) determined that mathematics teacher candidates posed problems generally about productive skills that is lower-level skills, when preparing a PISA-style question. When it is thought that those who would educate the students are mathematics teachers, it is important that the teachers can make the difference between the competency and process in order to make effective mathematics teaching. This questioned the content of the specific teaching methods given to them. In this study, prospective teachers had taken only 6 hours lesson about mathematics literacy. However, the thought of real context problems can be strengthened in the teaching during the whole course of the study which takes around a semester. In this way, it can be made possible that prospective teachers understand and internalize mathematical literacy problems and its requirements. Prospective teachers' training and professional development should be supported in order for them to gain the necessary competencies, teach the mathematical processes and finally increase their mathematical literacy levels.

CONCLUSIONS

The aim of this study was to determine the awareness of prospective mathematics teachers about the mathematical processes and competencies required by mathematical literacy problems. In the study, firstly, it was found that the participants were generally successful in in solving mathematical literacy problems. Depending on the context of some problems, success levels have changed. However, they did not achieve the same success in determining mathematical processes and the required competencies of the problems. Considering the participants' answers, it was found that they mistook reasoning and argument which was a competency for employing mathematical concepts, facts, procedures and reasoning which was a mathematical process. The researchers suggested that prospective mathematics teachers should take more courses on mathematical literacy for improving their awareness on mathematical literacy problems, competencies and mathematical process. If they improve themselves, their students will be successful in PISA. Therefore, the students can then internalize the mathematical literacy and their PISA scores can increase.

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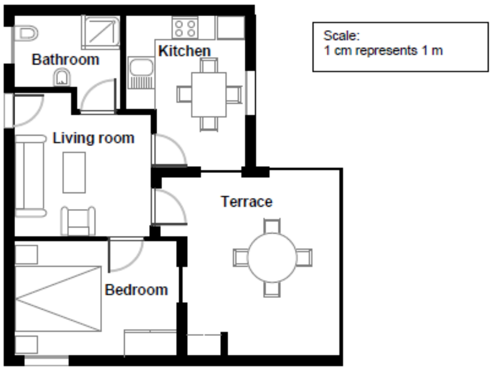
Appendix-1

APARTMENT PURCHASE

This is the plan of the apartment that George's parents want to purchase from a real estate agency.



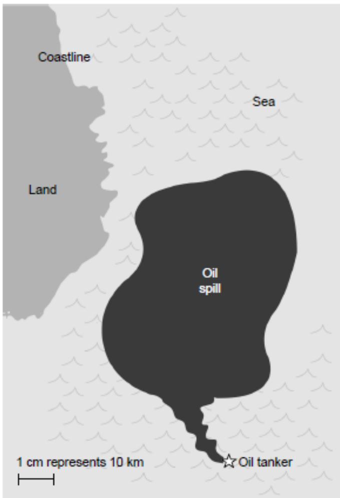
Translation Note: In this unit please retain metric units throughout.

Translation Note: Translate the term "real estate agency" into local terminology for businesses that sell houses.

Question: However, there is a more efficient method to estimate the total floor area where you only need to measure 4 lengths. Mark on the plan above the four lengths that are needed to estimate the total floor areaof the apartment.

OIL SPILL

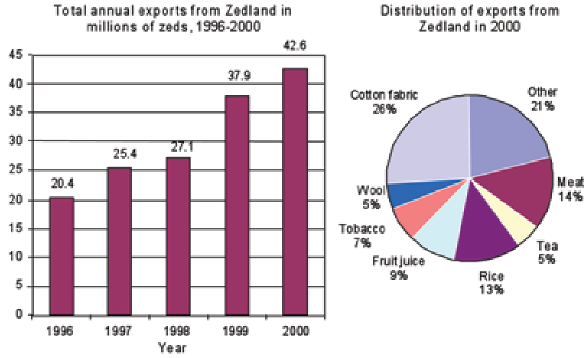
An oil tanker at sea struck a rock, making a hole in the oil storage tanks. The tanker was about 65 km from land. After a number of days the oil had spread, as shown on the map below.



Question: Using themapscale, estimatethearea of theoilspill in squarekilometres (km^2).

EXPORTS

The graphics below show information about exports from Zedland, a country that uses zeds as its currency.



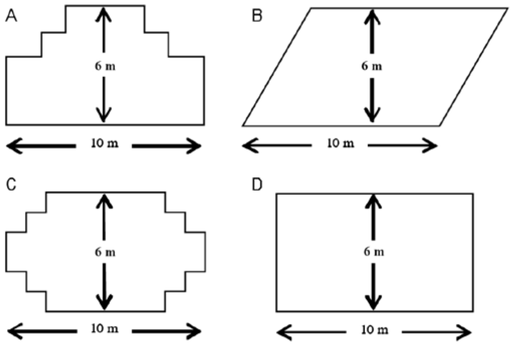
Q 1: What was the total value (in millions of zeds) of exports from Zedland in 1998?

Q 2: What was the value of fruit juice exported from Zedland in 2000?

A: 1.8 million zeds. B: 2.3 million zeds. C: 2.4 million zeds. D: 3.4 million zeds. E: 3.8 million zeds.

CARPENTER

A carpenter has 32 metres of timber and wants to make a border around a garden bed. He is considering the following designs for the garden bed.



Circle either "Yes" or "No" for each design to indicate whether the garden bed can be made with 32 metres of timber.

Garden bed design	Using this design, can the garden bed be made with 32 metres of timber?
Design A	Yes / No
Design B	Yes / No
Design C	Yes / No
Design D	Yes / No