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Development of Mathematical Literacy Question Writing Process and Skills *

Furkan Demir [1], Murat Altun [2]

Abstract

This study aimed to evaluate an instructional activity designed for providing preservice teachers with the mathematical literacy questions choosing and writing skills. The study was conducted with the mathematics group students of the pedagogical formation program. The data for creating the content of the instruction was obtained from the PISA applications and the related literature. The data for developing the instruction was obtained from the video recordings of the classes during the application process and the data for evaluating the instruction was obtained from the pretests and posttests, observations and interviews. The research findings showed that the preservice teachers were interested in the subject and actively participated in the instructional process. It was observed at the end of the applications that preservice teachers' levels of mathematical literacy awareness increased and their skills of question choosing and writing in the field improved. Furthermore, it was concluded that there were opportunities and challenges confronted by the preservice teachers in the process of question writing. It was accordingly decided that life experiences, topics of limitation or exemplifications through representations such as pictures and videos proved to be opportunities for the preservice teachers. It was recommended that the instruction within the scope of the study would be enhanced and included in the undergraduate programs.

Keywords

Mathematical literacy

Contextual problems

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Introduction

Mathematical literacy refers to an individual's "capacity to formulate, employ and interpret mathematics" in various life settings (OECD, 2013, 2016). The issue of how students can be help to acquire mathematical literacy has been among the fundamental problems of mathematics teaching (Altun & Bozkurt, 2017, p. 172). The mathematics assessment framework provided by the Programme for International Student Assessment (PISA) does not assess what is taught in schools, but rather assesses what individuals can do with what they have been taught and to what extent a mathematics curriculum is influential in an individual's participation in the social life (Berberoğlu & Kalender, 2005).

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[1] Dumlupınar University, Faculty of Education, Department of Math and Science Education, Turkey, furkan.demir@dpu.edu.tr

[2] Uludağ University, Faculty of Education, Department of Math and Science Education, Turkey, maltun@uludag.edu.tr

Accordingly, PISA assessments are very significant reference points for many countries to frame their educational policies (Breakspear, 2012). The secondary school mathematics curriculum implemented by the Ministry of National Education (MEB) in Turkey in 2013, which is still in force, includes statements that overlap with this description of mathematical literacy. The statement "the acquisition of mathematical knowledge and skills that may be necessary in everyday life" (Ministry of National Education [MEB], 2013), included in the objectives of the curriculum, is similar in content to the definition of mathematical literacy. Despite this similarity between the MEB secondary school mathematics curriculum and PISA assessments, Turkey's poor results in the PISA tests (Uysal & Yenilmez, 2011, p. 1; İlbağı, 2012, p. 159) have proven the failure of this mathematics curriculum to achieve its objectives. A reason behind this failure is that mathematical literacy questions are not adequately addressed in teaching. İskenderoğlu and Baki (2011) have argued that mathematics questions in the secondary school textbooks are mostly within the range of the first three levels of the six proficiency levels set by the PISA, questions at Level 4 are rarely present, and there are no questions at Levels 5 and 6. A similar problem is also observed in national qualifying examinations such as TEOG, YGS, and LYS. Due to the use of such examinations in Turkey to rank and place students in a school, they have become an objective for each student and, by extension, have an increasing effect on education (MEB, 2008). Altun and Bozkurt (2017) have reported that these exams are composed of multiple-choice questions which are limited in the measurement of process skills and this limitation leads to a disadvantage such as ignoring process skills during classes. All these assertions reveal the need for questions which

- consider the solution process in the evaluation of achievement,
- help to achieve the objectives of mathematics education exactly as they are,
- will indicate the degree to which students use their mathematical knowledge and skills.

The questions employed in PISA tests comply with this content described above (Breakspear, 2012). This shows that it is necessary to conduct studies on developing questions that take these criteria into account and to raise teachers who are able to choose and write questions of necessary qualities and include such questions in the education and training process.

The Nature of Mathematical Literacy Questions

PISA assesses the extent to which 15-year-old students use their mathematical skills to solve problems in various contexts (OECD, 2013, p. 28). Accordingly, the measurement of a mathematical literacy problem or solution involves at least three dimension including *context*, *mathematical content*, and *mathematical process*. Context refers to the condition in which a problem is set up (Altun, 2015). The definition of PISA given above guarantees the existence of context in each problem. PISA addresses contexts in four categories: (i) personal, (ii) occupational, (iii) societal, and (iv) scientific (OECD, 2016, p. 74). Mathematical content is the mathematical content knowledge that students need to solve a problem. It is addressed in four categories: (i) quantity, (ii) space and shape, (iii) change and relationships, and (iv) uncertainty and data (OECD, 2016, p. 71). Mathematical processes are actions performed by students during the process of problem solving. These processes are categorized into three categories: (i) formulating situations mathematically, (ii) employing mathematical concepts, facts, procedures, and reasoning, and (iii) interpreting, applying and evaluating mathematical outcomes (OECD, 2016, p. 66).

Each mathematical literacy problem in PISA assessments has the properties presented above and complies with all dimensions (OECD, 2016). Thus, it provides the basis of the present study for the mathematical literacy problem writing training. This study devotes close attention to include information on the dimensions and sub-dimensions described above.

Assessment of PISA Results

A main field is weighted in each PISA survey and this field is called weighted field (MEB, 2016, p. 1). Among previous five PISA surveys, the PISA 2003 and 2012 surveys focused on mathematics (the 2006 and 2015 surveys focused on science and the 2009 survey on reading). An overall review of the PISA 2003 and 2012 surveys are provided below. Turkey's mean scores of mathematical literacy in these surveys were calculated to be 423 and 448, respectively. In the scale by which the proficiency level is assessed in such a way that it corresponds to a natural number varying between 1 and 6, these scores correspond to Proficiency Level 2. For a more detailed examination, one can see Table 1 which presents the student percentages per level in the surveys (OECD, 2003, 2014).

Table 1. Distribution of 15-year-old Students by Proficiency Levels of Mathematical Literacy according to PISA Results (%)

		Average*	**Below Level 1**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Level 5**	**Level 6**
PISA 2003	Turkey	423	27,7	24,6	22,1	13,5	6,8	3,1	2,4
	OECD	500	8,2	13,2	21,1	23,7	19,1	10,6	4,0
PISA 2012	Turkey	448	15,5	26,5	25,5	16,5	10,1	4,7	1,2
	OECD	494	8,0	15,0	22,5	23,7	18,2	9,3	3,3

**Average calculated assuming that all the OECD member countries have the equal number of 15 age group students*

As seen in Table 1, more than a quarter of students in Turkey were below the first level in the PISA 2003 applications. According to the proficiencies summarized for Level 1 in the scale (OECD, 2013, p. 27), students did not have the proficiencies of,

- answering the questions which are clearly expressed, in which necessary information is given for solution and which are presented in a known scope,
- distinguishing the information in accordance with the directives given in regard to the known situations,
- performing the routine operations,
- and performing the operations which are possible by following an explicit, single stimulus

According to the number of students in Level 1, it is seen that about a quarter of the students had only the proficiencies above mentioned. The number of students in both levels (Below Level 1, and Level 1) corresponded to 52.3% of the Turkish sample in 2003 and 42% in 2012. This rate was 21.4% and 23%, respectively, in OECD countries. Based on the same table, there were very few students having the top-level (Level 5 and 6) skills and a lot of students below Level 1 and at Level 1 in terms of mathematical literacy proficiency in Turkey (Eğitimi Araştırma ve Geliştirme Dairesi [EARGED], 2005).

The findings given in Table 1 may put forth the idea that the mathematical literacy proficiencies were identified by PISA as being above what they should be. According to Figure 1 presenting the distribution of students by their proficiency levels in Turkey and all the OECD countries (EARGED, 2005, p. 16), the Turkish sample did not show a normal distribution at mathematical literacy levels.

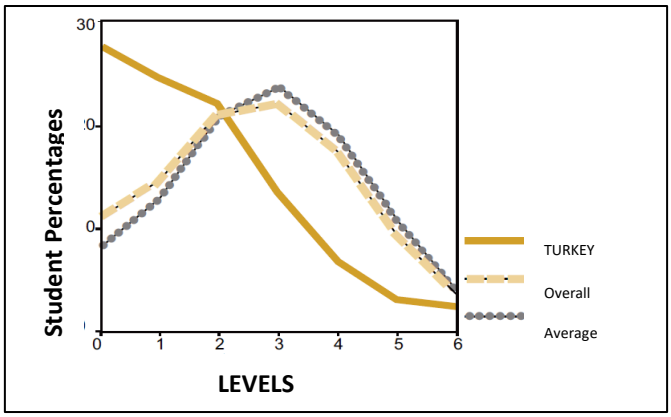

Figure 1. Students' Distribution by their Mathematical Literacy Proficiency Levels

Based on the data on all the OECD countries in Figure 1, the sample has a distribution close to normal at the proficiency levels of mathematic literacy. Thus, the mean score of the Turkish sample corresponded to Level 2 and this is an indicator of underachievement. Level 2 is regarded as the baseline of proficiency in mathematics on which students have just begun exhibiting their skills which enable them to use mathematics effectively (İskenderoğlu & Baki, 2011).

If the factors that lead to underachievement in the components of instruction are identified, it will help to know where to start and which components a possible solution covers. Thus, it is possible to plan the work that will reduce the influence of these factors. First, the scope of the planned work needs to be clarified. Baki (2008, p. 358) lists the components of instruction including purpose, content, physical spaces, teaching staff, quality control, teaching material, and assessment and evaluation.

The content, teaching staff, teaching material, and assessment, which can be modified on these seven components, are directly related to the quality of the teacher. In other words, a well-trained teacher can be influential as a person who determines content and plans, manages, and evaluates teaching in eliminating deficits in these components. Although there is a limited volume of research directly on teacher qualifications, research on textbooks highlights the need for selecting and writing mathematical literacy question. Saenz's (2009) study on teacher quality in mathematical literacy has reported that Spanish preservice teachers had more difficulty in contextual problem situations than in conceptual and procedural problem situations. As it is specified in the definition of mathematical literacy (OECD, 2013, p. 28), the content of each question has a *context*. Accordingly, this result of Saenz's (2009) study may indicate that preservice teachers have a number of deficiencies in mathematical literacy.

Paksu and Akkuş (2007) explained that more than half of mathematics courses did not include any other material than course books. These studies emphasizing the importance of course books bring about the discussion on whether these books are sufficient in the content wise.

As one of the studies examining the course books, in the study conducted by Dede and Yaman (2005), it was investigated how often problem solving and posing activities in PISA were included in the primary school second-level mathematics and science course books and it was stated that these activities were not sufficient in number. Çakır (2009, p. 73) examined the 5th-grade mathematics course books and determined that the assessment-evaluation questions at the end of each unit did not allow students at different levels to evaluate themselves and encourage them enough to investigate and examine and partially facilitated the development of higher order thinking skills.

Purpose of the Study

The results of literature studies examining course books and the poor national performance in PISA surveys show the need for questions which evaluate the mathematical literacy of students in Turkey. Therefore, this study focused on question writing training. The lack of questions that help to assess the mathematical literacy of students in Turkey and the lack of work on have proven the primary need for determining what and how PISA assesses in mathematical literacy and training individuals who can write questions to assess these specified fields. Teachers as part of the instructional components, hence preservice teachers, are considered an efficient power at this point. This shortcoming can be significantly met by preservice teachers achieving the competency of choosing and writing the mathematical literacy questions. In this context, the subproblems of the research are as follows:

1. What are preservice mathematics teachers' levels of awareness of mathematical literacy?
2.
    a. To what extent does the designed mathematical literacy education bring awareness to preservice mathematics teachers about the mathematical literacy?
    b. To what extent does the designed mathematical literacy education provide the question choosing and writing skills?
3. What are the opportunities and challenges confronted by preservice mathematics teachers in choosing and writing questions?

Solving the problems in question requires designing, applying and developing an instruction with the content that can explain which skills and how PISA assesses in the field of mathematical literacy. Thus, it is necessary first to reveal teachers' awareness of mathematical literacy for the idenfication of teaching content. Accordingly, within the scope of this research, an instruction help preservice mathematics teachers to acquire the skills of choosing and writing questions in mathematical literacy. This instruction will help to foster mathematics teachers' awareness of mathematical literacy and to improve their skills of choosing and writing questions in mathematical literacy. This instruction can be also utilized in teacher education and in-service seminars organized for teachers. From this perspective, the present research seems to have a profound influence.

This research is the first national educational study designed and reported on developing the skills of choosing and writing questions that will serve to the purpose of mathematical literacy assessment.

Method

The research aims at designing and testing an instruction for bringing preservice mathematics teachers to skills of choosing and writing questions in mathematical literacy. To this end, the research was carried out at four stages, each of which has their own sub-steps. Qualitative and quantitative research designs were used together to manage the processes.

A mixed methods research design is suitable for this research. For the purpose of clarification, it seems appropriate to compare all the research stages and the features of mixed methods research design.

The features of mixed methods research design are listed by Creswell (2013, p. 217) as follows.

i. It includes collecting qualitative (open ended) and quantitative (close ended) data for research questions and hypotheses.
ii. It covers both types of data.
iii. The two types of data are included in the design analysis, combination of data, association of data or placement of data.
iv. These procedures are incorporated in the mixed method design along with the timing of data collection (simultaneous or successive) and importance attached to each database (equal or non-equal).

Table 2. The Method of the Research

	MIXED METHODS				
Design	**Stage**	**Purpose**	**Model**	**Method**	**Technique**
Action Research	1	Testing the awareness	Survey	Quantitative	Descriptive
	2	Designing the instruction	Survey	Qualitative	Document Analysis
	3	Applying, developing and evaluating the instruction	Testing	Qualitative	Recording and Observation with Audial-Visual Materials Interview Content Analysis
	4	Evaluating the effects of the instruction with three variables	Testing	Quantitative	One-Group Pretest-Posttest

Features of the mixed method listed above and Table 2 shows that the research design coincides with the features of the mixed method. In addition, the researcher primarily seeks to make a change or provide solution to existing problems along with the effort of understanding the environment/subject of study. This effort and goal show that the study can be described as an action research (Yıldırım & Şimşek, 2008, p. 78). Action research studies are commonly used by in-class instructional applications and researchers of teacher training. Therefore, action researchers work with individuals in the social environment of study to make contribution to their developments or make an effort for providing solution to their certain problems rather than abstracting themselves from that environment (Norton, 2009; as cited in Karaman & Apaydın, 2014, p. 381). This feature is also in parallel with action research. Accordingly, this study can be defined as action research based on mixed methods research design.

Study Group

The study group was composed of the preservice mathematics teachers who enrolled in the pedagogical formation program in two state universities in the Aegean Region and the Marmara Region. Three reasons mainly came into play in choosing the preservice mathematics teachers who enrolled in the pedagogical formation program as the study group even though there are other teaching programs. The most important one is that most of the students who participated in the PISA 2012 project in Turkey were high school students. The reasons for choosing the study group above can be listed by their order of importance as follows:

1. 93% of the students involved in the PISA 2012 survey in Turkey was composed of 9th and 10th-grade students and the preservice mathematics teachers who enrolled in the pedagogical formation certification program will teach to those grades,
2. The instruction planned within the scope of the research can benefit from special teaching methods, teaching technologies, and material design courses,
3. The convenience of conducting research with these groups was provided by the officials.

The participant preservice teachers were placed in the program by a mixed score including 60% of the Academic Staff and Postgraduate Education Entrance Exam (ALES) score by the Assessment, Selection and Placement Center (ÖSYM) and 40% of the academic grade average in February 2014. All of the participants had graduated from the Mathematics Department in Faculty of Science.

The students in the university in the Aegean Region participated in the study as the pilot group while the students in the university in the Marmara Region were taken as the control group. There were 31 preservice mathematics teachers in the pilot group, the study group was composed of 39 preservice mathematics teachers. Some of the participants were also working for private educational institutions as mathematics teachers. The participants in the study group had higher placement scores than the scores of the participants in the pilot group.

Data Collection Instruments and Data Collection Process

The stages and the mixed design in the method required using different data collection instruments in the research. According to the research method, the first procedure was to identify preservice mathematics teachers' levels of mathematical literacy awareness. A pretest of mathematical literacy awareness was prepared with 10 questions with 2 of them being multiple choice, 8 being open ended questions to run this procedure. The test was reviewed by an expert of mathematics education who has studies on mathematical literacy and continues to engage in the subject currently. The frameworks and technical reports published by OECD for the PISA project, released PISA items, national reports published by Ministry of National Education, books of the authors in the PISA mathematical literacy expert team, correspondence (e-mails) between the researcher and some of the members of OECD-PISA mathematical literacy expert team and articles in the related literature were examined for the design of the instruction. All these resources were subjected to a document analysis so what and how PISA assesses in the field of mathematical literacy could be determined.

The features of criterion-based tests are suitable for the texture and the purpose of this research to collect quantitative data. The following explanations were made by McLoughlin and Lewis (1997) regarding criterion-based tests:

- They compare student performance to a prespecified mastery or achievement level.
- They focus on very precise and narrow fields of skill and summarized the degree of mastery in them. Therefore, they are more useful for planning a program and following up its development.

- Such tests can be developed by teachers as in most academic fields and are suitable for students who are learning certain skills.

The features of criterion-based tests mentioned above seem to coincide with the purpose of this research exactly. Hence, recommendations for developing criterion-referenced tests in the literature were considered when preparing the quantitative data collection instruments of the research. Furthermore, necessary adjustments were made to the tests in accordance with the opinions of a math specialist who works in the field of mathematics literacy. Following these procedures, the pretest, intermediary test and posttest used in the processes of applying, developing and evaluating the instruction were finalized. Accordingly, the numbers of questions used in the tests is presented in Table 3.

Table 3. Information on The Contents of The Tests

	Numbers of Questions		
	Pretest	**Intermediary Test**	**Posttest**
Awareness	10	8	-
Question Choosing*	-	20	20
Question Writing**	-	Questions written by the participant until the intermediary test	Questions written by the participant from the intermediary test until the posttest

** Some of the related 20 questions can evaluate mathematical literacy. It was evaluated whether the preservice teachers chose those questions out of others.*

*** The participants were asked to write at least 4 questions during the instruction.*

Semi-structured interviews were utilized for evaluating the instruction through the opinions of the preservice mathematics teachers who participated in the applications. The interviews were made in the eleventh week. The participants were asked "Can you choose or write questions that can evaluate students' mathematical literacy?" Next, the participants who stated that they could not choose or write questions were requested to explain the reasons and those who gave a positive answer were asked to explain the opportunities they had encountered during the instruction. This way, opportunities and challenges encountered by the preservice mathematics teachers when choosing and writing mathematical literacy questions were identified.

Validity and reliability of the interviews: The interviews were performed by an expert of mathematics education who master both the content and the process of the instruction applied within the scope of this study and recorded with a video recorder. Expert opinion was consulted when deciding the interview questions to achieve the scope validity. It was ensured with the statements "Did you learn how to write a mathematical literacy question? Please give your clearly and sincere answer" along with additional (probing) questions that the participants reveal their opinions. Indeed, it is quite important to set a sincere and reliable environment during an interview because it is more likely to obtain real data in that way (Çepni, 2012, p. 163).

Since the study is based mixed methods research design, a summarized table was created to present all the data collection instruments used in the research together and show that they are complementary to each other. Table 4 gives summarized information on the data collection process, all the data collection instruments used in the research, the reasons why they were used and their contents.

Table 4. Data Collection Process and Summarized Information on Data Collection Instruments

Stage	Week	Purpose	Medium	Content
1	Pre-application	Designing the instruction	Literature	OECD publications on the PISA project: frameworks, technical reports; MEB publications: national reports, books of the authors in the PISA mathematical literacy expert team, correspondence (e-mails) between the researcher and the expert team and articles in the related literature
2	1	Testing the awareness	Awareness Pretest	Do we know PISA? Do we know its content? Do we find it to be necessary/useful?
3	1-11*	Applying, developing and evaluating the instruction	Camera Interview	Course content, course flow and auxiliary materials Opportunities and challenges encountered when choosing and writing questions
4	8	Evaluating the effects of the instruction with three variables	Intermediary Test	Awareness + Choosing + Writing
5	12	Evaluation of instruction's effects with two variables	Posttest	Choosing + Writing

* *From the first week to the eleventh week.*

How the data were collected and which skills were assessed in the related weeks is summarized in the table. This way, the place of the measuring instruments was specified in the research process. The application time of the instruction is about 600 minutes. Including the tests, the data collection process took 12 weeks and the chance to perform repeated measurements arose. The aim with these repeated measurements were to increase the reliability of the data and therefore results obtained through the data.

Application

The designed instruction was applied to the pilot group and then to the study group upon the update with the data obtained from the first application. The purpose of studying with two groups is to observe the shortcomings of a course with a group and eliminate them in another course with the other group, and by extension, to improve the reliability and validity of the instruction.

An expert of mathematics education as the advisor of the research made observations in some part of the courses. The video recordings were watched after the courses and feedbacks were received. If the observer participated in a course, feedbacks regarding the observations were received right after the course. Thus, necessary updates were done in the course content and flow. The updated content and course flow were reflected on the course to be performed with the study group. The applications including the tests were completed in the pilot group in seven weeks and in the study group in twelve weeks. In this context, the video recordings of all the applications were analyzed to reveal the objectives of each course, the content and the process. The actions performed are listed as a term summary as follows.

Instruction of Mathematical Literacy Question Choosing and Writing:

1. Making the participants realize the importance of the problem design, the starting point and importance of PISA
2.
    a. Turkey has scores below the OECD average in PISA assessments. What PISA assesses is what we need to know to identify our shortcomings.

   b. What does the purpose of measuring mathematical literacy make it obligatory in questions? "Context"
3. Analysis of PISA mathematical literacy questions and their solutions
4. Choosing the mathematical literacy questions out of the others and briefing about the distinctive features of the questions
5. Discussing and evaluating the questions written to be mathematical literacy questions
6. Writing mathematical literacy question during the course
7. Assessment-Evaluation I (Awareness, Choosing, Writing)
8.
   a. Discussing and evaluating the written questions and providing feedbacks about them
   b. Ensuring that the participants see different examples of different question types and reflect the distinctive features of these questions to the ones they will write
9. Forming the groups to allow for a longer period of question writing (question writing out of the class) and briefing about how the questions may be set forth
10. Discussing and evaluating the written questions and providing feedbacks about them
11. Interview (Can you choose or write questions in this field? What were the opportunities and challenges you faced in the process?)
12. Assessment-Evaluation I (Choosing, Writing)

The content of a course is presented in the appendices to provide an example. Other courses were also given in line with this exemplary course. Moreover, a few questions written by the participants are given in the appendices.

Data Analysis

Each participant was graded out of 100 points through the data obtained from the mathematical literacy awareness pretest which is among the data collection tools used in this resarch. Voice and video recordings of the courses were written in the first place during the process of applying, developing and evaluating the instructional design. The texts obtained were analyzed to demonstrate the objectives, content and processes of each course. Similarly, voice and video recordings of the interviews performed after the applications were written in the first place and the texts were subjected to a content analysis to reveal the opportunities and challenges encountered by the preservice mathematics teachers when choosing and writing questions. In this research, positive judgments used by the preservice teachers regarding the question choosing and writing during the interviews were described as opportunities while the negative judgments were accepted as challenges. Strauss and Corbin (1990) state that an inductive analysis, or a content analysis based on encoding, need to be conducted where there is no theory on which a phenomenon can be based a code-based content analysis and a prespecified coding (opportunity-challenge) (Çepni, 2012, p. 174) were performed for the analysis of the data collected through interviews within the scope of this research. In order to ensure reliability, the original phrase-concept pairings introduced following the analysis process were examined by a second researcher; researchers discussed and agreed on the divergent results. Table 7 presents the original statements of the participants and the paired codes (opportunity-challenge) based on a descriptive approach (Le Compte & Goetz, 1982).

Participants' scores of (i) awareness, (ii) choosing and writing were separately calculated out of 100 points. Study group's scores of awareness in the intermediary test and their pretest scores were compared. The aim with this was to determine the level of development in participant's mathematical literacy awareness. Distribution of the pretest scores was tested with the Kolmogorov-Smirnov test and they were found not to be exhibiting a normal distribution ($p=0.001<0.05$). Therefore, Wilcoxon test was used for the comparison (Büyüköztürk, 2011, p. 162).

There are 20 questions in the question choosing part of the intermediary test with 10 (x) of them being able to assess mathematical literacy while 10 of them not. There are 20 questions in the question choosing part of the posttest with 5 (x) of them being able to assess mathematical literacy while 15 of them not. The participants were asked to choose the question that could assess mathematical literacy. The scores obtained by the preservice teachers in each of these test out of 100 were calculated with this equation:

$$[(\frac{\text{Number of Questions Correctly Chosen by the Participant}}{x} - \frac{\text{Number of Questions Wrongly Chosen by the Participant}}{20-x}).100]$$

Next, a participant's question choosing score was calculated by averaging the scores of choosing question in the intermediate test and the posttest.

The questions written by the preservice mathematics teachers in the question writing part were evaluated in regard to (i) whether they were literacy questions, (ii) their originality, and (iii) their intelligibility.

- The first item (i) was a prerequisite for a question written to be accepted for evaluation. If a question did not meet this term (i), it was not accepted for evaluation for other items (ii and iii) either. The part was graded out of 30 points.
- The originality of a question was graded out of 40 points in consideration of being extraordinary, its characteristics and author's devotion.
    - The grading processes (i and ii) were conducted by the researcher and an assessment-evaluation expert who is also a mathematics teacher. In order to improve the reliability, another expert of mathematics education who is currently interested in PISA was also asked to evaluate the suitability of the questions for the criteria described above (i and ii). It was observed that other two evaluators gave high points to the questions which were found to be suitable by the third evaluator. Hence, the points given by the first two evaluators were arithmetically averaged.
- The intelligibility was graded out of 30 points in total. Since the target group of the questions written is 15-year-old students, they were made solved by a group of students at the age of 15 so that the intelligibility scores could be calculated. For this process, 10th-grade students of a Science High School in the Aegean Region were accepted to be participants. The aim at choosing a Science High School was to make an evaluation with students who could see questions from a critical point of view. In this evaluation,
    - The questions that could not be understand and solved due to text, figures or lack of data were awarded 0 point,
    - The questions that could be solved with little adjustments in text, figures and data were awarded 15 points,
    - The questions that could be understood and solved as they were written were awarded 30 points.

By this means, all the questions written by the preservice mathematics teachers were evaluated for whether being literacy questions out of 30 points, for originality out of 40 points, and for intelligibility out of 30 points. This way, a score out of 100 was obtained for each question written by the preservice mathematics teachers. More than one question was written by a preservice mathematics teacher during the instruction and in the exams. The writing score of a participant was calculated as follows: The participant's question graded with the highest score was identified as a result of the evaluations defined above and the score of this question was evaluated as the participant's score of the writing test.

Following all these processes, each preservice teacher's scores of (i) awareness, (ii) choosing and writing tests were calculated out of 100 points. The scores of the preservice teachers in the question choosing and writing tests are presented under findings in such a way that participants' levels of attainments are shown in percentages.

Results and Interpretation

The research findings are given in the order of the subproblems of the study below. *The first subproblem* refers to determining preservice teachers' levels of mathematical literacy awareness before the instruction. The results of the mathematical literacy awareness pretest applied before specifying the objectives to be included in the instructional design are presented in Table 5.

The second subproblem of the study required determining the extent to which preservice teachers' awareness was improved at the end of the PISA mathematical literacy instruction. The results obtained in the awareness part of the intermediary test applied to the study group are presented in Table 5. The results obtained by the groups in the awareness pretest are given in the same table for comparison.

Table 5. The Results of Mathematical Literacy Awareness Test out of 100 Points

Study Group	N	Pretest		Intermediary Test	
		$\bar{x}$	sd	$\bar{x}$	sd
	39	8,65	9,50	52,42	24,93

As can be seen in Table 5, the data obtained before the applications revealed that it was necessary to include general information and definitions of mathematical literacy concept measured in PISA in the instruction in a detailed way. Table 5 shows that study group's awareness of PISA mathematical literacy has increased significantly and exceeded the level of 50%. In addition, it was determined whether this difference between the pre- and post-application of the instruction was statistically significant. So, study group's scores of the awareness part in the pretest and intermediary tests were compared. Since these scores belonging to the dependent sample were not distributed normally, the Wilcoxon's Signed-Rank test was performed and the results are shown in Table 6.

Table 6. Farkındalık Puanlarının Karşılaştırılması

Study Group	Intermediary test – Pretest	N	Mean Rank	Mean Total	z	p
	Negative Rank	3	3,33	10,00	-5,304*	,000
	Positive Rank	36	21,39	770,00		
	Equal	-				

* *Based on positive ranks*

The analysis results show that study group students' mathematical literacy awareness statistically and significantly improved with the applications ($z = 5.304$, $p < 0.05$).

The third subproblem of the study required determining the extent of question choosing and writing skills in mathematical literacy acquired by the preservice mathematics teachers in the PISA mathematical literacy instruction.

Awareness of mathematical literacy was assumed in this study as a prerequisite of question choosing and writing skills which are more decisive in the field. Therefore, in consideration of participants' low scores in the awareness pretest, it was not needed to assess mathematical literacy question choosing and writing skills before the instruction.

Figure 2 includes the information on the distribution, the mean and standard deviation of choosing and writing scores obtained by calculating the arithmetic mean of each participant's *choosing and writing scores* are given in Figure 2.

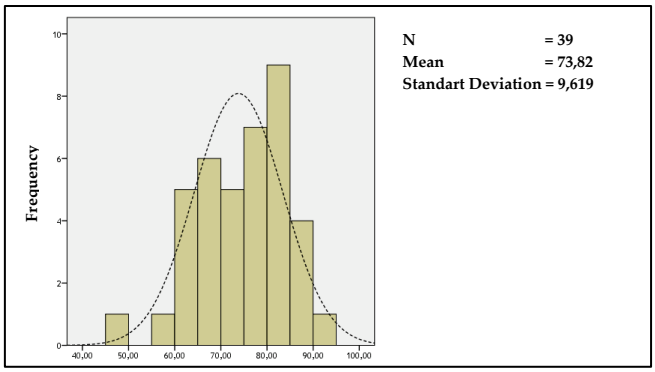

Figure 2. Distribution of Mutual Choosing and Writing Scores in the Study Group

According to Figure 2, the study group acquired these two skills at the level of 73.82%.

The fourth subproblem of the study required determining the opportunities and challenges encountered by the preservice mathematics teachers when choosing and writing mathematical literacy questions. The content analysis showed that the opinions of the preservice mathematics teachers gathered in five categories and some categories included the explanations regarding the opportunities and challenges. Explanations by the participants and related classifications are given in Table 7. Each sentence given in the finding column represents other findings which had the same meaning with it. For instance, the sentence expressed by a participant "It is not an easy task to write a question" represents other sentences expressed by other participants like "a difficult task" and "it takes a lot of thinking".

Table 7. Categorization of the Preservice Teacher Opinions in Accordance with their Goals

Category	No	Finding	Evaluation
What Kind of a Task is Writing a Question?	1	It is an enjoyable task to write something we have lived as a question	Opportunity
	2	PISA is not a thing that one would not be interested in	Opportunity
	3	Writing questions is a skill that will improve in time	Challenge
	4	One cannot write a question by contemplating it	Challenge
	5	It can occur to one when seeing an event outside (association of ideas)	Opportunity
	6	It is not an easy task to write a question	Challenge
Reasons for not Being Able to Write	7	Pace of life, KPSS exam, there is no time	Challenge
	8	I cannot write because I cannot attend to it	Challenge
	9	The questions are different from the problems we are accustomed to	Challenge
Problems Encountered when Writing Questions	10	I want to write original questions but I am thinking I have seen them somewhere before.	Challenge
	11	I mix them up with the logic questions (ALES, intelligence questions, etc.)	Challenge
	12	I noticed I cannot ask the questions about life	Challenge
Criticism about Content of the Instruction	13	Feeling the pressure of grades affects our question writing skill negatively	Challenge
	14	It would have been better if there had been topic titles	Challenge
	15	There was little guiding information in the course	Challenge
	16	I am learning a new thing in each course	Opportunity

Table 7. Continued

Category	No	Finding	Evaluation
Topics that may Present Resources for Mathematical Literacy	17	Shopping Energy consumption and diet Physical characteristics of the human body Production of food-beverage Movement on Earth and climate events Environmental pollution and precautions Technological supporters of daily life Efficiency (economic design, time planning) Laws of nature (free fall, effort distance, etc.) Setting or living environment organization (house, garden, park, etc.)	Opportunity

In the interview, the preservice teachers who stated that they could choose and write the mathematical literacy questions expressed the sentences which were accepted to be "opportunities" while other preservice teachers used the statements which were accepted to be "challenges". When examining the first, fifth and seventeenth statements as opportunities, it is seen that mathematical literacy being about life was featured whereas the interest of the preservice teacher was in the forefront when examining the second and sixteenth statements. Then, the quality of being about life in mathematical literacy question choosing and writing and the consequent interest come across as two important opportunities.

As challenges, the third and fourth statements are about how task of writing require long-term focusing, the sixth statement is about the difficulty of the task, the seventh statement is about participants' conditions of life, the eighth statement is about indifference, the ninth, tenth, eleventh and twelfth statements are about not going beyond the ordinary, and the thirteenth, fourteenth and fifteenth statements are about the content and process of the instruction. It is seen here that the challenges were due to the content and process of the instruction and various precautions can be taken against the challenges in the thirteenth, fourteenth and fifteenth statements because these are variables that can be intervened with. The explanations of these precautions are presented under the recommendations.

Discussion, Conclusion and Recommendations

As one of the objectives specified by the Ministry of National Education (MEB, 2013) for the primary education is providing students with the basic mathematical knowledge and skills which can be needed in other disciplines and in daily life, it seem a remarkable result that the preservice mathematics teachers have a low level of awareness of the PISA mathematical literacy. Tekin and Tekin (2004) concluded that the preservice teachers had moderate levels of mathematical literacy whereas Güneş and Gökçek (2013) found the levels to be above the moderate. Although these studies demonstrate that there is no problem regarding the question solving in mathematical literacy, these studies revealed that the preservice teachers have no awareness of the basis of the questions they solved. Gürbüz (2014, p. 90) discovered a relevant result and reported that the mathematical literacy education led to an increased awareness. The lack of awareness among teachers, as revealed by Gürbüz's (2014) research, has proven the importance and requirement of the instruction applied in the present study.

Another result of this study is that the preservice teachers had trouble with writing questions beyond the customary question patterns. In the studies on problem writing in the literature (Silver, Mamona-Downs, Leung, & Kenney, 1996; Silver & Cai, 1996; Cai & Hwang, 2002; Akay & Boz, 2010; Kar, Özdemir, İpek, & Albayrak, 2010; İskenderoğlu, & Güneş, 2016, p. 46), the participants were asked to stick to the given problem situation and reproduce new problems by changing certain conditions and certain quantitative data. These studies have focused on testing or determining the existence of a relationship between problem writing and various variables (problem solving, self-efficacy, etc.). The

present study asked the preservice teachers to write problems during "a mathematical literacy training". Thus, the preservice teachers acquired the basic knowledge and skills of mathematical literacy in this process and were able to discuss their example problems within the group. Thus, the study can serve as a model in the instructional planning related to mathematical literacy problem writing. With this aspect, this study differs from other problem writing studies.

Altun and Bozkurt (2017) have categorized mathematical literacy questions into six components through factor analysis. These components include making algorithmic operations, mastering rich mathematical content, mathematical inference, developing mathematical proposals and interpreting a developed proposal, understanding the mathematical equivalence of real world situations, and understanding the counterpart of mathematical language in life. In each of these six components, or especially in the components in which the students are foreign, it is also possible to write questions for more specific purposes in the field of question writing.

It was also found in the study that there were two factors which made the preservice teachers be interested in mathematical literacy question choosing and writing. One of these factors is that the preservice teachers found it to be an "enjoyable task" to turn what they experienced and saw into questions. The other one is that they had been participated in such a study for the first time. It was concluded that these two factors increased the interest and therefore were described by the preservice mathematics teachers as an opportunity during the process of mathematical literacy question choosing and writing (Table 7).

Altun and Akkaya (2014, p. 34) have reported that the lack of association between the instruction and real life was considered a problem by teachers. This study has found that real-life connectedness as indispensable part of the concept of mathematical literacy, which refers to the nature of mathematical problems based on real-life contexts, was considered an opportunity by the preservice mathematics teachers in mathematical literacy question choosing and writing. Thus, the present study and other studies can help to overcome the problem revealed by Altun and Akkaya (2014, p. 34). With the results of both studies being in parallel, it was revealed that the instruction design in this study and the mathematical literacy questions could be utilized for remedying the shortcoming mentioned in the former study.

Ellerton (1986) stated in the study performed with 11-13 age group students that a well-planned act of problem writing was a characteristic of mathematics students with high performance. In this study, how the action of mathematical literacy question writing requires a long-term focusing and the difficulty was found to be a challenge by the preservice teachers. Despite having different samples, the two studies are in parallel with each other.

There are a considerable volume of research on mathematical literacy that statistically illustrate the existing situations and examine various variables that may cause such situations. In this study, the results obtained by Turkey in the field of mathematical literacy which is assessed by PISA were evaluated through the factors in the instructional process and a contribution was made through those factors in an effort. It was taken into account that the most important factor in the instructional process is teacher and the auxiliary materials which teachers consult to most are course books (İskenderoğlu & Baki, 2011). It was ensured with the applications carried out that the preservice mathematics teachers reached a certain level of competency in mathematical literacy question choosing and writing. In this way, it is possible to overcome the highlighted shortcomings of textbooks (Altun & Akkaya, 2014; Çakır, 2009; Dede & Yaman, 2005; İskenderoğlu & Baki, 2011) through the teacher candidates trained within the scope of this study and individuals who will be trained in similar studies.

İlbağı (2012) have found that the majority of students could not answer the mathematical literacy questions of higher proficiency levels and could answer half of the questions of lower and moderate proficiency levels. The fact that upper-level mathematical literacy questions are not adequately included in course books might be a reason for the result achieved by İlbağı (2012). Because İskenderoğlu and Baki (2011) state that course books are the most consulted materials in mathematics

classes. Hence, questions that measure higher proficiency levels can be produced by training teachers who can choose and write mathematical literacy questions through the instruction reported at the end of this study.

The literature studies on PISA and mathematical literacy are mostly case studies such as studies carried out Silver and Cai (1996, p. 524), Cai and Hwang (2002, p. 404), Kar et al. (2010, p. 1578). This study has demonstrated a case in the area of PISA and mathematical literacy and designed, applied, developed and reported possible solutions. In other words, from the aspect of purpose, method and products obtained, the study is distinguished from other studies on PISA, mathematical literacy and problem writing.

The reported instructional design and the questions written by the preservice mathematics teachers are the two important products of this study. The instructional design stands out among other studies in the literature due to helping preservice mathematics teachers write more original questions. Furthermore, these questions produced by the preservice teachers in the study were evaluated by the tenth-grade students who are the target group of the questions. This action which was performed within the frameworks of the research method is in parallel to the item paneling process defined by PISA as the first step of question development process in OECD (2005). Thus, this study seems to provide a database for future studies.

Recommendations

The recommendation offered in this study are classified under two sub-headings including recommendations for instructional practices and recommendations to researchers.

Recommendations for Instructional Practices

More time can be devoted to question writing based on the statements of the preservice teachers such as "One cannot write a question by contemplating it. It can occur to one when seeing an event outside." The instruction was given like a unit in a course within this study; however, it can be suggested that mathematical literacy is included as a course in related programs in consideration that it has the scope which can present course content in a term. By this mean, it can be ensured that preservice teachers look at events from this perspective for question writing throughout a term.

The majority (93 %) of the Turkish sample of PISA survey is composed of secondary school students. However, it may be too late to introduce the concept of mathematical literacy to students at 9th and 10th grades. To this end, it should be ensured that teachers who are or will be serving in primary education acquire the awareness of mathematical literacy and gain the competency of question choosing and writing which are more advanced skills. Therefore, besides in-service trainings, courses regarding the mathematical literacy can be included in the undergraduate and postgraduate programs of Primary Education and Secondary Education Mathematics Teaching.

The mathematical literacy problems written by the preservice teachers and solved and evaluated by the 10th-grade students in this study and the questions that have shortcomings as emphasized in the literature (İskenderoğlu & Baki, 2011; Çakır, 2009) can be included in the course books and used in teaching processes after they are classified and improved. Based on the fact that the students found questions interesting, these questions can be utilized for various significant purposes such as, motivating students, and creating a discussion platform in the classroom except for the assessment-evaluation purposes.

The four categories established based on the content analysis and presented in Table 7 can shed light on interview questions to be prepared in similar future studies. These categories include "What kind of task is problem writing? What are the reasons for the inability to write problems? What problems do you encounter in problem writing?, and Do you have any criticism about the content of the instruction?"

Problem writing is a mathematical goal. This study asked the preservice teachers to sample possible life events using four categories (personal, occupational, social, scientific) determined by PISA in order to frame the context of problems. This method was perceived by teacher candidates as a very general expression and a difficulty in problem writing. Therefore, experienced life events and limited content strands can be used as examples to further specify problems. The categories given in Table 7 seems to guide future studies on problem writing. Just as the method used Aydın's (2014, p. 262) study, representations such as life-nature paintings for this limitation process can be used to help preservice teachers to think. Future studies can use visual representations (photographs, pictures, videos, etc.) in addition to limited content strands.

Recommendation to Researchers

The sequential actions described in the method of this study are listed under Heading Application. Information on objectives, contents and processes of a course presented in Appendices are available and reported for each course carried out during application. Programing the applications for creating the mathematical literacy awareness and developing the question choosing and writing skills to form the content of a course in a term based on all these data should be regarded as the next step of this study. This way, the instruction can be expanded one step further and turn into an instructional program. Projects to serve to this purpose can be commenced. Hence, it is anticipated that the study will contribute to the field of teacher training.

The adaption of the instruction to real life events is an issue of mathematics and other fields of knowledge. From this perspective, similar studies can be conducted on science literacy, reading skills and social studies as well as mathematical literacy in teacher education.

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Appendix 1. Study Group: Course 7

Course Code:	uu_6_ 22.05.14
N.	35
Duration (min.):	66
Auxiliary Materials:	DVD Rental 1 and 2, Cable Television 1 and 2, Apartment Purchase, Sauce, Seeing the Tower, Car Drive 1, 2 and 3 (among the questions used and released by PISA)

Objectives

- Solving the PISA questions on the worksheet given in the course 6 and evaluating them in terms of mathematical processes
- Students explain the results they achieved after their evaluation of mathematical processes
- Dwelling on the "interpretation" processes due to its short name, drawing the attention to the longer name (interpreting, applying and evaluating the mathematical outputs) and making the meaning of this noticed on the cycle model
- Briefing about in regard to which criteria the problem they wrote will be evaluated
- Question writing in groups
- Managing the question writing process by providing students with directing and guiding feedbacks

Content and Process

- The answers given by the students to 10 PISA questions distributed in the course 6 and evaluated by the students in terms of context, mathematical process, and mathematical content were evaluated.
    - For the students to be able to remember their answers, the papers they marked in the sixth week were distributed back to them.
    - Each question was discussed in 3 dimensions (content, process, and context).
    - Where the same answers were given to the same questions, the students were asked to explain on what they based their answers. The questions correctly classified by all the groups were not dwelled on. The details on the process are given below:
    - Firstly, it was noticed on students' papers that the Apartment Purchase question had been placed in the "interpretation" process by many groups.
    - The question asks to determine the variables so the area can be calculated. It was established that this action had been stated as "Determination of a real-life problem's mathematical appearance and problem's significant variables" in the explanations on the mathematical process and the situations had been included in the process of formulating the problems mathematically.
    - The solution of the "Seeing the Tower" problem, another question in which different classifications had been made, was also addressed.
    - One the groups stated "We thought it was interpretation." and the feedback "Show me a single mathematical output here, and I'll say it is interpretation" was provided. Because the mathematical process described with the short name "interpretation" is the process of interpreting, applying and evaluating the mathematical outputs. It is thought that the problem was caused by the fact that the short names for the processes had been given at the very beginning. Indeed, this perceptive problem due to using the short name of this process was not observed in the pilot group.
        - The longer names for the mathematical processes were remembered once again.
        - Through the products achieved at the end of each process in the cycle model, it was explained that was meant with the word "interpretation" to refer to the longer name was the process of "interpreting, applying and evaluating the mathematical outputs."

- Following these explanations, the question "Is there any mathematical output?" was directed to the whole classroom. Many students answered "no." Upon the explanation "We need to write such a question that it will make one see how many faces there are whichever way they look at it." a student gave the answer "formulating" right away. The thing to be noticed here was to realize which variable would determine the number of faces one can see; the rest of it was to apply that for the five points. Hence, the last answer given by the student is right.
- All the students gave the answer "interpretation" for the Car Drive 1 and 2 questions The graphic and the data on it were the mathematical outputs regarding a section taken from an event. It was clearly asked to interpret these outputs in these two questions. So, the groups gave the right answer.
- The groups gave the answer "using" for the Car Drive 3 question. Here, it was asked to calculate the area under the graphic. This required using the formula "Distance=Speed x Time". Therefore, the answer given by the groups was right.
- By this means, attention was drawn to the differentiations among the mathematical processes through the problems on the worksheet.

- An introduction was made for question writing.
  - Since the students had encountered many examples of PISA questions to date, the next part of the course continued with question and answers. Upon the question "What was a must for the questions?" one of the students gave the answer "being about life." The following explanations were made: "What makes a mathematical problem about life is context." There should be contexts that one is likely to face in their lives. Measuring the unlikely contexts is less valuable for mathematical literacy."
  - A student's question "Are we free when writing questions?" was answered with the statement "You can write them in groups of 2-3 people." Blank pages were distributed to the students.
  - The question "We've come across interesting questions like Revolving Door 2 and Seeing the Tower. What attracted attention to such questions?" One of the students gave the answer "curiosity, feeling the need." Following the explanation "Another point to consider is that a question should be arousing the curiosity of the student." it was stated that they could write mathematical literacy questions without the limitation of subject, age, content and context.
  - It was explained that the problems they wrote would be evaluated with regard to
    - Whether they can be mathematical literacy questions,
    - The context of questions being about life
    - Intelligibility and originality (making feel the need, arousing curiosity, being original).
- Upon the explanations, the students started to study freely in groups for question writing.
  - It was observed that the students started exchanging ideas. In the first minutes, it was seen that they generally concentrated on deciding a context.
  - The students firstly thought of contexts regarding cost,
  - and secondly a context about calculating how a house catch the sun.
  - The students were warned about the fact that a long situation was not requested in the text part of the questions.
  - Visiting the groups, opinions were expressed on the contexts of the question they were trying to shape and the ideas were discussed with them. Upon the request of a group, the question they had written was read by the researcher. Next, the question was discussed with the students. On the other hand, how willingly a student explained and solved the question naturally showed that the student remarkably satisfied with this task. The process of the solution was discussed subsequently.

- The context which was in the design stage and the solutions of the questions, if they could write, was discussed. The discussions on the context rather included the sentences orientating them towards providing the context with the quality of being about life.
  - Each group experienced important discussions and exchanges of ideas to succeed in the task.
- It was declared in the classroom that two good questions had already started to shape 15 minutes after question writing had begun. The two questions shaped in this course are presented below.

  Example 1: Two brothers are supposed to share a land of 100 m^2. The younger brother tells his elder brother "The land you can enclose with the thread wrapped around this reel belongs to you, the rest of it is mine." The length of the thread around the reel is 28 m.

  a) Do you think the elder brother should accept the offer?
  b) How much land can take the elder brother at most?
  c) How should they shape the threat if they want a fair share of the land?

  Example 2: Gamze goes to a printing house to have invitation cards of her oncoming wedding printed. The owner of the printing house explains that the invitation cards are charged in 3 different packages and gives Gamze the card on which the table below is printed.

Package name	Number of Invitation Cards in the Package	Package Price
A	1	1 liras
B	100	90 liras
C	300	250 liras

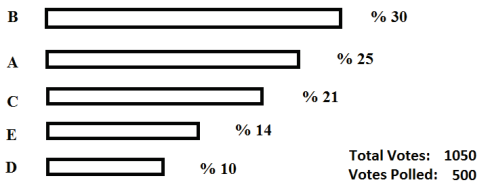
  Accordingly;

  a) How many of the packages each should Gamze who wants 170 invitation cards for the lowest cost?

  a) How many of the packages each should Gamze for the lowest cost if she wanted 170 invitation cards?
- The groups were visited to read questions and guiding explanations were made to the students with the questions. It was noticed that these explanations concentrated especially on making the context about life.
- A group doing a good job (that wrote the thread question) cooperated to solve and evaluate their question. Firstly, they explained their solution and then continued to discuss over the question.
- Following this period of about 40 minutes, it was requested that names of the group members were written under the questions and the papers were collected.

Appendix 2. Examples of Questions Written by the Preservice Teachers

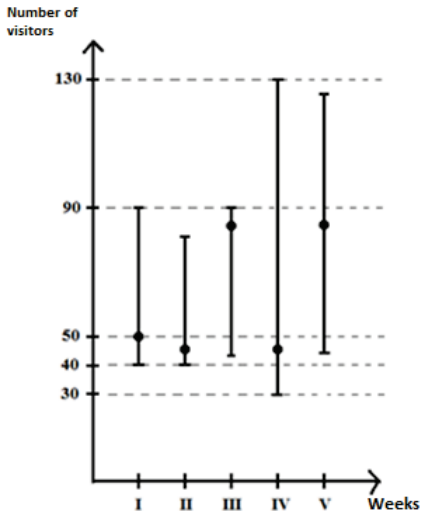
Example 1:



The graphic shows the distribution of the votes polled by the political parties in the 2014 local election of Üzümlü Municipality. Vote counting is in progress. The party polling the highest vote will win the election.

If the votes continue increasing at the same rate, when at least how many votes are polled the party B is sure to win the election?

Example 2:



The graphic shows the information on the 5-week number of visitors that passed through the ticket office of a museum open 7 days of a week. Bottom ends of the bars show the number of visitors on the quietest days, upper ends show the number of visitors on the busiest days, dots show the daily average number of visitors in the related week.

Accordingly, which one of the following cannot be the total number of visitors in any week?

A)273 B) 308 C) 350 D)560

Example 3:

A carpet factory advertises its carpets and sells it to the public with the help of salesmen. The number of carpets sold by three salesmen of the factory is given below.

	Week 1	Week 2	Week 3	Week 4	Week 5
Akın	11	12	12	11	9
Bora	12	9	8	16	10
Cevdet	3	25	5	6	16

Which salesman's sale is more consistent? Explain why.