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An analysis of the interaction between mathematical literacy and financial literacy in PISA*

Abdullah Ozkale [a] and Emel Ozdemir Erdogan [b]

[a]Department of Finance Banking and Insurance, Keciborlu Vocational School, Isparta University of Applied Science, Isparta, Turkey; [b]Faculty of Education, Department of Mathematics and Science Education, Anadolu University, Eskisehir, Turkey

ABSTRACT

Nowadays, individuals are expected to be literate in different areas. Mathematical literacy and financial literacy are among them. Mathematical literacy has been evaluated in PISA since 2000 while financial literacy has been included in PISA since 2012. Based on the idea that there is a close relationship between these literacies, in this study PISA mathematical and financial literacies questions were analysed in order to identify the interaction between them. For the analysis, the interaction model of mathematical and financial literacies model, which was worked out to examine the interaction between these literacies, was used. A total of 17 PISA questions including 13 mathematical literacy questions released since 2002 and four financial literacy questions released since 2012 were analysed. The results of the study show that literacy questions have potential to support conceptual and process skills for both literacies although PISA documents state that financial situations are only a context for mathematical literacy and that mathematics, is only a tool for financial literacy. This result strengthens the idea that financial literacy education can be easily integrated into mathematics courses, at least for 15 year old students.

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Mathematics education; mathematical literacy; financial literacy; PISA; OECD

1. Introduction

Literacy is a competency that enables people to apply their knowledge and skills to everyday life in order to identify, interpret and solve problems in a variety of situations (Organization for Economic Cooperation and Development Countries [OECD], 2005, 2016a). Mathematical literacy and financial literacy are two important literacies in education. The concept of mathematical literacy specifically involves understanding mathematics, doing mathematics, and being interested in mathematics (Van de Walle et al., 2007). In Programme for International Student Assessment [PISA] 2018, mathematical literacy is defined as an

CONTACT Abdullah Ozkale abdullahozkale@isparta.edu.tr Department of Finance Banking and Insurance, Keciborlu Vocational School, Isparta University of Applied Science, Isparta 32700, Turkey
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> 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. (OECD, 2019, p. 75)

As for the concept of financial literacy, it involves being able to use knowledge and skills to make proper financial decisions with confidence (Lusardi, 2012; OECD, 2016b). In PISA 2018, financial literacy is defined as

> knowledge and understanding of financial concepts and risks, and the skills, motivation and confidence to apply such knowledge and understanding in order to make effective decisions across a range of financial contexts, to improve the financial well-being of individuals and society, and to enable participation in economic life. (OECD, 2019, p. 128).

Financial literacy is not a qualification specific to the field of finance, it is a set of skills that is of interest to everyone and affects all our lives (Shim et al., 2010). The basic skill in financial literacy is to make conscious choices (Aprea et al., 2016; Financial Literacy and Education Commission [FLEC], 2016). In the modern world, access to financial institutions has intensified. As a result, financial literacy affects individuals and their families as well as society, financial institutions, and social policies (Hoadley et al., 2015; Remund, 2010).

Many countries consider financial literacy as a twenty-first century skill[1] (Lusardi, 2015) and, some countries (e.g. Canada, Singapore, and the United States) have developed initiatives to integrate financial literacy into their education systems. Through these initiatives, led by OECD, financial literacy is either organized as a separate course or integrated into related courses such as mathematics (Ministry of Education of Ontario, 2010). Sole (2014) argues that mathematics educators should pay more attention to financial literacy so that it can be integrated into mathematics courses. OECD (2016b) recognizes mathematical literacy as a prerequisite for financial literacy. In addition, skills in mathematical literacy such as reasoning and comparing have been noticed to be effective when making financial decisions (Lusardi, 2012). Furthermore, studies examining the relationship between mathematical literacy and financial literacy have found that competencies in both literacies are mutually supportive (Sole, 2017); they have common process skills and; interaction between them should occur more often in curricula (Ozkale & Ozdemir Erdogan, 2020). Thus, the relationship between mathematical literacy and financial literacy is underlined as well in research paper as official documents. However, the interaction between two literacies has not yet been specifically investigated based on the educational data. Therefore, the aim of this study is to provide an analysis of mathematical literacy and financial literacy questions in PISA from the perspective of this interaction.

2. An overview of mathematical literacy and financial literacy in PISA

Held since 2000, PISA is an international examination conducted by the OECD that measures real-life skills of students aged around 15 years old. PISA includes mathematical, scientific, reading literacies and financial literacy (OECD, 2016b). Member of OECD and several partner countries have attended PISA. PISA have carried out every three years, following which OECD has analysed PISA data in detail and has shared findings. Accordingly, PISA has provided a resource for whom wishes to compare the performance of educational systems in the defined areas (OECD, 2019).

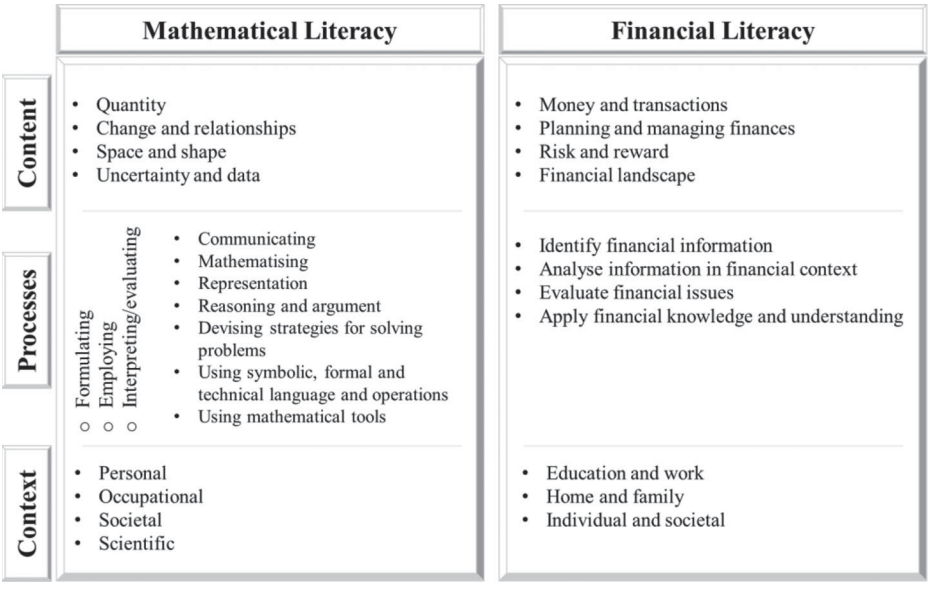

Figure 1. Components of mathematical and financial literacies framework in PISA (OECD, 2016a).

The OECD (2017) underlines that social permeability is increasing, families and individuals have to establish a new order considering their financial situation, and this also affects the social order. Therefore, OECD has pioneered financial literacy education initiative since the early 2000s and has incorporated financial literacy into PISA. The main objective of PISA regarding financial literacy is to measure the skills of students whose financial responsibilities increase over time. These skills include problem solving and understanding of financial situations and financial concepts in different contexts such as home, work, school, and social life (OECD, 2016b).

In PISA, a common framework (content-processes-context) is used for all literacy areas. The content means the area of selected concepts, the processes mean ways and techniques students can apply to solve the questions and the context means the domains of the life from where the questions are drawn. The components of the framework for mathematical literacy and financial literacy are presented in Figure 1. For mathematical literacy, the content is composed of four components which are *quantity*, *change and relationships*, *space and shape*, *uncertainty and data*. Quantity refers to numbers and operations; change and relationships refers to algebraic structures, space and shape refers to geometrical concepts, uncertainty and data refers to structures involving probability and statistics. Three processes *formulating, employing, interpreting/evaluating* are defined in PISA with seven fundamental capabilities for mathematical literacy: communicating, mathematising, representation, reasoning and argument, devising strategies for solving problems, using symbolic, formal and technical language and operations, using mathematical tools. Four components are defined for the context of mathematical literacy: *personal, occupational, societal and scientific*.

For the financial literacy, the content also includes four components: *financial transactions*, *financial management and planning, risk and rewards* and *financial landscape*.

These key financial concepts form nested financial situations in PISA questions. For example, in the travel to a different country, the tasks that need to be mastered are currency exchange (*financial transactions*), spreading expenditure throughout the period of travel (*financial management and planning*), and understanding the value of currencies (*financial landscape*) (OECD, 1999, 2014). For the processes, students are required to *identify financial information*, to *analyse information in financial context*, to *evaluate financial issues* and to *apply financial knowledge and understanding*. Three components are defined for the context of financial literacy: *education and work; home and family; individual and societal*.

3. The interaction model of mathematical and financial literacies [IMMFL]

Two main approaches adopted for the acquisition of the financial literacy competencies in school are either providing a separate financial literacy course or integrating financial literacy into related courses such as mathematics. Addressing financial literacy in mathematics teaching opens up a wide area for mathematics literacy, and it is also valuable for the integration of financial literacy as a twenty-first century skill into the education system (Lusardi, 2015). IMMFL was worked out as a model to examine the interaction between both literacies from the perspective of mathematics education. It is aimed that the model can be used in task design and analysis, textbook reviews and curriculum development studies to be carried out especially for the integration perspective of financial literacy into mathematics education (Ozkale & Ozdemir Erdogan, 2020). Within the scope of this study, this model was used in the analysis of PISA mathematics and financial literacies questions. The IMMFL is shown in Figure 2.

Adapted from the PISA literacy framework, *content, processes and financial context* were named as the dimensions of the model and they were defined based on the research about mathematical and financial literacies.

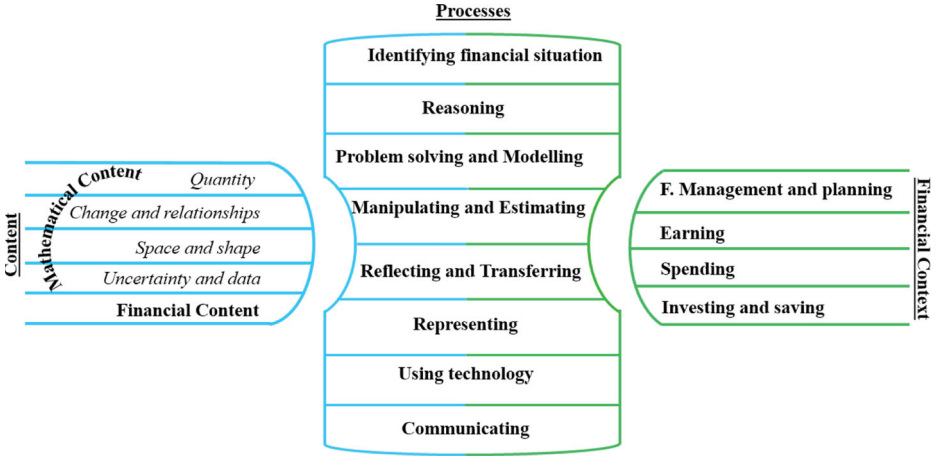

Figure 2. The interaction model of mathematical and financial literacies (IMMFL) (Ozkale & Ozdemir Erdogan, 2020).

Content It consists of mathematical contents of PISA for mathematical literacy (*quantity, change and relationships, space and shape, uncertainty and data*) as well as financial content containing financial concepts.

Processes It means how students should approach a problem using their mathematical and financial knowledge, and skills that are required to reach a solution. The processes of IMMFL were grounded on the processes in mathematical and financial literacies literature (Geiger et al., 2015; Kilpatrick, 2001; Lusardi, 2015; OECD, 2016b; Pugalee, 1999) and on mathematical processes standards and competencies (Common Core State Standards Initiative, 2010; National Council of Teachers of Mathematics [NCTM], 2000; National Research Council [NRC], 2001). Finally, the processes were composed of *identifying financial situation*, *reasoning, problem-solving and modelling, manipulating and estimating, reflecting and transferring, representing, using technology* and *communicating*.

Financial Context The interaction that IMMFL aims to reveal includes the identification of mathematical knowledge and skills needed to make financial decisions. Therefore, financial situations reflecting financial experiences of individuals in everyday life were emphasized in terms of the context (Lusardi & Mitchell, 2014; Shim et al., 2010). Finally, four components were identified: *financial management and planning, earning, spending, investing and saving*.

In this study, with an analysis of mathematics and financial literacies questions using the IMMFL, it is aimed to show that the targeted relationship between mathematics and financial literacies goes beyond the use of financial context in mathematics literacy and the use of four mathematical operations in financial literacy. Through IMMFL answers to the following research questions were sought: What content, processes and context do PISA financial and mathematical literacies questions include? How the interaction between content, processes and context does occur in PISA mathematical and financial literacies questions?

4. Method

About 80 mathematical literacy questions released since 2002, and four [2] financial literacy questions released in 2012 and 2015 were analysed. Finally, 17 questions were found to be included in this study. Depending on the financial context, 13 of the mathematical literacy questions were found to be related to financial literacy (OECD, 2007; 2013; 2014) and the four released financial literacy questions were included in the study (Table 1).

As shown in Table 1, the selected mathematical literacy questions are related to financial literacy through real-life situations relevant for 15-year-old students (for example, ordering

Table 1. PISA analysed questions.

	Mathematical literacy													Financial literacy			
No	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17
Question group	Exchange Rate	Postal Charges	Pizzas	Skateboard	Exports	Payments by Area	Sailing Ships	Which Car?	Power of The Wind	Mp3 Players	Holiday Apartment	DVD Rental	Selling Newspapers	Invoice	Shares	Pay Slip	New Offer

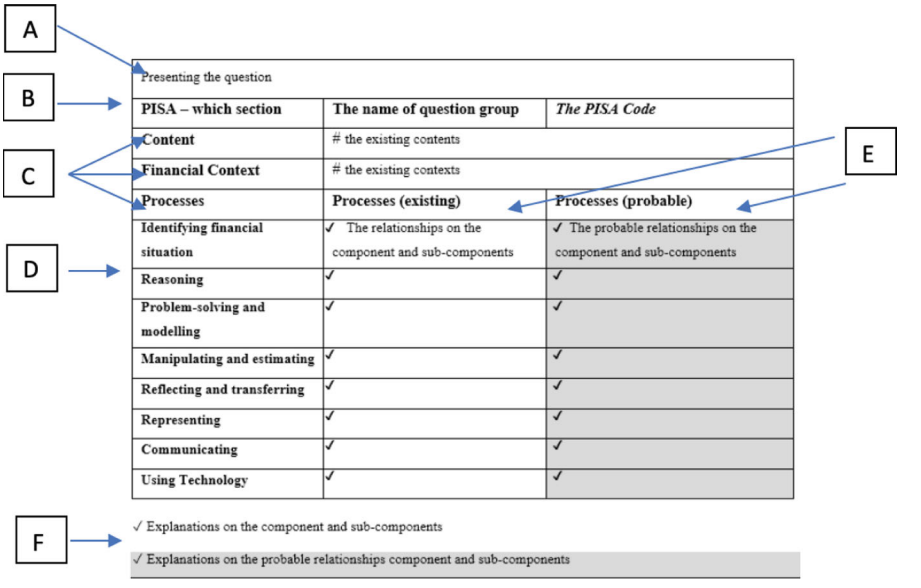

Figure 3. The checklist based on IMMFL.

a pizza or buying a skateboard) or situations they might meet in the future (for example, selecting the most appropriate vehicle or addressing the factors affecting house prices) or situations they might make face in professional life (for example, building a wind power station or developing a wind power support for tankers).

The released financial literacy questions include the ability to read and understand stock graphs, invoice, and pay slips as well as problems based on the financial contexts of earning, spending, financial management and planning, such as the *New offer* (Q17) question. In these questions, both mathematical skills such as calculating and reasoning and an understanding of financial concepts are required.

The analysis consisted of three steps. In the first step, a descriptive analysis for each question was carried out through a checklist based on the IMMFL (Figure 3).

In the checklist, two first sections inform about the question text (A) and the question identity (type of literacy, name and code) in PISA (B). Then, the dimensions of the IMMFL (content, processes and financial context) are included (C). The checklist also includes all the components and sub-components of the processes (D). In addition, the processes are to be examined in two columns as existing and probable ones (E). The probable processes refer to the diversification and enrichment that can be carried out without altering the basis of the questions. In order to include in the checklist all the information related to the questions, a last section where sub-component of the processes will be explained is provided (F).

In the second step, relationships between components and the dimensions were analysed using statistical data. This analysis was based on the frequencies of relationships and related criteria. Tables and diagrams containing frequencies and percentages were used to present the results. As literacy questions were selected on the basis of their financial content, in this study financial content component was not taken into account in the analysis. The third step consisted of a question-based analysis of the statistical results. Through an

analysis of the structure of questions, this step focused on determining how the interaction between the dimensions and components of the IMMFL occurs.

4.1. An example of the mathematical literacy questions: exchange rate

In the *Exchange Rate (Q1)* question, a context was created based on the concept of parity. Mei-Ling, who goes to South Africa as an exchange student, wants to change her Singapore dollars (SGD) to South African rand (ZAR). When she returns, she changes the remaining ZARs back into SGD. The question illustrates the process of bi-directional change of currencies. In the question, an explanation is required regarding the change between the values of the two currencies in terms of parity after a certain period of time. Thus, the aim is to test whether students can understand the change in parity caused by the changing values of these currencies. In the question, there are no transactions using money. Furthermore, this change does not involve any investment or saving. The question focuses on financial management in terms of parity between national currencies. Therefore, the financial context of the problem was defined as *financial management and planning* within the framework of IMMFL. The analysis carried out through the checklist for the *Exchange Rate (Q1)* question is shown in Figure 4.

Because the question focuses on exchanging and revaluing *(change and relationships)* currencies *(financial content),* the first process skill is *identifying the financial situation* within the framework of IMMFL. In the question, there is an emphasis on change in foreign currency and its value. Purchasing power is also added as a probable process in the checklist for *Exchange Rate (Q1)* (Figure 4). Thus, an easier and more applicable understanding can be achieved through comparison of currencies. A comparison of unit price of the same products for two different currencies in two different countries can be given as an example. When comparing the currencies, students are asked to use proportional reasoning, perform operational skills, and demonstrate conceptual understanding (Kilpatrick, 2001). These were noted in the checklist of this question as the sub-components of reasoning (Figure 4). Moreover, students may be asked to evaluate the factors that affect the value of a currency. Individuals may struggle when comparing two currencies. For example, the question 'How many American dollars would 100 Euro be?' may be answered incorrectly. If people are not familiar with these currencies, the comparison may be more difficult (Sayinzoga et al., 2016). In this process, estimations can be supported by calculation. The reciprocal change of currencies can add flexibility to the estimating process. The fundamental aim of the question is to reflect quantitative skills in understanding changing currencies. In the checklist (Figure 4), this was noted as using the quantitative operation skill for exchange currency in reflecting and transferring process. A person who perceives the basic operations involved will acquire the ability to monitor both directions. In this way, he will be able to track the effect of changes in currencies and to interpret figures and graphics on these changes more effectively.

4.2. An example of the financial literacy questions: new offer

In the *New offer (Q17)* question, calculations and interpretations are to be made on the compound interest payment of a loan withdrawn from the bank. First, calculations of the two loans should be made, following which the advantages and disadvantages of the loans

Exchange Rate

Mei-Ling from Singapore was preparing to go to South Africa for 3 months as an exchange student. She needed to change some Singapore dollars (SGD) into South African rand (ZAR).

Question 1: Mei-Ling found out that the exchange rate between Singapore dollars and South African rand was: 1 SGD = 4.2 ZAR Mei-Ling changed 3000 Singapore dollars into South African rand at this exchange rate. How much money in South African rand did Mei-Ling get?

Question 2: On returning to Singapore after 3 months, Mei-Ling had 3 900 ZAR left. She changed this back to Singapore dollars, noting that the exchange rate had changed to: 1 SGD = 4.0 ZAR How much money in Singapore dollars did Mei-Ling get?

Question 3: During these 3 months the exchange rate had changed from 4.2 to 4.0 ZAR per SGD. Was it in Mei-Ling's favor that the exchange rate now was 4.0 ZAR instead of 4.2 ZAR, when she changed her South African rand back to Singapore dollars? Give an explanation to support your answer.

PISA - ML	**Question group:** Exchange Rate	***No*** *M413Q01-2-3*
Content	# Change and relationship	
Financial Context	# Financial management and planning	
Processes	**Processes (existing)**	**Processes (probable)**
Identifying financial situation	✓ Currency exchange ✓ Currency value	✓ Purchasing power
Reasoning	✓ Comparing ✓ Conceptual understanding ✓ Procedural understanding ✓ Proportional reasoning	✓ Evaluating
Problem-solving and modelling	✓ Problem-solving ✓ Algebraic modeling	
Manipulating and estimating	✓ Estimating ✓ Calculating	✓ Calculating ✓ Manipulating
Reflecting and transferring	✓ Using operating skills for exchange currency	
Representing	✓ Symbolic representation ✓ Linguistic representation	✓ Symbolic representation
Communicating	✓ Explaining	✓ Presenting
Using Technology		✓ Calculator

✓ Comparing: The comparison of values of these currencies

✓ Problem-solving: Problem-solving on the exchange currency

✓ Calculating: Metric conversion

✓ Explaining: It is expected that she/he can explain the situation about the conversion using her/his mathematical skills

✓ Purchasing power: The comparison of charges of the same products in different countries can be examined.

✓ Evaluating: The positive or negative results in the case the value of a currency is high or low.

✓ Calculating: The conversions on Zar/Dollar and Dollar/Zar can be used.

✓ Manipulating: A table can be used in the currency conversion in order to compare these currencies.

✓ Symbolic representation: The symbols of the currencies can be related to mathematical symbols like a fraction line. This proportion is important the correct comparison of these currencies. A table can be used for the correct results.

✓ Presenting: A table, presentation or a board can be prepared for the explanations.

Figure 4. The checklist for Exchange Rate (Q1).

should be compared. The analysis performed through the checklist for *New offer (Q17)* is presented in Figure 5.

In the *New offer (Q17)*, financial management and planning, investing and saving contexts are presented in a loan situation. Change and relationships between quantitative values constitutes the general content of the question. The question primarily requires the ability to understand the financial situation surrounding the use of loans. In particular, the effect of compound interest rate, number of periods, and principal on the loan are to be examined. The question also requires estimating process to be conducted through calculation. Moreover, comparisons are to be made between two loans and more than one credit calculation are required. In these calculations, algebraic modelling should enable students to examine the effects of parameters of the credit. Symbolic representation should also be observed, as process, through the use of mathematical notations. In addition, students are

New Offer

Mrs Jones has a loan of 8000 zeds with First Zed Finance. The annual interest rate on the loan is 15%. Her repayments each month are 150 zeds. After one year Mrs Jones still owes 7400 zeds. Another finance company called Zed best will give Mrs Jones a loan of 10 000 zeds with an annual interest rate of 13%. Her repayments each month would also be 150 zeds.

Question 1: If she takes the Zed best loan, Mrs Jones will immediately pay off her existing loan.

What are two other financial benefits for Mrs Jones if she takes the Zed best loan?

1. ……

2. ……

PISA-FL	New offer	
Content	# Quantity # Change and relationship	
Financial Context	# Financial management and planning # Investing and saving	
Processes	**Processes (existing)**	**Processes (probable)**
Identifying financial situation	✓ The understanding the concepts of loan and compound interest	
Reasoning	✓ Algebraic reasoning ✓ Making connection ✓ Evaluating ✓ Procedural understanding ✓ Conceptual understanding ✓ Comparing	✓ Evaluating
Problem-solving and modelling	✓ Algebraic modeling	✓ Graphical modeling
Manipulating and estimating	✓ Calculating ✓ Estimating	✓ Calculating ✓ Estimating
Reflecting and transferring	✓ The using mathematical skills in loan process	
Representing	✓ Symbolic representation ✓ Linguistic representation	
Communicating	✓ Explaining	✓ Explaining ✓ Presenting
Using Technology		✓ Spreadsheets can be used for calculating, create graphs and formulating. ✓ Calculator

✓ Algebraic modeling: Loan

✓ Comparing: Comparing of calculations

✓ Calculating: Simple interest calculations

✓ Manipulating and Estimating: Manipulating and estimating on the variables of time, ratio and monthly payment

✓ Symbolic representation: Algebraic calculations on loan

✓ Explaining: Explaining of the advantages of the new offer

✓ Graphical modeling: Both loan can be modelled graphically.

✓ Evaluating: Evaluating the situations of the loans according to rest of the time, rest of borrow and total interest.

✓ Calculating: Compound interest calculations can be worked.

✓ Estimating: Comparing and estimating the results of simple and compound interest in the same rate.

✓ Linguistic representation: Using financial concepts

✓ Explaining: It can be asked that explanations and reasons through detailing of solutions.

✓ Presenting: Dramas can be presented for options.

✓ Spreadsheets: Using spreadsheets for calculations, graphs and other formulas

Figure 5. The checklist for New offer (Q17).

required to explain their comparisons using correct mathematical expressions. Mathematical operations should be used intensively in calculations on loans and deposit accounts based on compound interest. Procedural understanding is likely to be demonstrated in people who are constantly engaged in such transactions (Geller et al., 2017). However, creating graphical models for the transactions and relating compound interest operations to the concept of exponential function will provide a deeper understanding of the effect of the parameters. This was noted as graphical models for problem-solving and modelling process in the checklist (Figure 5). In such operations, a calculator or a spreadsheet can be

used to perform numerous manipulations for credit transactions. This enables changes in the transactions to be tracked effectively. Thus, using technology was marked as a probable process in the checklist (Figure 5).

5. Findings

5.1. Statistical findings

An overview of the distribution of the mathematical and financial literacies questions according to the dimensions of the model is given in Figure 6.

Quantity is present in all questions. It is observed that change and relationship (82%) and uncertainty and data (53%) are also considerably included in the questions. When the eight components of the processes are examined, identifying financial situation and representing are present in each question, followed by reflecting and transferring in 16 questions (94%), reasoning in 15 questions (88%), manipulating and estimating in 15 questions (88%), and problem-solving and modelling in 14 questions (82%). However, using technology is included in only one question (*MP3 players-Q10*). Furthermore, more than a half of the questions do not contain communicating process. For the context, financial management and planning occurs in 10 mathematical literacy questions and in all financial literacy questions. Spending can also be considered as a frequent financial context in the questions (53%).

5.1.1. The relationships between the dimensions and components

In this section, each dimension was examined under a separate heading in order to clarify the relationships between the components of each dimension. Statistical findings are presented using tables and diagrams.

The content dimension. The frequencies are shown in Table 2. According to this table, each question is related to at least three components. There is only one question *(Power of the wind-Q9)* where the five components are used together. With four components, *Shares*

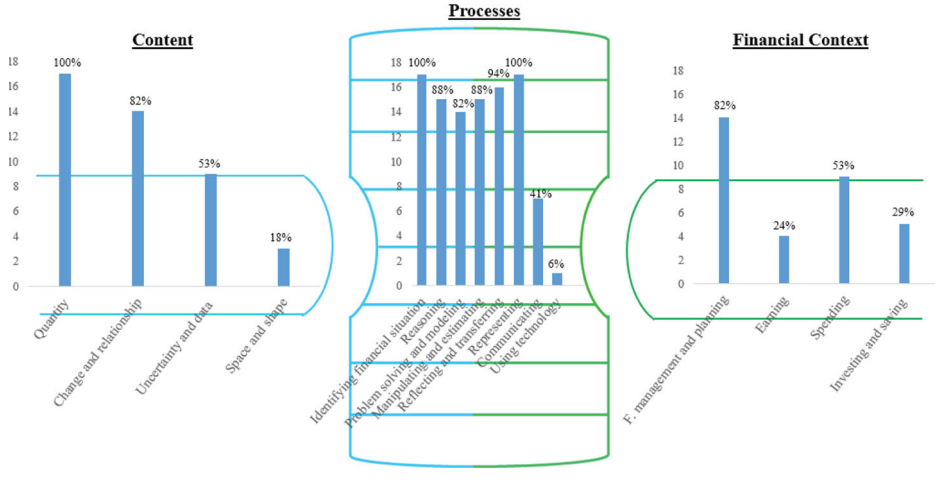

Figure 6. Frequencies of the components for each dimension of the IMMFL in PISA questions.

Table 2. Frequencies of the questions in the content dimension.

			Mathematical literacy													Financial literacy			
Content	%	*f*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Quantity	100	17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Change and relationship	82	14	1	1	1	1	1	1	1		1	1	1		1		1		1
Uncertainty and data	53	9	1			1		1		1	1	1		1	1	1	1	1	
Space and shape	18	3			1		1				1								

%: percentage f: frequency 1: existing.

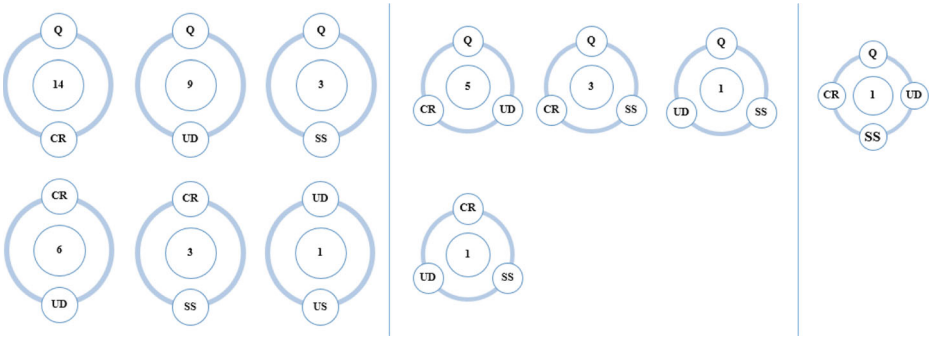

Figure 7. Relationships between the components of the content dimension (Q: Quantity CR: Change and relationship UD: Uncertainty and data SS: Space and shape).

(*Q15)* is the most intensive question among the financial literacy questions in terms of content. According to Table 2 quantity is included in all the questions. Change and relationships is present in 14 questions. In terms of the relationships between the components, a diagram is shown in Figure 7.

The number of questions in which change and relationships is present along with quantity is also 14. Change and relationship and uncertainty and data components exist together in six questions (Figure 7). Quantity and change and relationship are present in 12 (92%) of the mathematical literacy questions, while quantity and uncertainty and data are present in 3 of the financial literacy questions.

The processes dimension. The eight components of the processes were analysed along with 29 sub-components. Located in reasoning are comparing (12 questions, 71%) and procedural understanding (10 questions, 59%); in problem-solving and modelling is algebraic modelling (9 questions, 53%); and in representing are symbolic representation (12 questions, 71%) and visual representation (9 questions, 53%). Among sub-components, proving (in reasoning), and manipulative and realistic representations (in representing) are not present. Among four financial literacy questions, reasoning is included in two questions and problem-solving and modelling is included in only one question.

In terms of bipartite relationships, comparing and procedural understanding (9 questions, 53%), conceptual understanding and procedural understanding (6 questions, 35%), procedural understanding and manipulating and estimating (10 questions, 59%), and algebraic reasoning and algebraic modelling (6 questions, 35%) are used together. It is to be noticed that procedural understanding and algebraic modelling are used in each question in which a conceptual understanding takes place. Similarly, reflecting and

Table 3. Frequencies of the questions in the processes dimension.

			Mathematical literacy													Financial literacy			
Processes	%	*f*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
I. financial situation	100	17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Reasoning	88	15	1	1	1	1	1	1	1	1	1	1	1	1	1		1		1
Connecting	18	3			1														1
Comparing	71	12	1	1	1		1	1			1	1	1	1	1		1		1
Evaluating	47	8		1					1			1	1	1	1		1		1
Proving	0	0																	
Conceptual understanding	35	6	1				1	1	1						1				1
Procedural understanding	59	10	1	1	1		1	1	1		1				1		1		1
Proportional R.	35	6	1		1	1	1			1	1								
Algebraic R.	41	7							1	1	1	1	1		1				1
Geometric R.	12	2			1					1									
Quantitative R.	18	3										1	1				1		
Data-driven R.	6	1								1									
Spatial R.	6	1								1									
***P.* solving and modeling**	82	14	1	1	1	1	1	1	1	1	1	1	1	1	1				1
Algebraic M.	53	9	1				1	1	1	1		1	1		1				1
Graphical M.	24	4		1		1				1					1				
P. solving	41	7	1		1			1	1	1	1			1					
P. designing	6	1		1															
Manipulating and estimating	88	15	1	1	1	1	1	1	1	1	1	1	1	1	1		1		1
Reflecting and transferring	94	16	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1
Representing	100	17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Linguistic R.	47	8	1	1				1			1	1				1		1	1
Symbolic R.	71	12	1		1	1	1		1	1	1	1	1	1	1				1
Visual R.	53	9		1	1	1				1			1	1	1	1	1		
Manipulative R.	0	0																	
Realistic R.	0	0																	
Communicating	41	7	1		1		1			1		1	1						1
Using technology	6	1							1										

%: percentage f: frequency 1: existing.

transferring and identifying financial situation are included in each question in which communicating takes place. Statistical findings about these relationships are displayed in Table 3.

In the existing processes, using technology is limited due to the modality of the PISA. Communicating is used in only seven questions. By contrast, both using technology and communicating are included in all the probable processes. Similarly, while the problem designing component is included in only one question, it is seen that it can be used in six questions in the list of probable processes. Furthermore, the financial literacy questions can be enriched with probable new mathematical processes. Therefore, probable processes may contribute to the use of technology in 100% of the questions; followed by communicating in 75% of the questions; reasoning in 50% of the questions; problem-solving and modelling, manipulating and estimating, and reflecting and transferring in 25% of the questions. Statistical data for probable processes are presented in Table 4.

The financial context dimension. The statistical results of the financial context dimension are indicated in Table 5 and Figure 8. These tables show that the questions are usually based on either one (30%) or two (60%) contexts. The only question using four contexts is the *Power of wind (Q9). Invoice (Q14)*, which is a financial literacy question, uses three contexts.

Table 4. Frequencies of the questions in the probable processes.

			Mathematical literacy													Financial literacy			
Processes	%	*f*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
I. financial situation	35	6	1				1	1						1			1	1	
Reasoning	65	11	1				1	1			1		1	1	1	1	1	1	1
Connecting	6	1															1		
Comparing	18	3											1	1				1	
Evaluating	53	9	1				1	1			1		1		1	1	1		1
Proving	0	0																	
Conceptual understanding	0	0																	
Procedural understanding	12	2												1				1	
Proportional R.	6	1																1	
Algebraic R.	18	3												1		1	1		
Geometric R.	0	0																	
Quantitative R.	0	0																	
Data-driven R.	12	2														1	1		
Spatial R.	0	0																	
***P.* solving and modelling**	71	12		1	1		1	1		1	1	1	1	1	1	1		1	
Algebraic M.	53	9		1	1		1			1	1			1	1	1		1	
Graphical M.	18	3					1			1									1
P. solving	0	0																	
P. designing	35	6		1	1			1				1	1			1			
Manipulating and estimating	65	11	1		1	1	1	1			1		1	1		1		1	1
Reflecting and transferring	65	11	1		1	1	1		1		1			1	1	1	1	1	
Representing	53	9	1	1	1		1		1	1						1	1	1	
Linguistic R.	6	1								1									
Symbolic R.	29	5	1	1												1	1	1	
Visual R.	29	5			1		1		1							1	1		
Manipulative R.	0	0																	
Realistic R.	0	0																	
Communicating	100	17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Using technology	100	17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

f: frequency 1: existing

Table 5. Frequencies of the questions in the financial context dimension.

			Mathematical literacy													Financial literacy			
F. context	%	*f*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
F. management and planning	82	14	1			1	1	1		1	1	1	1	1	1	1	1	1	1
Earning	24	4								1					1	1		1	
Spending	53	9		1	1		1	1	1	1			1	1		1			
Investing and saving	29	5								1	1	1					1		1

%: percentage f: frequency 1: existing.

Financial management and planning is present along with the spending in six questions; with investing and saving in five questions; and earning in four questions. Financial management and planning is included in all the questions, which includes the context of investing and saving.

5.1.2. The relationship between the dimensions

The relationships between content and financial context are expressed in Table 6.

Because quantity is present in all questions, it is used in each financial context. Another notable statistic is the use of change and relationship content in 11 of the 14 questions in financial management and planning context (79%). Furthermore, all the questions containing uncertainty and data content are in financial management and planning context.

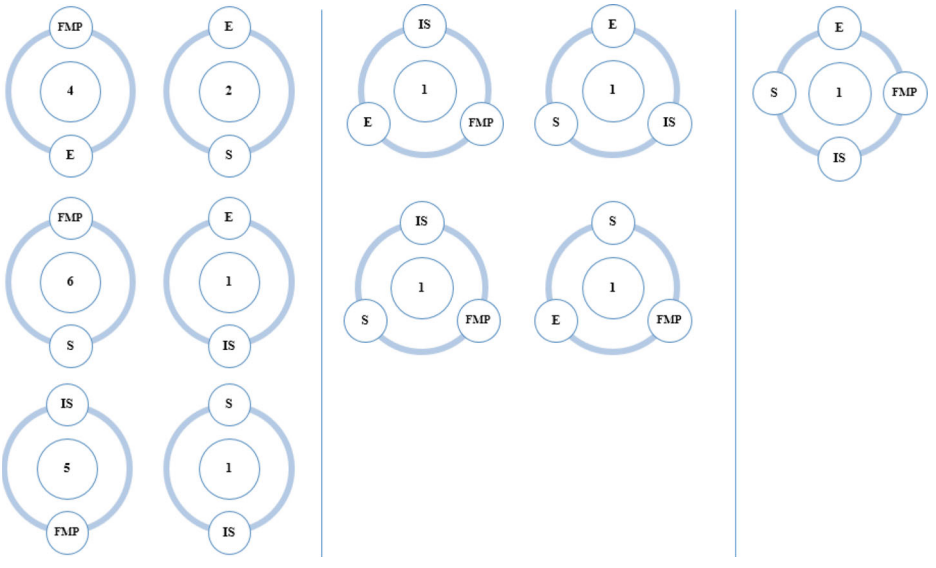

Figure 8. Relationships between the components of the financial context dimension (FMP: Financial management and planning E: Earning S: Spending IS: Investing and saving).

Table 6. Review of the content and financial context.

	F. context	FMP (14)		E (4)		S (9)		IS (5)	
Content	f	%	f	%	f	%	f	%	F
Quantity	17	100	14	100	4	100	9	100	5
Change and relationship	14	79	11	50	2	78	7	100	5
Space and shape	3	14	2	25	1	33	3	20	1
Uncertainty and data	9	64	9	100	4	44	4	60	3

%: percentage f: frequency
FMP: Financial management and planning E: Earning S: Spending IS: Investing and saving (): How many related questions are this context?

Similarly, all the questions established in earning context include uncertainty and data content. In addition, change and relationship content is present in 78% of the questions in spending context and in all the questions in investing and saving context.

In terms of the relationships between processes and financial context (see Table 7), the percentages of the process components, which appear in financial management and planning context, are as follows: identifying financial situations (100%), comparing (64%), algebraic modelling (50%), manipulating and estimating as well as reflecting and transferring processes (79%), symbolic representation (71%), and visual representation (50%). In earning context, reflecting and transferring and visual representation processes are found in 75% of the questions. In spending context, the processes of reasoning, problem-solving and modelling, manipulating and estimating, reflecting and transferring are present in 89% of the questions while comparing, symbolic representation, and visual representation are present in 67% of the questions. All the questions, which address investing and saving context, include the processes of manipulating and estimating, representing along with reflecting and transferring. Within the same context, comparing and algebraic reasoning

Table 7. Review of the processes and financial context.

		FMP (14)		E (4)		S (9)		IS (5)	
	f of P	C/*P* (%)	*f*	C/*P* (%)	*f*	C/*P* (%)	*f*	C/*P* (%)	*f*
I. financial situation	17	100	14	100	4	100	9	100	5
Reasoning	15	86	12	50	2	89	8	100	5
Connecting	2	7	1	0	0	00	0	20	1
Comparing	12	64	9	25	1	67	6	80	4
Evaluating	8	43	6	25	1	44	4	60	3
Proving	0	0	0	0	0	0	0	0	0
Conceptual understanding	6	29	4	25	1	33	3	20	1
Procedural understanding	10	43	6	25	1	56	5	60	3
Proportional R.	6	29	4	25	1	33	3	40	2
Algebraic R.	7	43	6	50	2	33	3	80	4
Geometric R.	2	7	1	25	1	22	2	20	1
Quantitative R.	3	21	3	0	0	11	1	40	2
Data-driven R.	1	7	1	25	1	11	1	20	1
Spatial R.	1	7	1	25	1	11	1	20	1
***P.* solving and modelling**	14	71	10	50	2	89	8	80	4
Algebraic M.	9	50	7	50	2	56	5	60	3
Graphical M.	4	21	3	50	2	22	2	20	1
P. solving	7	7	1	25	1	56	5	40	2
P. designing	1	0	0	0	0	11	1	0	0
Manipulating and estimating	15	79	11	50	2	89	8	100	5
Reflecting and transferring	16	79	11	75	3	89	8	100	5
Representing	17	93	13	100	4	100	9	100	5
Linguistic R.	8	43	6	50	2	33	3	60	3
Symbolic R.	12	71	10	50	2	67	6	80	4
Visual R.	9	50	7	75	3	67	6	40	2
Manipulative R.	0	0	0	0	0	0	0	0	0
Realistic R.	0	0	0	0	0	0	0	0	0
Communicating	7	43	6	25	1	44	4	60	3
Using technology	1	0	0	0	0	11	1	0	0

f of *P*: frequency of the process C/*P*(%): percentage of financial context to process
( ): How many related questions are this context?
FMP: Financial management and planning E: Earning S: Spending IS: Investing and saving

are used in 80% of the questions and procedural understanding and communicating processes in 60% of the questions.

The relationships between processes and content are presented in Table 8. All the questions containing change and relationship content involve identifying financial situations, manipulating-estimating and reflecting-transferring processes, followed by 79% of the questions which involve comparing and symbolic representation sub-components, 64% of the questions which involve procedural understanding and algebraic modelling processes, and 50% of the questions which involve algebraic reasoning and visual representation processes. 78% of the questions, which include uncertainty and data content, use manipulating processes, 56% of the questions use comparing, and 67% of the questions use visual representation. It is notable that symbolic representation and communicating processes are used in all the questions that include space and shape content. In addition, change and relationship content is used in all the questions containing communication and in 93% of the questions containing reasoning, problem-solving and modelling processes.

5.2. A question-based analysis of the statistical findings

Among the 17 PISA questions that were analysed, the most frequently used contents are quantity (100%) and, change and relationship (88%). In all the questions, at least one

Table 8. Review of the content and processes.

		Q (17)		CR (14)		UD (9)		SS (3)	
	f of P	C/*P* (%)	*f*	C/*P* (%)	*f*	C/*P* (%)	*f*	C/*P* (%)	*f*
I. financial situation	17	100	17	100	14	100	9	100	3
Reasoning	15	88	15	100	14	89	8	100	3
Connecting	2	18	3	21	3	0	0	33	1
Comparing	12	71	12	79	11	56	5	67	2
Evaluating	8	47	8	50	7	44	4	0	0
Proving	0	0	0	0	0	0	0	0	0
Conceptual understanding	6	35	6	43	6	22	2	33	1
Procedural understanding	10	59	10	64	9	33	3	67	2
Proportional R.	6	35	6	36	5	22	2	67	2
Algebraic R.	7	41	7	50	7	33	3	33	1
Geometric R.	2	12	2	14	2	11	1	67	2
Quantitative R.	3	18	3	21	3	22	2	0	0
Data-driven R.	1	6	1	7	1	11	1	33	1
Spatial R.	1	6	1	7	1	11	1	33	1
***P.* solving and modelling**	14	82	14	93	13	67	6	100	3
Algebraic M.	9	53	9	64	9	44	4	67	2
Graphical M.	4	24	4	29	4	33	3	33	1
P. solving	7	41	7	43	6	33	3	67	2
P. designing	1	6	1	7	1	0	0	0	0
Manipulating and estimating	15	88	15	100	14	78	7	100	3
Reflecting and transferring	16	94	16	100	14	89	8	100	3
Representing	17	100	17	100	14	100	9	100	3
Linguistic R.	8	47	8	43	6	44	4	0	0
Symbolic R.	12	71	12	79	11	56	5	100	3
Visual R.	9	53	9	50	7	67	6	67	2
Manipulative R.	0	0	0	0	0	0	0	0	0
Realistic R.	0	0	0	0	0	0	0	0	0
Communicating	7	41	7	50	7	22	2	100	3
Using technology	1	6	1	7	1	0	0	0	0

f of *P*: *f* requency of the process f: frequency C/*P* (%): percentage of financial content to process
( ): How many related questions are this content?
Q: Quantity CR: Change and relationship UD: Uncertainty and data SS: Space and shape

financial context is mentioned and contents related to the financial field are included. However, two financial literacy questions (*Invoice-Q14* and *Pay slip-Q16*) only include quantity along with financial content. The content the least identified in the analysis is space and shape (18%). However, this is enriched by processes such as proportional reasoning, comparing, geometric reasoning, algebraic modelling, estimating, and visual representation. In the *Postal charges (Q2)* question, change and relationship, quantity along with financial content are included. These are also included in the *Pizzas (Q3)* question, along with the content of space and shape.

These questions are designed to prepare students for a real-life situation. In this respect, exchanging money in the *Exchange rate (Q1)* informs students about the purchasing power of money besides requiring them to use mathematical methods to show how the transactions take place. Additionally, selecting the most appropriate option within the content of uncertainty and data can lead to different combinations according to the individual's preferences. Moreover, the topics on energy production and oil savings in the *Sailing Ships (Q7)* and *Power of wind (Q9)* reflect macroeconomic realities and the regulation of the financial budget. Similarly, the ability to read and understand documents such as payslips, invoice, and commercial agreements in the *Invoice (Q14)* and *Pay slip (Q16)* is a financial experience

that will concern all individuals from early ages. Questions on stock markets in the *Shares (Q15)* include financial issues such as individuals' investment portfolios.

The findings of the study show that the processes addressed in the interaction model are prominent processes in both literacies. Selecting the best option, an important skill in financial literature entails critical processes such as comparing and proportional reasoning. Proportional reasoning regarding the values of currencies, comparison of purchasing power in the *Exchange rate (Q1),* comparison of pricing criteria in the *Postal charges (Q2),* proportional reasoning regarding price-product-service in the *Pizzas (Q3),* comparison of rental and purchase options in the *DVD rental (Q12),* comparison of multiple choices in a case such as the collection of skateboard parts in the *Skateboard (Q4),* proportional reasoning in relation to earnings by working hours in the *Selling newspapers (Q13),* reasoning multiple variables on loans in the *New offer (Q17),* are all valuable processes for solving financial problems and understanding financial situations. In financial situations, reasoning process can be given as an example of geometric reasoning in question with space and shape content, algebraic reasoning in questions related to variables, and combined algebraic and geometric reasoning. In the *Pizzas (Q3)* question, there is a relationship between diameters and prices. In this question, students can use algebraic modelling to compare the area of the pizza with its price. At the same time, this may facilitate reasoning process regarding the areas of discs. There are cases in the question where both conceptual and procedural understanding processes are required. In the *Exchange rate (Q1)* question, transactions on currency conversion may foster conceptual understanding. In the *Skateboard (Q4)* question, students may try to use algebraic models to balance their saving and spending while developing procedural understanding skills through different manipulations. The *Selling newspapers (Q13)* question may help students develop conceptual understanding within the algebraic models of the related tables through the use of graphs. The *New offer (Q17)* question may enable students to learn how the effects of variables of compound interest can be observed through multiple manipulations.

In question with the contents of change and relationships, space and shape, and uncertainty and data, algebraic and graphical models are used. For example, the *Postal charges (Q2)* question presents a situation involving the concept of the greatest integer function that requires algebraic modelling to be used to select the most appropriate option. Graphical models in the question involve generating a graph to solve a problem as well as carrying out an interpretation of the graph. Similarly, in the *Export (Q5)* question, a bar graph and pie chart are given and they are to be interpreted together. In the question, visual models are also used. To enable students to demonstrate their communication skills, open-ended questions, which include mathematical notations as symbolic representation, and graphs and tables as visual representations, are used. For instance, in the *Holiday apartment (Q11)* question, visual representation explaining the criteria for house options, linguistic representation by asking students to explain their preferences, and symbolic representation are required to demonstrate the procedural operations fluently. Manipulating is an effective tool for tracking changes in variables when carrying out calculations for a loan. Some manipulations can also reveal which are the two items that should be selected in the *MP3 players (Q10)* question. Similarly, to buy a car based on its features, several calculations involving manipulations can help students carry out correct comparisons. Furthermore, algebraic or graphical models may provide ideas for evaluations. Estimating is also used as a starting point for generating a solution for problems and it can be used as a mathematical

tool. For example, in the *DVD rental (Q12)* question, students may focus on the advantage of membership; however, when they use algebraic reasoning, they should realize that the membership is reasonable only for an interval of time.

The probable processes in the analysis show how the enrichment can be made. For example, in the *Which car (Q8)* question, both existing and probable processes include the process of comparing. It is suggested that a comparison of cars should be made according to their features in the existing PISA question. Thus, a comparing skill is added to the probable processes to realize the effect of a feature when everything else is constant. The *Invoice (Q14)* question focuses only on reading and understanding the invoice, while the probable processes of calculating the price by number, creating new visuals to examine invoice details, and product manipulations according to the money limit are added to the question. With these enriched questions in the classroom, technological tools may be used and communication opportunities can be diversified. For example, the *Power of the wind (Q9)* question can be enriched through probable processes. Students can be asked to calculate the energy capacity which requires analytical solutions using dynamic geometry software. Similarly, the *New offer (Q17)* question can be applied in the classroom as a drama on the manipulation of variables.

6. Conclusion

This study shows that the financial contexts in the mathematical literacy questions and the relationships between the financial literacy questions and mathematical contents emphasize the intensity of the interaction beyond the statement of OECD (2016b) according to which the interaction is only based on the arithmetic field. Parallel to the studies of Lusardi (2012) and Sole (2017), this study points out the necessity of using mathematical contents and processes in solving financial problems and supports the idea that mathematics is not only a calculation tool for financial literacy.

According to the analysis, the questions involve a variety of contexts and contents. They include students' experiences and future perspectives beyond the daily activities, and the financial content in the questions is supported with mathematical content. The shape and space content is included in only three questions and this can be explained with the fact that it is a mathematics-specific content. However, the fact that financial literacy has been associated with such mathematics-specific content shows that these two literacies may be more related to each other than they seem to be. In this manner, students may acquire familiarity with financial concepts and develop financial reasoning while establishing a relationship between mathematical concepts (Lusardi & Mitchell, 2011). Because the structures of the questions entail mathematizing solutions, the change and relationship content is frequently used in questions. For this to occur, algebraic modelling of financial situations or tracing patterns are required (Wake, 2016).

Another result of the study is that more than one process, included in the interaction model, can be used in solving a question. Using several processes together can enrich the interaction and enable students to solve problems in different ways (Star, 2005). A combination of geometric and algebraic reasoning, tracing manipulations and estimating strategies, and using technology for both calculating and realizing problems are evident in the questions. In addition, Sole (2014)'s idea that reasoning should be supported by manipulating and estimating processes is also evident in some questions. The results show that reasoning,

which includes comparisons, frequently occurs in the questions. This result is in line with existing research (Grody et al., 2008; Hasek & Petraskova, 2013). It is thought that comparisons do not only contribute to the understanding of financial situations as they also support reasoning (NCTM, 2000). As for communicating and using technology processes, it is evident that the modality of the PISA limits the place of these processes. However, the results of probable processes show that PISA questions can be enriched and used in classroom or in other teaching and learning environments (Lewis, 2017).

This study shows that although mathematical and financial literacies questions are prepared for separate evaluations, they have potential to support both literacies. This result strengthens the idea that financial literacy education can be easily integrated into mathematics courses, at least for 15 years old students, and that it is possible to support both literacies with a common content.

Notes

1. In educational documents, the terms 'skills' and 'competencies' are often used together and sometimes with distinct meanings. For example, in the OECD reports on mathematical literacy, transformations from 1999 to 2012 have been observed, and the terms skills, mathematical competencies and fundamental mathematical capabilities have been used interchangeably. Further details about the genesis and development of the competency concept in PISA can be found in Niss (2015).
2. In the study, the questions shared until 2016 were handled.

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ORCID

Abdullah Ozkale http://orcid.org/0000-0003-1115-5924
Emel Ozdemir Erdogan http://orcid.org/0000-0003-2703-9530

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Abdullah Ozkale & Emel Ozdemir Erdogan

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