Education and Science tedmem

Vol 45 (2020) No 201 1-37

Thematic Analysis of Articles Focusing on Mathematical Literacy in Mathematics Teaching-Learning Process *

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Abstract

The issue of how to increase the achievement level of mathematics literacy has become the focus of studies on mathematics education. Even though there have currently been many studies, no detailed study has been found related to their methods, content, and which component of mathematics literacy. The aim of this study is to carry out thematic analysis of the articles focusing on mathematics literacy in the education process and reveal the extent to which the researched subjects meet the needs in terms of quality and quantity, and what kind of research is needed. However, the fact that there are many studies (181) on mathematics literacy has led to the need to classify the articles before the thematic analysis. Based on the Principles of School Mathematics (equality, curriculum, teaching, learning, evaluation, and technology), 74 articles were selected for analysis after a preliminary classification of the articles followed by at least one of the principles. In this study, the general characteristics (types of journals and year of publication), rationale, purpose, research methods, sample, results and suggestions of the examined articles were analyzed and presented. Two main categories were identified in the studies examined in this study: (i) Describing a situation by summarizing the information and making it more distinguishable, (ii) Identifying the problem and proposing a model for the solution of this problem, and increasing the ML achievement level by testing and evaluating this model. Most of the studies examined were classified in the first category. It was observed that the studies in the second category were insufficient in number. In particular, the results of studies reporting difficulties in solving the ML problems can be a starting point for improving the teaching and repetition of such studies is considered as a need.

Keywords

Mathematical literacy

Mathematics learning-teaching process

Thematic analysis

Article Info

Received: 07.07.2018

Accepted: 11.20.2019

Online Published: 01.28.2020

DOI: 10.15390/EB.2020.8028

* This article is orally presented at the International Conference on Mathematics and Mathematics Education (ICMME-2017).

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Introduction

The power of mathematics as a branch of science is stems from its ability to explain many physical phenomena and events in human life and in the world of science with abstract mathematical rules (Stacey, 2015). From this point of view, it should be one of the main objectives of school mathematics to make it possible to be able to explain and examine the actions that individuals are exposed to in daily life. However, algebra and calculus, which are the predominant subjects of today's school curriculum, have a structure used by specialists of certain fields rather than being used as calculation tools outside the school (Steen, Turner, & Burkhardt, 2007). Considering similar situations, there seems to be a need to provide training in an attempt to eliminate the "disconnectedness" between the school mathematics and everyday life. The elimination of this disconnectedness is possible through intervention in life events with the learned mathematics. This situation allows students to compare the events that require the use of knowledge in the lessons, provide the students with their own suggestion about the solution and defend their ideas about the solution (Altun & Bozkurt, 2017).

Accordingly, at the present time, the concept of "Mathematical Literacy (ML)", which means "understanding the role of mathematics in daily life and using mathematics in solving the problems in daily life (McCrone & Dossey, 2007)", has come to the forefront and the issue of how to increase the mathematical literacy capacity has been centered upon the education debates (Altun & Bozkurt, 2017). In addition to what ML is due to its place and importance in teaching, it emerges as a need to explore to what extent and with which dimensions the ML is reflected in the school curricula and educational research (what are the missing dimensions, if any).

ML was originally declared within the Principles and Standards for School Mathematics (National Council of Teachers of Mathematics (NCTM) as the goal of mathematics teaching in the late 1990s. Together with the transition from the industrial society to the information society, some researchers, for example; Kaiser and Willander (2005) and Ojose (2011) interpret as one of the keys in coping with change. When we look at the last 10 years, the term "mathematical literacy" has penetrated almost every field within the mathematics education reform literature. ML is neither a broad topic to be added to the mathematics curriculum nor is it merely the basic skills of the traditional mathematics program (Steen et al., 2007). To put it simply, ML is the knowledge of basic mathematics and how to apply it in our daily life (Ojose, 2011) and this applies to each and every mathematical subject (Altun, 2018).

Different names for ML that have overlapping meanings are used in different countries (Burkhardt, 2008; Steen et al., 2007). While the terms *quantitative literacy* in America and *functional literacy* in England are very popular nowadays, the term mathematical literacy (ML) they issued most commonly (Burkhardt, 2008). In the present study, the term Mathematical Literacy "ML" was used; predetermined 181 articles were classified according to the Principles of School Mathematics (NCTM, 2000) and 74 articles related to these principles were subjected to thematic analysis. In this context, the general characteristics of the studies, the reasons (such as the type of journal and year of publication), justifications, research methods, samples, results and suggestions were analyzed and presented in tables.

Meaning and Scope of Mathematical Literacy

The increasing importance of ML in the mathematics education literature has made the current place of PISA (Program for International Student Assessment) organized by the OECD, whose main theme is the assessment of literacy, more prominent (Breakspear, 2012). The PISA, which is an international comparative study, assesses the functional application of mathematics in everyday contexts. The OECD defines the ML as an individual capacity as "to grasp and define the role of mathematics in real life, make decisions in a constructive, relational and reflective way if it is necessary in life and make it a way of life" (OECD, 1999, 2003, 2006, 2009). Similarly, the OECD revised ML with a partial change in its definition as "the capacity of an individual to formulate, apply and interpret mathematics in daily life events" (OECD, 2013, 2016). This definition is shaped around the wider use of mathematics in human life and it expresses that it is not limited to mechanical operations. ML is used here to describe the capacity to use mathematical knowledge and skills, rather than merely to master the subjects within the school curriculum (Kramarski & Mizrachi, 2004). The concept of ML aims to examine the world from the perspective of mathematics. It emphasizes the development of high-level thinking (general problem-solving skills) that improves the use of basic mathematical skills. The ability to use mathematics to solve problems is the primary goal of possessing mathematical literacy (Pugalee, 1999). This concept is comprised of building and solving mathematical problems, analyzing ideas and conclusions, reasoning and communication skills (Jablonka, 2003). This process is one of the basic processes of mathematical modeling or mathematization that De Lange (2003) expressed as the main objective of Realistic Mathematics Education (RME) (OECD, 2006).

PISA examines and describes the developmental level of achievement in ML (Steen et al., 2007) focusing on a number of mathematical competences (OECD, 2009, 2013, 2016).These mathematical competences were first put forward by Niss (2003) and referenced in various studies (e.g. Dossey, McCrone, Turner, & Lindquist, 2008; Saenz, 2009).These competences that are expected to be active in the process of mathematical intervention to solve a contextual problem have been stated as follows: (i) Using Mathematics in communication, (ii) Mathematising-modeling process, (iii) Reasoning and argument construction, (iv) Representation, (v) Devising strategies for solving problems, (vi) Using symbolic, formal, and technical) language and operations, and (vii) Using mathematical tools (OECD, 2016). Evaluations aimed at identifying the ML level of achievement is based on giving students the opportunity to use their mathematical competences by directing contextual, conceptual and operational problems to them (Saenz, 2009).

According to OECD (2019), in the context of ML achievement level, students' ability to effectively analyze, reason and communicate mathematical ideas needed to solve mathematical problems is studied. This problem-solving process studied requires students to use the mathematical knowledge and skills acquired through school and life experiences, and the basic operations used in this process are called mathematising (OECD, 2019). Within the framework of PISA applications, the processes experienced in solving literacy problems and the mathematical outcomes expected from the individual in this process have been defined in three different mathematical processes (formulating, applying and interpreting-evaluating). According to OECD (2019) in the solution of an ML problem, the process of *formulating* shows how effectively students can recognize and define mathematics in the problem and how effectively they can create the mathematical structure necessary to formulate the contextual problem (converting it into a mathematical form). The *practice / execution* process shows how well students can apply the concepts and facts to a mathematical solution to a mathematically formulated problem. The *interpretation / evaluation* process, on the other hand, shows how well the students can interpret mathematical solutions or results in the context of a real-world problem and how they can comment on whether the results are reasonable. It is possible to see that the ML definitions previously presented also cover these three mathematical processes. Therefore, these processes provide a useful and meaningful structure for organizing and solving mathematical processes that define what an individual does in order to relate the context of a problem to mathematics (OECD, 2019). In the present study, *the mathematical processes* were discussed together with *the difficulties encountered in solving an ML problem* obtained from the results of the articles examined. It was thought that determining which mathematical process would match the difficulties in solving ML problems would have some benefits. As a result of this study, it is thought that a starting point can be determined for researchers and educators in order to find solutions to the difficulties in solving ML problems. Students' chances to apply mathematics depends on the skills available in all three of these processes, and understanding their effectiveness in each category can be a source of both policy-level discussions and decisions to be taken close to the class level (OECD, 2019).

Development of Mathematical Literacy in School Mathematics

While school mathematics focuses on the basic skills of advanced mathematics, ML focuses on advanced uses of basic mathematics (Steen et al., 2007). The ML practices to be carried out at schools are the first steps students will take to become mathematically literate and students should experience these steps in the best way at their schools. Being trained as mathematically literate depends on classroom relations being reshaped to make research, explanation and justification an explicit focus in mathematics (Solomon, 2009). Although the curricula of mathematics courses, including traditional school mathematics subjects (arithmetic, algebra, geometry), have undergone profound changes, it is still observed that the concept of ML is still (unable) to be addressed in detail within the teaching process (Jurdak, 2016).

An individual with a mathematical literacy has the skills to understand a problem, interpret the data, design solutions to the consequences and evaluate the suitability of the results. However, s/he can reason about statistical, graphical and geometric situations and communicate using mathematics (Doyle, 2007; Ojose, 2011; Pugalee, 1999). These skills are revealed in such situations such as during the mathematical intervention of "real life" problems, while reading a train schedule, dealing with hand-crafts, shopping, or taking advice from bank employees (Jablonka, 2003). Mathematical reasoning and conceptualization are crucial for the progression of students in ML (Pugalee, 1999). The objective of mathematics teaching system should be to train individuals with these skills.

It is thought that the value of mathematical activities that focus on the majority of people in society (and therefore on the students) can be determined by the contribution that the ML can make in improving the level of achievement of the students (Gellert, 2004). At this point, in order for the teachers to transfer the ML to their class, the teachers need to understand the ML themselves first (Mosher, 2015; NCTM, 2000). Previous studies half-opened a window in an attempt to investigate the role of teachers, who could be positive or negative influences on students' becoming mathematically literate. A qualified teacher should seek ways to create an environment to create mathematical meanings (Schoenfeld, 2002). Many of the mathematics teachers rarely establish relationship between the students' daily life and mathematics (Steen et al., 2007). Even though the emphasis of studies on ML on teaching practices that support high-level thinking are promising, there is still need further research on how mathematics teachers should prepare for the teaching of ML (Colwell & Enderson, 2016). The common result of research on improving the ML achievement level indicated that the ML achievement significantly depends on the nature of the classroom relationships and the way it is taught. Students should be encouraged to express their ideas, discuss and create arguments during teaching and opportunities aimed at motivating them should be created.

Together with the importance given at the international level, as it is the case with the PISA practices, ML was reflected in the curriculum of many countries including Turkey as well (e.g., Australia, Indonesia, South Africa). In our country, the Ministry of National Education (MoNE) recently published a mathematics curriculum for elementary and secondary school students, which included the statements "improving students' ML skills and getting them to use those skills effectively" (MoNE, 2017).

As a result of international scale achievement evaluation studies such as PISA, many studies and projects related to ML have so far been carried out and are still in progress. Some of these studies (eg: Akyüz & Pala, 2010; Liang, 2010; Lydia & Wilson, 2009; Ross, 2008; Satıcı, 2008; Wood, 2007) were aimed at comparing countries countries (eg: USA and Finland, Turkey and Hong Kong, the US and Hong-Kong) in terms of many variables and based on it, finding the factors related to ML's achievement out of those variables. In these studies, it is generally seen that any country is compared with the country(s) with high PISA success.

In this context, how to plan and implement mathematics teaching in accordance with the development of ML competencies, how to evaluate teaching are the final questions and these questions firstly require a breakdown or analyses of field studies. No study that included an analysis that could meet this need was found. From this point of view, the present study aims to thematically analyze the studies on ML in the learning-teaching process.

Purpose and Importance of the Study

The present study, which examined the academic results of published studies on ML, aimed to fill the gap in the literature because it was not an article that organized, evaluated and synthesized these articles. Moreover, by examining the studies on ML in the mathematics learning-teaching process as a whole, it is thought that readers may be able to recognize the risks and opportunities in this subject. The content analysis of the national and international articles within the scope of this study is also important in terms of presenting new ideas to the researchers in this field and revealing the unstudied parts of the subject and new research topics. This thematic analysis study can be used as a resource, as well as generating ideas for new researches in the field. In this context, the present study aims to review and analyze the studies done on ML in the mathematics learning and teaching process in terms of research types, general characteristics (such as the type of journal published and the year of publication), reasons, purposes, research methods, samples, results and Suggestions.

In this study, which deals with thematic literature review, the research problems were determined by taking into account the physical texture and content of a document as follows:

1. What are the general characteristics of the studies focusing on the ML in the mathematics learning-teaching process (such as the type of journal published and the year of publication)?
2. What are the reasons of the studies focusing on ML in the mathematics learning-teaching process?
3. What are the purposes of the studies focusing on ML in the mathematics learning-teaching process?
4. Which research methods, samples and data collection tools are used in studies focusing on ML in the mathematics learning-teaching process?
5. What are the results of studies focusing on ML in the mathematics learning-teaching process?
6. What are the suggestions of studies focusing on ML in mathematics learning-teaching process?

Method

This study focuses on a thematic analysis of studies focusing on ML in the learning-teaching process. Thematic analysis involves the analysis, synthesis and interpretation of studies focusing on the same subject within the framework of specific themes or templates. Thematic analysis constitutes a rich source of reference for researchers, practitioners and policy makers in terms of revealing the common and similar aspects of the studies that deal with a particular subject from different dimensions (Çalık, Ayas, & Ebenezer, 2005; Gül & Sözbilir, 2015). This section describes how the 74 articles reviewed were identified and analyzed.

Data Collection

The articles analyzed were obtained from the databases such as Web of Science, ERIC, Science Direct, EBSCO, and Google Academic. The search terms (key concepts) in the literature search included "mathematical literacy", "mathematically literate", and "literacy in mathematics education". Key concepts were searched in both Turkish and English. In order to establish a broad ML picture, all articles that were published until July 30, 2017 and those that were accessed were searched, despite the fact that there was no starting date restriction during the screening of the studies. Studies conducted in peer-reviewed national and international journals were identified and examined. 74 articles covering a total of 21 years between 1997 and 2017 were analyzed by skim through the articles up to the completion date of the study without determining any starting date. In this context, a comprehensive field study, which is one of the strategies of ensuring theoretical validity (Christensen, Johnson, & Turner, 2015), was tried to be ensured.

This classification may be based on whether the articles are relevantly related to ML, whether they are theoretical or practical, etc. The existence of a large number of studies on ML in the relevant literature led to the need to introduce a classification for the analyses to be carried out. In this study, the articles were classified in terms of their relevance to the Principles for School Mathematics set out by the National Council of Teachers of Mathematics (NCTM) 2000 (Figure 1) in the United States. The articles (74 in total) included in any of these principles were reviewed. The Principles of School

Mathematics are one of the frameworks to guide the professional decisions about the learning-teaching process (NCTM, 2000), and even though they were not important for this article, this is the reason why they were used as a reference for the classification of articles. In order to be able to comment on the relevance of these principles related to ML, the principles and their meanings (NCTM, 2000) are presented in Figure 1.

Equality	Excellence in mathematics education is essential. A robust mathematical education support should be provided for every student.
Curriculum	The curriculum is more than a series of activities, and should be consistent, focused on mathematics, and sufficiently well expressed for class levels.
Teaching	The form of teaching should be of a quality in which pupils learn and where the students are encouraged to grasp what they need to learn, and to learn
Learning	Students should learn by understanding the mathematical knowledge and actively create new knowledge based on experience and prior knowledge.
Assessment	Assessment should support learning of mathematics and provide useful information for both teachers and students.
Technology	Technology is important for teaching and learning mathematics. Technology influences the mathematics that is taught and increases students' learning. Adequate technological support should be provided in the teaching process.

Figure 1. Principles for School Mathematics (NCTM, 2000)

The principle of equality according to NCTM (2000) requires equal opportunities for all, taking into account the students with different learning styles, and providing resources and support to every individual and class in order for everyone to learn mathematics. While determining what and how much students will learn at school, the curriculum principle defines a harmonized and leveled mathematics curriculum framework that supports literacy, focusing on the use of learned mathematics in everyday life. The teaching principle emphasizes that the teachers understand mathematics and use this knowledge in the teaching process for effective mathematics teaching. In this process, it is emphasized which subject the teachers should present with what kind of activity or method, and that the students should be supported in problem solving, argument generation and discussion processes. According to the learning principle, students are expected to learn mathematics through conceptual understanding and be able to apply it. In this principle, it is emphasized that conceptual understanding is one of the important determinants of student achievement and, on this occasion, it will both make students' future learning easier and determine more easily how and when to use what they have learnt in new situations. It is emphasized that conceptual understanding will also support in-class learning processes and is an important criterion for solving problems in daily life and providing mathematical reasoning skills. The evaluation principle states that evaluation should be done for the student and should improve learning. The evaluation process emphasizes the need to contribute to the development of independent individuals who can take responsibility for their own learning. However, it is stated that the discussions that will be included in the evaluation process will provide the opportunity for students to discuss and reflect on the procedures of discussion. The principle of technology focuses on how technology can affect learning and the taught mathematics. It is stated that the use of technology will support decision-making, reflection, reasoning and problem-solving skills and contribute to in-depth learning of mathematics. It is also stated that technology increases the types of problems that students will work on, supports modeling and conceptualization, and increases the learning opportunities. In addition, it is stated that technology changes the boundaries of the mathematical field by helping to develop generalization and abstract skills.

When these principles are considered in general, it is seen that they are compatible with the definitions of ML identified in the relevant literature. According to these principles, the education process should enable the individual to understand the role of mathematics in life (McCrone & Dossey, 2007; OECD, 1999, 2003, 2006, 2009; Steen et al., 2007), to know when and how to use what they have learnt in real life (Bansilal, 2014; Evans, 2000; Sari & Wijaya, 2017), and have the skills of mathematical reasoning in problem solving processes in daily life (Colwell & Enderson, 2016; Hoogland, 2003; Spangenberg, 2012), argument generation (Venkat, Graven, Lampen, Nalube and Chitera, 2009)), judgment (Colwell & Enderson, 2016), decision-making (Colwell & Enderson, 2016) and effective discussion (Colwell & Enderson, 2016; Hillman, 2014; Jablonka, 2003; Venkat, Graven, Lampen, Nalube and Chitera, 2009). The basic requirements of each principle overlap almost exactly with the ML literature. In this context, it is possible to say that the mathematics education that is introduced by the Principles of School Mathematics aims to educate individuals who are mathematically literate. Pre-classification of the articles to be included in this study where thematic analysis of the articles about ML in mathematics learning-teaching process was done was implemented on the basis of the principles of School Mathematics explained in relation to ML. The studies included in more than one principle during the examination were classified under the principle in which they were emphasized.

As a result of preliminary review, 181 articles were collected. 10 of these articles (Ex: Garfunkel, 2007; Yenilmez, 2011) were not included in the study because they included on mathematical literacy in a few sentences and focused on different subjects. Even though 12 articles contained ML, they were excluded since those articles contained conceptual content (e.g. Bansilal, 2014; Kilpatrick, 2001; Ojose, 2011) that the nature of mathematics the essence of ML, etc., that did not conform to the principles. In 28 articles, the relationship between ML and language, professional interest, writing skills and so on variables was examined. Since these articles were not appropriate with the principles, it was decided that they were not related to the mathematics learning and teaching process and were not included in the study. In 55 articles, PISA results rather than ML and PISA’s data collection tools other than literacy were emphasized. These articles were also found to be inconsistent with the principles and were not included in the analysis. In two other articles, a new approach (Gabriel, Signolet, & Westwell, 2018) and discourse analysis in ML (Hillman, 2004) were emphasized. These studies had an academic emphasis, but were not included in the analysis since they were not related to the educational process. The remaining 74 articles were found to be related to the principles in terms of content and examined by thematic analysis. A few examples of the evaluation related to the principles are presented in Table 1.

Table 1. Example of Classification of Articles in Terms of Compliance with the Principles of School Mathematics

Article	Content	Principle
Cheung (2017)	Examining the disadvantaged students of the top five Asian countries by ML and some variables according to PISA 2012	Equality
Vithal (2006)	A discussion on the ML curriculum reforms in South Africa	Curriculum
Leibowitz (2016)	Examining a teacher's teaching strategies aiming to help students to gain basic literacy knowledge about algebra	Teaching
Firdaus, Wahyudin, & Herman (2017)	Improving ML achievement levels of primary school students through problem-based learning and direct instruction	Learning
Sari and Wijaya (2017)	Determining students' ML achievement levels through ML problems	Assessment
Verster (2009)	Supporting ML teachers through the online network in ML practices and the ML problem solving process	Technology
Ojose (2011)	The essence and competencies of ML, the nature of mathematics	Not applicable

The articles in the relevant literature in the direction of Principles for School Mathematics (NCTM, 2000) were examined and the distribution of the studies according to the principles was given in Table 2.

Table 2. Distribution of Studies by the Principles of School Mathematics

Principles of School Mathematics	**f**	**%**
Equality	1	1.4
Curriculum	2	2.7
Teaching	24	32.4
Learning	31	41.9
Assessment	8	10.8
Technology	8	10.8
Total	74	100

41.9% of the articles whose given frequencies and percentages were given in Table 2 were related to the learning principle of these principles in question. The minimum percentage belonged to the principle of equality with only one article.

Data Analysis

The thematic matrix developed by Çalık et al. (2005), Ünal, Çalık, Ayas, and Coll (2006) and Kurnaz and Çalık (2009) was used to determine the content of thematic analysis. The main themes focused on by these studies are as follows: reasons, purposes, methodology (sample type and size, data collection, data analysis, etc.), general claims, conclusions for teaching and learning, implications for curriculum development and future research (Çalık et al., 2005; Ormancı, Çepni, Deveci, & Aydın, 2015; Ultay & Çalık, 2012; Ünal et al., 2006). In a thematic analysis where this matrix is used, the general tendencies, similarities and differences of the studies will be revealed (Çalık et al., 2005) and it will be possible to define and interpret the studies. This matrix, which was used in the organization and processing of data, consisted of two main themes of general characteristics and content characteristics and their sub-themes: The general characteristics of the research included the types of journals and the year of publication. Content features, on the other hand, included reasons, purpose, research methods, sample, results and Suggestions. Each theme included in the matrix was considered as a research problem in the study together with its sub-themes. Descriptions for each of these theme are presented in Table 3.

Table 3. The Matrix for Thematic Analysis Used in the Study

Themes	Sub-themes	Explanations
General properties	Study types	Where the study was published
	Date of Study	The year when the study was published
Content properties	Reasons	Reasons of the study
	Purpose	Main purpose of the study
	Research methods	Qualitative (such as case study, action research), quantitative (descriptive), and others (such as mixed method)
	Sample	Study sample / study group (such as teacher, teacher candidate, student)
	Results	The main results of the study
	Suggestions	The main Suggestions of the study

A total of 74 articles included in the analysis were subjected to document analysis using the matrix as illustrated in Table 3. The data obtained from the examined articles were analyzed using descriptive analysis and content analysis method. General information, defined as general characteristics, was included in the descriptive analysis and content properties were included in the content analysis. Descriptive analysis included the percentages and frequencies of the data; content analysis involved first coding the data and then combining them under appropriate themes. At the last stage, frequencies and percentages for each analysis result were calculated.

From the databases presented in the text, articles on ML were identified during the education process. Among these articles, articles addressing any of the Principles of School Mathematics introduced by NCTM (2000) were included in the study. Two researchers collaborated in this process. Even though inter-rater reliability was a controversial concept in the qualitative research (Armstrong, Gosling, Weinman, & Marteau, 1997; Pope, Ziebland, & Mays, 2000), it was used in order to increase the reliability of the qualitative analysis of the study. Two different researchers took part in the review, selection and interpretation of the articles. The articles were read individually according to the Thematic Analysis Matrix and codes were determined. Three authors collaborated during the creation of themes and categories. In the last stage, the code-categories and themes created as a result of the tripartite study were finalized in meetings with researchers working in the field of ML (other than the authors of the present study). With this style of study, a diversity of researchers was aimed (Christensen et al., 2015) which was one of the strategies of providing descriptive validity. On the draft form of the study, interviews were conducted with 3 different researchers working in the field of ML in a session where all authors were present. In this context, code-category names were updated. At the same time, it was decided to evaluate the codes under this category according to the mathematical processes as a result of the discussions on the difficulties encountered while solving the ML problems obtained from the study results. In these discussions, an arbitrator review (Christensen et al., 2015), which included a discussion with experts other than the authors, who were among the strategies to ensure theoretical validity, was conducted. Besides, the codes obtained from the analysis of the studies were presented as they were obtained from the articles in the tables available in Appendices 2, 3, 4 and 5. With this process, it was aimed to ensure the validity of interpretation (Christensen et al., 2015).

Results and Conclusion

In this section, the findings of the studies with regards to distribution were presented on the general characteristics (the type of journal and year of publication), reasons, purposes, research methods, samples, results and suggestions were given according to the order in which they were included in the research problems.

Findings Regarding the Journal Types and Years of Publication

The distribution of the studies by the types of journals presented in Table 4 and Table 4.1 in Appendix 1 were illustrated and frequency and percentages were given.

Table 4. Distribution of Studies by the Type of Journal

Index	f	%
SSCI	15	20.1
ISI	4	5.4
ESCI	21	29.
Field index	14	18.8
Other index	19	25.3
Not indexed	1	1.3
Total	74	100

When the frequencies and percentage values (Table 4) of the74 articles published in 51 different academic journals analyzed within the scope of this research are examined, it is seen that the majority of the articles were in other index, SSCI and field indexes. 25 of these articles that were published in journals indexed in national and international literature (33.7%) were carried out in Turkey.

Distribution of studies by years was given in Table 5 together with frequency and percentages.

Table 5. Distribution of Studies by Years

Years of publication of the studies	SSCI	ISI	Emerging Sources Citation	Area index (Eric)	Other index	Not indexed	Total	Percentage
2017	2			1	4		7	9.5
2016	2	2	1	2	4	1	12	16.2
2015		1		2	3		6	8.1
2014	1						1	1.3
2013	1		4	2	4		11	14.9
2012		1	4	2	2		9	12.1
2011	2		1		1		4	5.4
2010			1		1		2	2.7
2009			2		1		3	4.1
2007	2		1	1			4	5.4
2006	1		5	1			7	9.5
2005			2	1			3	4.1
2004	2						2	2.7
2002	1			1			2	2.7
1997	1						1	1.3
Total	15	4	21	13	20	1	74	100

According to Table 5, it was seen that 9.5% of the studies were published in 2017, 16.2% in 2016, and 27% of the studies in total were published between 2012 and 2013. Especially after 2012, there was clearly an increase in the studies on ML in mathematics learning-teaching process.

Findings Related to the Reasons for the Studies

While preparing Table 6 and Table 2 in Appendix 2, the frequency and percentage values of the reasons for the ML studies in the mathematics learning-teaching process were taken into account. Initially, the reasons for the studies were analyzed and they were divided into themes under the headings of shortcomings in the field, ML-related needs, the effect of teaching methods on the ML achievement, variables related to ML, achievement level in national / international examinations, teacher / student ML achievement level and use of mathematical tools. These themes were obtained by the researchers by subjecting the purposes of the studies to the content analysis and bringing similar names together within the framework of the concepts in the literature.

Table 6. Distribution of Studies by Purposes

Theme	f	%
Factors Affecting ML Achievement	25	34.2
Shortcomings in the field	14	18.9
Teacher / Student ML Achievement Level	10	13.6
The Effect of Teaching Methods	9	12.1
Level of Achievement in National / International Examinations	8	10.8
ML-Related Needs	4	5.2
Use of Mathematical Tools	3	3.9
Purpose not Specified	1	1.3
Total	74	100

When the results were examined, it was found that 20.4% of the studies emphasized the importance of Mathematical Literacy Self-Efficacy Belief (MLSEB) and the need to examine the relationship with various variables (such as sex, school achievement). For that reason, studies were carried out on students of different ages (group), teacher candidates and teachers. 8.3% of the studies indicated the need for qualified teacher training for the teaching of ML as the reason for conducting the study. Only 1.3% of the studies emphasized the necessity of taking part of ML in mathematics curricula.

Findings Related to the Aims of the Studies

Table 7 and Table 7.1 in Appendix 3 include the frequencies and percentage values for the purposes of the ML-related studies in the mathematics learning-teaching process. Firstly, the reasons for the studies were analyzed and they were divided into themes under the headings of ML achievement level (current situation, developmental process), ML teacher training, the factors effective on ML, national / international exams and problem solving (problem types, process analysis).

Table 7. Distribution of Studies by their Purposes

Theme	Category	f	%
MO Achievement Level	- Current state - Developmental process	33	44.7
ML Teacher Training		7	9.5
Factors Affecting ML		21	28.5
National / International Examinations		4	5.3
Problem Solving	- Types of Problems - Process analysis	9	12
Total		74	100

According to Table 7 and Table 7.1, the ML achievement level, which was the first main one among the themes formed within the scope of the aims of the studies, was composed of two sub-themes as it consisted of studies that described the current situation and aimed to develop and enhance this situation. The studies on the ML achievement level, which were evaluated in these two sub-themes, were statistically distinguished. For instance, 9.5% of the studies aimed to examine the effect of different teaching models on increasing the current ML achievement level of students. Moreover, 8.2% of the studies aimed to determine the current ML achievement level of the students / teachers, 5.5% the opinions about ML, and 2.7% the effect of the application on the achievement level of the students. After the ML achievement level, the second (12%) place was occupied by the studies focusing on the problem of ML and those focusing on problem solving. These studies were also classified in the sub-themes of problem types and analysis of problem solving process. In the studies classified under the sub-theme of problem types, the context preferences of the participants, the problems in the textbooks and the ML problem writing were emphasized. In the second sub-theme, the thinking styles that emerged during the ML problem solving process, the relationship between different thinking styles and ML performance and problem solving patterns were dealt with. Taking into consideration all the themes, it is seen in the MLSEB with different variables. These studies were followed by those studies that dealt with training ML teachers with 9.5% and national / international exams with ML in 5.3%.

Findings Related to the Methods, Sampling and Data Collection Tools of the Studies

Table 8 contains the frequencies and percent values for the methods of the studies on ML in the mathematics learning-teaching process.

Table 8. Distribution of Studies by their Methods

Methods	**f**	**%**
Quantitative - screening method	29	39.2
Case study	10	13.5
Qualitative research	9	12.2
Theoretical study	8	10.8
Experimental method	7	9.4
Mixed method	5	6.7
Document analysis	3	4.1
Developmental research method	2	2.7
Qualitative - teaching experience	1	1.4
Total	74	100

According to Table 8, it is seen that the screening method (39.2%), which was carried out as a quantitative research in particular, had the highest percentage. Following the screening method, it was that the case study, qualitative research and theoretical studies were predominant. In some studies (e.g. Kabael & Barak, 2016; Nel, 2012), the design of the research method was not specified and it was stated that the study was conducted only in the form of qualitative research method. This also required the writing of a qualitative research category.

Table 9 contained the frequencies and percentage values for the sample numbers of the studies examined.

Table 9. Distribution of Studies by Sample Numbers

Sample numbers	**f**	**%**
0 (No sample)	11	14,9
1 – 10	7	9,5
11 – 30	7	9,5
31 – 100	14	18,9
101 – 200	15	20,3
200 and over	20	27,0
Total	74	100

According to Table 9, 8 of the 20 articles in which there are 200 and more samples with the maximum percentage of 27% are the studies where the PISA data were used and thousands of people were included in the sample. It was seen that 20.3% of the other studies were conducted on 101-200 people and 18.9% of them were on 31-100 people. In the studies classified as 'no sample' (14.9%), conceptual explanations and discussions were conducted and therefore no sample was studied. The studies with the number of samples in the range of 1-10 and 11-30 were less than those conducted on large samples.

Table 10 contains the frequencies and percentage values of the sample and study group types included in the studies.

Table 10. Distribution of Studies by Sample Types

Sample types		f	%
Students	Undergraduate student	29	32.2
	Secondary school student	13	14.5
	High school student	8	8.9
	Primary school student	2	2.2
Teachers		19	21.1
No sample		11	12.2
PISA data		8	8.9
Total		90	100

17 of the 19 teachers mentioned in Table 10 were mathematics teachers, 1 was classroom teacher and 1 science teacher. The undergraduate students with the highest frequency were basically divided into two categories: Education faculty teacher candidates (n = 24) and other faculty undergraduate students (n = 5). 14 studies were carried out with 14 mathematics teacher candidates at the education faculty, 6 studies with science teacher candidates, 3 studies with class teacher candidates and 1 study with computer science teacher candidate. A total of 12.2% of the articles in the no sample category were theoretical, 2 were the book reviews, and 1 was curriculum review. Since the data from an international study were used without creating a new study group, it was considered appropriate to collect the PISA data under a separate categorization. Even though the number of articles examined was 74, since some articles worked with more than one sample (e.g. both teacher and students), the total number here, therefore, was 90.

Findings Related to the Results of the Studies

The results of the ML-based studies in the mathematics learning-teaching process as frequency and percentage were presented in Table 11 and Table 11.1 presented in Appendix 4. These results were divided under the themes of ML and learning-teaching models, improving ML (Problem solving and context, tips for ML education), determining and evaluating ML achievement level, the difficulties in solving ML problems, teachers' opinions about mathematics and ML, the MLSEB (variables that make / do not make (any) difference in MLSEB, variables related to MLSEB, others) and technology.

Table 11. Distribution of Studies by their Results

Theme	Category	f	%
MLSEB	- Variables that make (not) a difference in MLSEB - Variables related to MLSEB - Other	48	41.7
Improving the ML	- Problem solving and context - Tips for ML training - Student dimension - Teacher dimension	21	18.3
Difficulties Experienced in Solving ML Problem	- Comprehension oriented - Solving oriented - Evaluation oriented	14	12.2
ML and Learning-Teaching Models		7	6.1
Determining - Evaluating ML Achievement Level	- Effective factors - Evaluation tools - Other	7	6.1
Teachers' Opinions about Mathematics and ML		5	4.3
Technology		4	3.5
No Results for ML		9	7.8
Total		115	100

As seen in Table 11 and Table 11.1 regarding the results of the studies reviewed, 6.1% were related to the ML and learning-teaching models, 18.3% to developing ML, 6.1% to identifying and evaluating ML, 12.2% to the difficulties experienced in solving the ML problems, 4.3% to teachers' opinions on mathematics and ML, 41.7% to MLSEB and 3.5% to technology. In the results of 7.8% of these studies in question, no ML topics in the mathematics learning-teaching process were encounter. Let us briefly examine the three main points that have the greatest percentage. MLSEB, which was among the purposes of 24.5% of the studies reviewed (Table 7 and Table 7.1) constituted 41.7% of all the results obtained from the studies (Table 11 and Table 11.1). As shown in Table 11.1 in Appendix 4, 11 studies focused on the gender variation, and 45% of them reported that there was significant difference in the MLSEB by gender in comparison to the 55% that reported that there was no significant difference. Similarly, the differences with regards to variables such as class level, high school type graduated from, academic achievement, parental education level, teaching branch, age, seniority and type of institutions where the teachers worked were also examined. Among the results, the category of problem-solving and context under developing ML, which had 18.3% of the results, accounted for 47.6% of these results while the category of tips for ML education accounted for 52.4% of the results. When analyzing the theme of the problems experienced while solving the ML problems with the third highest percentage (12.2%), it is easily observed that understanding the problem and interpreting and using the contextual solution were among the most common difficulties experienced.

Findings Related to the Suggestions Offered in the Studies

The suggestions offered in the studies on ML in mathematics learning-teaching process in terms of frequency and percentage are illustrated in Table 12 and Table 12.1 in Appendix 5. These results were divided into themes such as academic suggestions (suggestions for the method, suggestions for the research topics, suggestions for the MLSEB perception studies, suggestions for the technology), teaching method suggestions for ML applications, suggestions to the teacher in the teaching process, teacher training suggestions and program development suggestions for the implementation process of the program, and suggestions for the assessment process).

Table 12. Distribution of Studies by their Suggestions

Theme	Category	f	%
Academic Suggestions	- Suggestions for the method - Research topic suggestions - Suggestions for the studies of MLSEB perception - Technological suggestions	76	52.4
Suggestions to Teachers in the Teaching Process		26	17.9
Teacher Training Suggestions		14	9.7
Program Development Suggestions	- Suggestions for the process of creating the program - Suggestions for the process of applying the program - Suggestions for the evaluation process	14	9.7
No Suggestion on ML		12	8.3
Teaching Method Suggestions for ML Applications		3	2.1
Total		145	100

As it is seen in Table 12 and Table 12.1, more than half of the suggestions of the studies (52.4%) consisted of academic suggestions. Academic suggestions were 44.7% in the way of method, 7.9% the research topic, 42.1% the perception of MLSEB and 5.3% the technology suggestions. 2.1% of the non-academic suggestions were teaching method for ML application suggestions, 17.9% for teaching suggestions, 9.7% for teacher education suggestions, and 9.7% program development suggestions. In 8.3% of the suggestions in these studies, the subject of ML in the mathematics learning-teaching process was not mentioned.

Discussion and Suggestions

The discussion and suggestions of the study were presented in terms of research problems in order to facilitate traceability.

Assessment and Suggestions of the Studies According to their General Properties

Within the scope of this study, a total of 74 articles were analyzed from 51 different academic journals, mostly indexed in other indexes, SSCI and field indexes. The history of studies on ML in the mathematics learning-teaching process goes back to the 90s. When we look at the distribution of the studies that constituted the sample of the present study (Table 5), it is clearly seen that the majority of the articles published between 1997 and 2017 were written after 2012. In this context, it is possible to say that the importance attached to the ML during education-training process increased especially since 2012. This increase in the number of studies can be attributed to many reasons. One of these is to increase the awareness of the gap between school mathematics and life and take into account the reorganization of national education systems accordingly. Almost all of the studies examined drew attention to the importance of PISA, developed in 1997 and implemented in 2000 for the first time, and explained how the ML was addressed in this framework.

Assessment and Suggestions of Studies by their Reasons

Considering the definitions of ML, mathematics-specific high-level thinking skills and competencies are emphasized (Kramarski & Mizrachi, 2004; Meaney, 2007); similarly, within the scope of PISA studies, it was stated that a mathematic literate person should have certain mathematical competences (communication, representation styles, strategy creation, mathematization, reasoning and arguments, symbolic language and operations, and using mathematical tools). It was also emphasized in the studied reviewed what these basic mathematical competences were and that students should attain these competences within the teaching process (e.g. Bansilal, Webb, & James, 2015; Gellert, 2004; Tai & Lin, 2015; Vithal, 2006). A limited number of studies were encountered focusing on how these competencies could be improved in the studies investigated (Oktiningrum, Zulkardi, & Hartono, 2016; Thompson & Chappell, 2007). It is clearly seen that in the studies on ML, the mathematical modeling skill, one of these competencies, was highlighted. It was stated that modeling and mathematical modeling process in these studies was one of the basic building blocks of ML and its importance for mathematical literacy was emphasized (Jablonka, 2015; Julie & Mbekwa, 2005; Kaiser & Willander, 2005; Lengnik, 2005; Mbekwa, 2006). However, when we look at the subjects of the studies carried out, it was revealed that there were a few studies that dealt with the mathematical modeling process in school mathematics in order to train mathematically literate individuals (Brown & Schäfer, 2006). From this point of view, it is understood that that there is a need for studies how mathematical modeling and mathematical competences can be handled in the teaching processes, and which teaching environments and methods should be preferred by the teachers in order to develop these competencies. Considering the fact that the competency to educate mathematically literate individuals significantly depends on the type of teaching (Altun & Bozkurt, 2017), the studies on ML can be expected to be related to the ML-appropriate organization and assessment of the teaching. The current relevant literature reveals a shortcoming in this respect. For instance, no longitudinal study of the subject has been encountered. This particular result discloses the need for a qualified planning, implementation and evaluation of teaching that will reveal the modeling and other competences.

Assessment and Suggestions of Studies by their Aims

Generally speaking, with regard to aims of quantitative based studies, the following studies were noticeably in abundance: Identifying the ML level of achievement, reclassification of ML questions (e.g.: Altun & Bozkurt, 2017), effect of different teaching models on ML achievement level (e.g.: Firdaus et al., 2017; Khaerunisak, Kartono, Hidayah, & Fahmi, 2017; Sari, Yandari, & Fakhrudin, 2017), the fact that MLSEB identified (e.g. Özgen & Bindak, 2011; Yavuz, Günhan, Ersoy, & Narlı, 2013) the relationship between the variables such as problem solving (e.g.: Gülten, 2013; Memnun, Akkaya, & Hacıömeroğlu, 2012; Sümen & Çalışıcı, 2016) and affective properties, improving the ML achievement level in technology-supported learning environments (e.g.: Chen & Chui, 2016; Kramarski & Mizrachi, 2004) and the effects of centralized examinations on ML.

In the case of qualitative-based studies, it was revealed that there were studies that addressed the opinions of what the ML was, examined the achievement level of the previous ML exams, and investigated the mathematics curricula and textbooks in terms of their suitability for mathematical literacy (e.g. İskenderoğlu & Baki, 2011). Most of these studies (Table 7 and Table 7.1) were on identifying the views of teachers and students on ML and examining the relationship of MLSEB to various variables and limited to describing them. The need to increase the number of studies focusing on the solution of teaching-related problems has become evident.

Evaluation of Studies by their Research Methods, Sample Type and Numbers

When we look at the research processes of the ML-related studies in the mathematics learning-teaching process, we can see that the most commonly used method was the screening method (e.g. Demir, 2015; Güneş & Gökçek, 2013) and this was followed by the case study method (e.g. Leibowitz, 2016; Machaba & Mwakapenda, 2017).

When we look at the distribution of the ML studies according to the sample numbers (Table 9), it is seen that the number of studies carried out with 200 and more participants was high. Some articles in this range (n = 8) were written using the PISA data. All the studies involving 101-200 participants were conducted on secondary and high school students, teachers and undergraduate students by screening method. In the other studies carried out with low number of participants ranging between 31 and 100, both qualitative and quantitative researches were carried out. These studies were qualitative studies conducted with only teachers and teacher candidates, even though they were the studies conducted with fewer participants (less than 1-10). However, the fact that the sample or the study group consisted of a small number of participants was not considered as a weakness for the study. In conclusion, the sample numbers of the researches had sufficient diversity.

The majority of the studies were conducted on students, and it is noticeable that the highest proportion of these studies was composed of undergraduate teacher trainee students (Table 10). This is thought that there may be two reasons for it: The first one is the idea of training mathematically literate teachers in the name of educating mathematically literate individuals and the second one is that the undergraduate students are the easily accessible study group for researchers. In this context, similar to the examples of Colwell and Enderson (2016), Frith and Prince (2006), there is a need to educate mathematically literate pre-service and in-service and teacher training programs of universities on how to educate mathematically literate individuals should be revised, and there seems to be a need to conduct studies on the in-service ML training for the practicing mathematics teachers. Since PISA is applied to 15-year-old students and the importance given to ML has increased with PISA, the number of studies conducted with secondary and high school students is noteworthy.

Assessment and Suggestions of Studies by their Results

When the studies on ML were examined in the education-training process, it was seen that there were largely the results related to MLSEB in the relevant literature. The studies reviewed within the scope of this particular study and whose primary aim was to identify the MLSEB levels of students, teacher candidates or teachers were all conducted in Turkey. While this particular result is indicative of the interest in the relevant field, it gives us the impression that the emphasis is on issues that are easy to investigate. It is clear that such investigations without an intervention in the teaching process are to give similar results limited to the definitions only. In fact, it was found that the teachers (Tarım, Baypınar, & Keklik, 2015) in Turkey perceived themselves to have a high level of competence in terms of MLSEB, teacher candidates (Özgen, 2015) of medium level or high-level (Güneş & Gökçek, 2013; Yavuz et al., 2013), high school students (Özgen, 2013a, 2013b; Özgen & Bindak, 2011) and FEAC (Faculty of Economics and Administrative Sciences) (Uzun & Yenilmez, 2016) students of medium level. This suggests that there is a shortcoming regarding the patterns in these studies. For instance, Bandura (1997) defined self-efficacy, one of these traits, as the perception of the ability of an individual to organize and successfully perform the activities necessary to generate a certain performance. Given this definition of self- efficacy, there should initially be an activity that must be accomplished in order for an individual to be able to create a perception, and the individual, however, should be familiar with such activities. It is clear that the results of tests such as attitudes, beliefs and self-efficacy perceptions etc. before and after the interventions that can be implemented to the teaching process can be utilized more. This result also emphasizes the need for the design and implementation of educational situations in accordance with ML.

Some other studies, on the other hand, discussed the content of programs and their resources related to ML. As an example, İskenderoğlu and Baki (2011) examined the problems, exercises and examples in the 8th grade mathematics textbook according to the PISA mathematical proficiency levels and reported that there were no questions on the 5th and 6th levels in those textbooks. Kabael and Barak (2016) examined the way that secondary school mathematics teacher candidates evaluated the PISA questions and determined that teacher candidates evaluated the objectives of these questions in terms of concept knowledge and mathematical skills measured in the question.

There are also studies that revealed the results reporting the factors that influenced the achievement of the students and what the teachers could do to improve students' the ML achievement levels. Altun and Bozkurt (2017) proposed a new classification for ML problems using the data they obtained from assessing the responses to the ML problems they applied to the 8th grade students and identified six categories. 435 eighth grade students were presented contextual ML problems and the results obtained were subjected to factor analysis, and as result of the analysis, the main components of ML were found to be *algorithmic processing, command of rich mathematical content, mathematical inference, development of mathematical suggestion for solving a problem and / or interpreting the developed suggestion, comprehension of the real life situation in mathematical language, and understanding of mathematical language in real life*. These ML studies concluded that the students failed primarily in three of these three categories; mathematical inference, development of mathematical suggestion for solving a problem and / or interpreting the developed suggestion, and comprehension of the real life situation in mathematical language. These kinds of studies can help teachers to decide where to start their endeavor in order to increase their students' ML level of achievement. This part of the literature produces teacher/teaching-oriented results. There is limited number of studies, though. More comprehensive similar studies can be carried out regarding the organization of teaching. While a meaningful relationship between ML and problem solving was mentioned in a few studies close to these researches (Akyüz & Pala, 2010; Demir, 2015; Memnun et al., 2012), it was reported that students were motivated to solve new problems that gave a sense of real events for themselves (Goldman & Hasselbring, 2010). In a study where students were made aware to realize what was important to solve a structured contextual problem and were enabled to practice to organize pieces of information, it was concluded that working and practicing on ML problems helped to improve ML (Goldman & Hasselbring, 1997). Furthermore, it was stated that with the project and research assigned to the students within the scope of ML, it was possible to provide students with the opportunity to experience and know the strengths and boundaries of mathematics (Vithal, 2006) and at the same time, generate an effective environment for structuring the curriculum of the ML course through such studies (Frith & Prince, 2006). The discussion of ML's relation to problem-solving is valuable in terms of clarifying the boundaries of these concepts.

Frith and Prince (2006) stated that while designing a curriculum for a ML teacher training that would improve teachers' ML achievement levels, it would be useful to use contextualized social practices and that teachers should be exposed to applications involving ML-based strategies or frameworks. Such studies may provide useful opportunities for the development of mathematics teaching. Additionally, these results suggest that it will be useful to examine the relationship between ML teaching methods and some of the qualities gained by being a mathematically literate. In this context, the impact of a teaching program that aims to increase ML achievement on the 21st century skills (critical thinking and problem solving, communication and collaboration), on the development of problem solving skills, the effect to development of mathematical thinking, on acquiring the basic objectives of mathematics teaching are open to discussion. Helping the students to gain a critical perspective (Frith & Prince, 2006; Lengnik, 2005) and directing the students who were open communication and collaboration to the ML classes (Spangenberg, 2012) are among the suggestions for ML training process.

In the literature regarding the difficulties experienced while solving the ML problems, the following were identified; reading comprehension (Khaerunisak et al., 2017), comprehending the problem itself (Khaerunisak et al., 2017; Sari & Wijaya, 2017), creating a mathematical model of the problem or translating it into a mathematical language (Khaerunisak et al., 2017; Sari & Wijaya, 2017), translating the mathematical model into the daily language (Altun & Bozkurt, 2017; Kaiser & Willander, 2005), implementing the necessary procedures to complete a job or solve a problem (Khaerunisak et al., 2017; Sari & Wijaya, 2017), interpreting and using the contextual solution (Bansilal, Mkhwanazi, & Mahlebela, 2012; Brown & Schäfer, 2006; Sari & Wijaya, 2017), assessing and discussing an explanation, assessing and discussing a solution (Altun & Bozkurt, 2017; Sari & Wijaya, 2017) and distinguishing the information to be used in the solution (Meaney, 2007).

In many studies, measures to improve ML achievement level are expressed. It is important to pay attention to the principles and methods of mathematics education in order to increase students with lower ML achievement levels to higher levels (Cheung, 2017). It was stated in order to develop ML in students, the following were necessary; concretization, interest, interaction, thinking (Özgen & Kutluca, 2013), attitude (Akyüz & Pala, 2010), communication, representation (Thompson & Chappell, 2007), paying attention to the emotional properties (Demir, 2015) and flexible participation in both contextual and mathematical fields (Bansilal et al., 2012). In addition to these, in ML education, it was stated that in order to make the right choices, it was beneficial to know students' thinking styles (Spangenberg, 2012), use mathematical idealization and interpretation together (Brown & Schäfer, 2006). Spangenberg (2012) revealed the importance of thinking styles for ML achievement in her study that aimed to compare students' thinking styles and ML achievement for the students taking mathematics and ML courses. In their study in which they used modeling as a tool for ML teaching, Brown and Schäfer (2006) emphasized that the teacher's lack of mathematical skills was not the only obstacle in their attempt to succeed, but the teacher's mathematical skill level was also an important factor of the overall achievement. These studies that touched on the quality and content assessed ML teaching in different ways. They offered many new opportunities to increase ML achievement in terms of their reflection in teaching.

Some studies discussed the teaching models that were effective on ML teaching. It was stated that ML was affected by the teaching model that was used (Firdaus et al., 2017; Özgen & Kutluca, 2013) and the problem-based learning model (Firdaus et al., 2017; Sari et al., 2017), the RME (Khaerunisak et al., 2017), the inclusive strategy-based mathematics education (Gellert, 2004) were the effective models in ML teaching. According to Lutzer (2005), although literacy could be taught directly in a simple way, it was necessary to practice intensively for the strongest teaching of ML. Teachers can present this to the students through daily exercises, discussions and demonstrations.

Evaluation of the Studies by the Suggestions

Suggestions of the studies analyzed within the scope of thematic analysis; they were classified as suggestions for teaching process, teacher training and curriculum development suggestions, academic suggestions for the researchers. Some of the suggestions mentioned in the scope of the studies are listed below.

Some of the suggestions for the teaching process are as follows: It was emphasized that the problem-based learning approach (Firdaus et al., 2017; Oktiningrum et al., 2016; Sari et al., 2017) and the RME (Khaerunisak et al., 2017) should be included in the ML applications that would allow for concrete and intuitive reasoning (Akın & Kabael, 2016). In the teaching process, it is recommended that teachers should take into consideration students' pre-learning (Spangenberg, 2012), thinking (Spangenberg, 2012) and learning styles (Özgen, 2013b); they should also take into consideration the environmental conditions (Frith & Prince, 2006; Julie, 2006; Khaerunisak et al., 2017), analyze the difficulties students experienced (Khaerunisak et al., 2017), apply teaching methods (Gatabi, Stacey, & Gooya, 2012; Leibowitz, 2016; Özgen, 2013a; Tai & Lin, 2015) that catered for students with different individual characteristics and develop (Geldenhuys, Kruger, & Moss, 2013) and use (Uysal & Yenilmez, 2011) materials and practices that would make the lessons interesting.

It was stated that teachers should use the ML problems (Bansilal, 2011; Dewantara, Zulkardi, & Darmawijoyo, 2015; Uysal & Yenilmez, 2011) that would include real world contexts in the teaching process (Kaiser & Willander, 2005), taking into account their vital interests beyond the instructional notes for the development of ML (Matteson, 2006) and getting them to do certain activities (Khaerunisak et al., 2017; Uysal & Yenilmez, 2011) that would contribute to the development of ML skills. It was stated that the ML should play a more central role relationship between mathematics and the real world in the programs (Kaiser & Willander, 2005), that the use of context in mathematics curriculum should be clearly demonstrated taking into account the importance of context in the development of ML (Machaba & Mwakapenda, 2017), that contextual problems should be dealt with more intensive and that meta-cognitive competencies should be given more consideration (Kaiser & Willander, 2005).

Some suggestions for program development are as follows: It was suggested that the ML course should be added to the teacher training programs (Güneş & Gökçek, 2013; Kabael & Barak, 2016; Machaba & Mwakapenda, 2017; Özgen, 2015; Özgen & Kutluca, 2013; Şefik & Dost, 2016) and the activities related to the ML should be implemented in the courses (Güneş & Gökçek, 2013; Machaba & Mwakapenda, 2017; Şefik & Dost, 2016) and the current ML approach should be adopted in the undergraduate courses (Memnun et al., 2012; Özgen, 2015). In the environments where ML courses were already given; the teachers were suggested to guide the students who were collaborative and outgoing to choose the ML courses (Spangenberg, 2012), make students become aware of the strengths / weaknesses of mathematics and give the students activities that would help them to gain a critical perspective on mathematics in social life (Frith & Prince, 2006; Lengnik, 2005). However, it was suggested that teacher training programs be implemented and monitored at various stages, importance be given to the recruitment and placement processes of teachers (Bansilal, Goba, Webb, James, & Khuzwayo, 2012) and programs be prepared that would respond to individual differences of teacher candidates (Nel, 2012).

It was suggested that literacy problems be increased in the national examinations (Jürges, Schneider, Senkbeil, & Carstensen, 2012; Uysal & Yenilmez, 2011), the mathematical application and modeling process be implemented at the elementary level (Kaiser & Willander, 2005), the changing nature of the students' interests, the concept of a "universal" curriculum implemented for ML among countries, in countries and even at individual levels be adopted. Furthermore, it emphasized that teachers be supported in order to improve the classroom practices (Geldenhuys et al., 2013), seminars be provided to the teachers and parents (Akyüz & Pala, 2010; Uysal & Yenilmez, 2011), shortcomings in the programs be eliminated using the results of the PISA, TIMSS and PIRLS projects and the programs be improved (Howie & Plomp, 2002; Uysal & Yenilmez, 2011).

General Evaluation

An article on ML may intrinsically have two main categorical objectives: The first is *to describe a situation by summarizing the information and so make it more easily perceivable,* and the second is *to identify the problem and propose a model for solving these problems, to improve the ML achievement level by testing and assessing this model.* The majority of the studies reviewed and especially the ones done in Turkey in particular are classified in the first category; that is, they are limited to descriptive definitions (e.g., demographic characteristics of the participants, attitudes, beliefs, self-efficacy, and book review). The studies in the second category, namely the studies aimed at solving the problem, are not sufficient in number.

Particularly, results of the studies that reported the difficulties experienced in solving the ML problems (e.g., Altun & Bozkurt, 2017) may be a departure point to improve the ML teaching and replication of such research seems to be a need. When the results of these studies are taken into account together with the problem-solving process skills (formulating, implementing, assessing (OECD, 2016)), a new classification of sources of difficulty (Table 11) would be obtained. It is possible to benefit from this classification in teaching as well. In OECD (2016), it was clearly stated which skill or behavior the individual was expected to demonstrate during the process of problem solving. In this context, it is clearly seen which process corresponds to the difficulties identified in the study. Of these difficulties identified in the literature, *understanding the problem, creating the mathematical model of the problem, assessing and discussing an explanation* seem to point to the difficulties regarding the formulation step of the process; *distinguishing the information to be used and applying the necessary procedures for a solution* seem to point to the difficulties regarding the implementation step of the process; *interpreting and using the contextual solution, translating the mathematical model into the daily language, assessing and discuss a solution* seem to point to the difficulties regarding the interpretation and assessment step of the process (Figure 2).

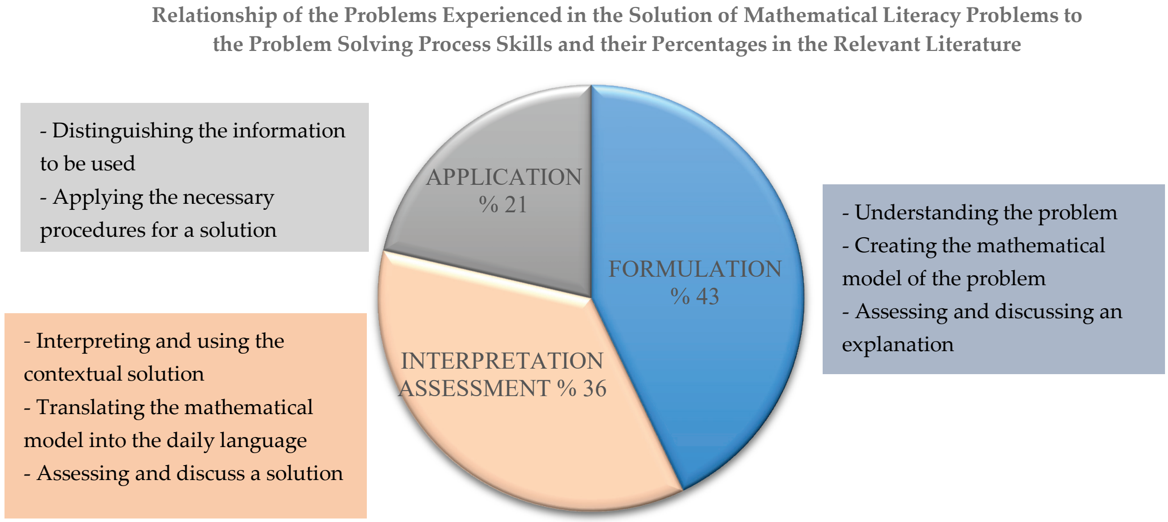

Figure 2. Relationship of the Problems Experienced in the Solution of Mathematical Literacy Problems to the Problem Solving Process Skills and their Percentages in the Relevant Literature

- When the results OECD (2016) of the articles reporting the difficulties in solving the ML problem are evaluated together with the explanations given, it is understood that the studies concentrated on the formulation (43%) and interpretation-assessment (36%) processes (Figure 2). The difficulty frequency found in the implementation process (21%) is relatively low compared to the others. This review suggests that the knowledge regarding the formulation and interpretation-evaluation processes in the measures to be taken in teaching and the applications related to these processes should be increased.

In addition to the direct suggestions by the studies, the following are the suggestions of the authors based on their thematic analyses:

- It is observed that the study samples were restricted mainly to this age group or teacher candidates, with reference to the age group to which PISA was applied. Given the fact that mathematical literacy is a matter of process, there is a need for studies dealing with the appropriate ML teaching, including primary and secondary school students and other age groups,

- If the attitudes, beliefs, and perceptions of self- efficacy perception measurements regarding ML achievement tools are to be used as components in the studies involving teaching practices, they will have more beneficial consequences,

- It is thought that there are no studies related to the creation of social awareness about ML and increasing family and social awareness would be a good topic to investigate.

- It is commonly seen that the questions that measure ML achievement level in the PISA applications are varied. In the studies examined, no study or results were encountered which of these question types or which of them were more effective in revealing the ML achievement levels. The types of questions appropriate to the ML competencies and the limitations of current examinations in establishing the ML competencies can be investigated.

- There are sufficient numbers of studies that comparatively examine ML achievement levels of countries. Based on these studies, researches on how to reflect the local culture on to ML can be implemented.

- Most of the studies were limited to performing descriptive analyses. It is thought that there is a need for studies in which teaching applications and assessments are made based on these descriptive analyses. Additionally, using further statistical analyses, it may be useful to plan studies that can more clearly express the distinction between successful and unsuccessful ML.

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Appendix 1

Table 4.1. Distribution of the Studies by the Types of Journals

Journal Names	Index	f	%	f	%
Educational Studies in Mathematics	SSCI	2	2.8	15	20,1
Education and Science	SSCI	2	2.8		
International Journal of Science and Mathematics Education	SSCI	2	2.8		
International Journal of Educational Development	SSCI	1	1.3		
The Asia-Pacific Education Researcher	SSCI	1	1.3		
British Journal of Educational Technology	SSCI	1	1.3		
Teaching and Teacher Education	SSCI	1	1.3		
Journal of Learning Disabilities	SSCI	1	1.3		
Reading & Writing Quarterly	SSCI	1	1.3		
The Journal of Educational Research	SSCI	1	1.3		
Educational Sciences: Theory & Practice	SSCI	1	1.3		
An International Journal of Experimental Educational Psychology	SSCI	1	1.3		
South African Journal of Education	ISI	2	2.8	4	5,4
Participatory Educational Research (PER)	ISI	1	1.3		
International Journal of Education Science and Technology	ISI	1	1.3		
Pythagoras	ESCI	5	6.8	21	29,1
African Journal of Research in Mathematics, Science and Technology Education	ESCI	3	4.2		
Perspectives in Education	ESCI	3	4.2		
International Journal of Mathematical Education in Science and Technology	ESCI	3	4.2		
ZDM Mathematics Education	ESCI	2	2.8		
Africa Education Review	ESCI	2	2.8		
Hacettepe University Journal of Education	ESCI	2	2.8		
Research in Mathematics Education	ESCI	1	1.3		
Journal of College Teaching & Learning	Field index	2	2.8	14	18,8
Journal of Mathematics Education - IndoMS	Field index	2	2.8		
Educational Research and Reviews	Field index	2	2.8		
Journal of International Education Research	Field index	1	1.3		
Reading Psychology	Field index	1	1.3		
Economics of Education Review	Field index	1	1.3		
Mathematics Education Research Journal	Field index	1	1.3		
Problems, Resources, and Issues in Mathematics Undergraduate Studies	Field index	1	1.3		
Teaching Mathematics and its Applications	Field index	1	1.3		
International Journal of Research in Education and Science	Field index	1	1.3		
Journal of Mathematical Behavior	Field index	1	1.3		
Journal of Physics: Conference Series	Other index	2	2.8	19	25,3
Dicle University Journal of Ziya Gökalp Faculty of Education	Other index	2	2.8		
HAYEF: Journal of Education	Other index	2	2.8		
International Journal of Education and Development using Information and Communication Technology	Other index	1	1.3		
International Journal of Educational Sciences	Other index	1	1.3		
Jurnal Riset Pendidikan Matematika	Other index	1	1.3		
Journal of Qualitative Research in Education	Other index	1	1.3		
Journal Of Social Science, Eskisehir Osmangazi University	Other index	1	1.3		

Table 4.1. Continued

Journal Names	**Index**	**f**	**%**	**f**	**%**
Infinity Journal of Mathematics Education	Other index	1	1.3		
Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education	Other index	1	1.3		
Electronic Journal of Education Sciences	Other index	1	1.3		
Adıyaman University international journal of social science	Other index	1	1.3		
Trakya University Journal of Education	Other index	1	1.3		
Ankara University Journal of Faculty of Educational Sciences	Other index	1	1.3		
Elementary Education Online	Other index	1	1.3		
Turkish Journal of Computer and Mathematics Education	Other index	1	1.3		
Interdisciplinary Undergraduate Research Journal	Not indexed	1	1.3	1	1,3
Total		74	100	74	100

Appendix 2

Table 6.1. Distribution of Studies by Reasons

Theme	Code	f	%	f	%
Factors affecting the ML achievement	The need to examine the ML self-efficacy belief (MLSEB) in terms of various variables	15	20.4	25	34.2
	The necessity of revealing the relationship between context and content in terms of ML	3	4.3		
	The importance of investigating the impact of contextual changes on the ML level	2	2.8		
	Communication / representation processes as critical tools that help to improve ML	2	2.8		
	Teacher candidates' views on ML were important in terms of their significance to their knowledge and skills	1	1.3		
	The need to determine the variables that were thought to be related to ML	1	1.3		
	Describing the relationship between the emotional and ML skills of students contributed to the understanding of the nature of the concept	1	1.3		
Shortcomings in the field	A limited number of studies on teacher candidates' skills and views on ML	4	5.5	14	18.9
	A small number of studies on the impact of new technologies on ML	2	2.8		
	The influence of affective properties on ML were not examined	2	2.8		
	Lack of pedagogy and assessment examples of ML	1	1.3		
	A small number of studies examining the relationship between problem solving style and ML	1	1.3		
	The previous studies were only at the micro level	1	1.3		
	Knowing little about life orientation and how ML learning areas are experienced by the students	1	1.3		
	Teachers' preferences for contexts were a very unexplored area	1	1.3		
	Lack of international examples and experimental data on ML	1	1.3		
Teacher / student ML achievement level	The necessity of finding qualified teachers to teach ML	6	8.4	10	13.6
	Incompatibility of teachers' identities as envisaged in the curriculum and those receiving the ML education	1	1.3		
	Generating a mechanical solution as a reason for students' difficulties in ML	1	1.3		
	The necessity for each student to earn a certain level of ML	1	1.3		
	The importance of investigating the ML-related achievements of students studying in any discipline	1	1.3		

Tablo 6.1. Continued

Theme	Code	f	%	f	%
Effect of the teaching methods	The suitability of problem-based learning to develop the ML skills and competences	2	2.8	9	12.1
	Designing appropriate teaching instruction to develop ML	2	2.8		
	Realistic mathematics teaching (RMT) provided appropriate learning processes for the development of concepts and ideas related to everyday situations	1	1.3		
	The importance of offering ideas of how ML was taught in the classroom environment	1	1.3		
	If the practice community was an area where ML was shared and enabling the teachers to be in active communication	1	1.3		
	The traditional approach of the school were unable to develop the ML levels	1	1.3		
	Practices to develop ML and developing the teaching instructions that would help students to gain the ML specific skills	1	1.3		
Achievement level in national / international examinations	Low achievement levels Indonesian students in ML	2	2.8	8	10.8
	Effect of central examinations on ML	2	2.8		
	The importance of determining and comparing the PISA achievement level of students who succeeded in the central examinations	1	1.3		
	Academic resilient[1] students' ML achievement was worth investigating	1	1.3		
	High achievement levels of students in Finland in ML	1	1.3		
	International comparative examinations had various functions in terms of ML for educational policy makers, practitioners and researchers	1	1.3		
ML-related needs	Seeking classification based on the difficulty of explaining ML achievement	1	1.3	4	5.2
	Due to the differences in mathematics and ML nature, the need for students to have different thinking styles in attaining these topics	1	1.3		
	The growing awareness of the inadequacy of the 21st century skills created an atmosphere for the development of ML concepts	1	1.3		
	Existing evaluation systems have yet been unable to reveal the ML skills of the students	1	1.3		
Use of mathematical tools	The need to represent ML well in mathematics curriculum and textbooks	1	1.3	3	3,9
	Effect of the questions in the textbooks on the low achievement in the PISA exams	1	1.3		
	The important role of didactic material in the students' mathematical activities related to ML	1	1.3		
No reasons were specified		1	1.3	1	1.3
Total		74	100	74	100

[1] The students participated in PISA 2012 from disadvantaged homes were identified with the concept of academic resilient. Such students are able to overcome disadvantages problems and difficulties at home, and often achieve high academic achievement by international standards (Cheung, 2017).

Appendix 3

Table 7.1. Distribution of Studies According to their Purpose

Theme	Category	Code	f	%	f	%
ML achievement level	Current situation	Determining the ML achievement level	6	8.2	33	44.7
		Identifying opinions related to ML	4	5.5		
		Determining the progress related to ML	2	2.7		
		Identifying the key components that will explain ML achievement	1	1.3		
	Developmental process	Effect of teaching instruction models on the ML development	7	9.5		
		Demonstrating and proposing teaching practices related to ML	5	6.8		
		Helping students to gain ML skills in the technology environment	4	5.5		
		Studying the students' orientation on ML and life	1	1.3		
		Investigating what ML can offer in terms of mathematical competence	1	1.3		
		Explaining an instruction that will help students to understand what they read for their ML development	1	1.3		
		The effect of the significance given to ML on the didactic material concepts	1	1.3		
Factors that have effect over ML		Demonstrating the relation between ML and MLSEB together with other variables (affective characteristics, problem solving, etc.)	18	24.5	21	28.5
		Demonstrating communication and representation in attaining ML	2	2.7		
		Effect of context on the ML level	1	1.3		
Problem solving	Problem types	Identifying the context preferences and reasons for teachers / students' ML problems	2	2.7	9	12
		Examining the problems in the textbooks in terms of ML	2	2.7		
		Producing a series of PISA-like mathematical problems	2	2.7		
	Process analysis	Characterizing the thinking styles of math and ML students	1	1.3		
		Examining students' ways of thinking in the problem solving process and examining their ML performances	1	1.3		
		Identifying how problem solving patterns are related to ML	1	1.3		
Training ML teachers		Demonstrating ML teacher training process and making suggestions	6	8.2	7	9.5
		Determining the identity transformations of teachers in the process of becoming ML teachers	1	1.3		
National/ International exams		The effects of central examinations on ML	2	2.7	4	5.3
		Identifying the similarities and differences among students of highly successful countries in the PISA ML	1	1.3		
		Examining the relationship between Mathematics course applications and PISA achievements	1	1.3		
Total			74	100	74	100

Appendix 4

Table 11.1. Distribution of Studies by Results

Theme	Category	Code	f	%	f	%
MLSEB	MLSEB variables that make / do not make (any) difference	There is (no) a significant difference according to gender.	11(5/6)	9.6	48	41.7
		There is (no) a significant difference according to class level.	7(6/1)	6.1		
		There is (no) a significant difference according to the type of high school graduated from.	5(3/2)	4.3		
		There is (no) a significant difference according to academic success.	4(3/1)	3.5		
		There is (no) a significant difference according to parents' level of education.	2(1/1)	1.7		
		There is a significant difference according to the teaching branch (in favor of mathematics and science teachers).	2	1.7		
		There is no significant difference according to age.	1	0.9		
		There is no significant difference according to seniority.	1	0.9		
		There is a significant difference according to school type (in favor of secondary school teachers.	1	0.9		
	Variables Related to MLSEB	There is a significant relationship between problem solving skills and MLSEB.	3	2.6		
		There is a significant relationship between the attitude towards mathematics and MLSEB.	2	1.7		
		There is a significant positive relationship between critical thinking scores and MLSEB.	1	0.9		
	Other	Teacher candidates' MLSEB is medium / high.	4(1/3)	3.5		
		Teacher candidates need to develop their MLSEB.	1	0.9		
		Teachers' MLSEB is sufficient.	1	0.9		
		MLSEB varies significantly according to their learning styles.	1	0.9		
		Self-efficacy is the most important variable affecting the ML level.	1	0.9		
Improving ML	Problem Solving and Context	There is a significant relationship between ML and problem solving.	3	2.6	21	18.3
		In the development of ML, such factors as embodying, interest, interaction and thinking are important.	2	1.7		
		Working on PISA-like problems has the potential to improve ML.	1	0.9		
		The contextual problem allows students to realize what is important to solve the problem and practice to organize individual pieces of information.	1	0.9		
		Students feel motivated to solve new problems when problems give them a sense of reality.	1	0.9		
		Teachers should be exposed to practices that involve ML-based strategies or frameworks.	1	0.9		
	Teacher dimension	Knowing the way students think is helpful for teachers to choose the right subject.	1	0.9		
		The mathematical skill level of the teacher is an important factor of his/her success.	1	0.9		
	Student dimension	There is a significant relationship between ML skills and affective characteristics in 15-year-old students.	1	0.9		
		Hypersensitivity to memorization does not contribute to absolute ML achievement.	1	0.9		
	Tips for ML education	It is useful to use contextualized social practices when designing a curriculum for ML teacher education.	1	0.9		
		It is important to pay attention to the principles and methods of mathematics education in order to elevate students with lower ML achievement levels to higher levels.	1	0.9		
		Effective use of control strategies can contribute to ML achievement.	1	0.9		
		In ML education, it was found useful to consider mathematical idealization and interpretation together.	1	0.9		

Table 11.1. Continued

Theme	Category	Code	f	%	f	%
	Tips for ML education	Communication and representation are essential elements in the development of mathematical literacy.	1	0.9		
		For ML achievement, flexible participation is required both in contextual and mathematical fields.	1	0.9		
		Implementation of a research activity provides an effective environment for structuring the curriculum of the ML course.	1	0.9		
		Opportunity to work with a project that will help students to grasp the concept provides students with the opportunity to experience and know the limits and strengths of mathematics.	1	0.9		
Difficulties in solving ML problems	Comprehension oriented	Understanding the problem	3	2.6	14	12.2
		Interpreting and using the contextual solution	3	2.6		
	Solving oriented	Creating a mathematical model of the problem	2	1.7		
		Applying the necessary procedures for solution	2	1.7		
		Translating the mathematical model into everyday language	1	0.9		
	Evaluation oriented	Evaluating and discussing an explanation	1	0.9		
		Evaluating and discussing a solution	1	0.9		
		Distinguishing the information to be used	1	0.9		
No results available for ML			9	7.8	9	7.8
Determining and evaluating ML achievement level	Effective factors	Problem solving styles of students are influencing ML achievement levels.	1	0.9	7	6.1
		ML level of achievement may be related to mathematical thinking.	1	0.9		
		Increasing the emotional abilities of the individual may increase the level of ML achievement.	1	0.9		
	Evaluation tools	ML achievement level can be identified using PISA-like problems.	1	0.9		
		The key components that can be used to explain ML achievement can be determined by factor analysis.	1	0.9		
	Other	In the PISA questions, the 15-year-old group and undergraduate students show similar achievements.	1	0.9		
		The success of a program for everyone for ML is measured by the number of students who are persistent and confident in their mathematics work.	1	0.9		
ML and learning-teaching models		ML is influenced by the teaching model used.	2	1.7	7	6.1
		The problem-based learning model improves ML.	2	1.7		
		RMT is an effective approach on ML.	1	0.9		
		inclusive strategy-based mathematics education may be a suitable model for ML.	1	0.9		
		Intensive practice is the most powerful teaching tool for ML.	1	0.9		
Teachers' opinions about mathematics and ML		Mathematics is considered as an abstract and content-oriented discipline.	1	0.9	5	4.3
		The relationship between context and context is not well known.	1	0.9		
		Mathematics and ML are regarded as inseparable from each other.	1	0.9		
		Situations which come from students' past experiences and which do not conflict with their ideas can be used as context.	1	0.9		
		The context is considered as a means to access the mathematical content.	1	0.9		

Table 11.1. Continued

Theme	Category	Code	f	%	f	%
Technology		Online communities enable teachers to learn how to deal with problems.	1	0.9	4	3.5
		The resources they can access to establish learning links can create a comfortable space where they can access, share and interact with others.	1	0.9		
		Interactive video technology enables students and teachers to instantly review video sections.	1	0.9		
		Connected learning environments earn students experience in using mathematical skills to solve real-world problems.	1	0.9		
Total			115	100	115	100

Appendix 5

Table 12.1. Distribution of Studies by Suggestions

Theme	Category	Code	f	%	f	%
Academic suggestions	Suggestions for the method	Comprehensive / in-depth research should be implemented	11	7.6	76	52.4
		Mixed methods should be used	6	4.1		
		International comparative studies should be implemented	5	3.4		
		Large samples should be used	5	3.4		
		Similar studies should be repeated for different groups and class levels for the generalization of research results.	3	2.1		
		Experimental studies on ML and problem solving skills should be carried out	2	1.4		
		Samples should be chosen randomly	1	0.7		
		Experimental interventions that contribute to ML in researches should be done	1	0.7		
	Suggestions for the research topics	Research should be done to improve the ML of primary school students	1	0.7		
		Communication skills of the students in ML courses should be identified and analyzed	1	0.7		
		Investigating the factors affecting PISA mathematics achievement in natural environments	1	0.7		
		different variables in PISA data should be subjected to advanced statistical analysis	1	0.7		
		Examining the factors that hinder mathematics achievement	1	0.7		
		Examining the levels of the questions in the textbooks (8th and 9th grade)	1	0.7		
	Suggestions for the MLSEB	Identifying the MLSEB perceptions	8	5.5		
		Examining the MLSEB beliefs in terms of different variables	8	5.5		
		Examining the relation of MLSEB perception to some variables	6	4.1		
		Improving the MLSEB perceptions	5	3.4		
		Investigating the causes why MLSEB perception is not at high level	3	2.1		
		Investigating the relationship between ML level and MLSEB level of perception	1	0.7		
		Investigating the MLSEB perceptions of teachers who are not graduates of Faculty of Education	1	0.7		
	Suggestions for the technology	Networks should be created where teachers can share	1	0.7		
		Exploring the differences between cooperative learning and a teacher's teaching through face-to-face computerized scenarios	1	0.7		
		Examining the reciprocal interaction between students' metacognition and academic achievement in a learning environment where technology is used	1	0.7		
		Implementing research about how efficient discussions will arise in online communication	1	0.7		
Suggestions to the teacher in the teaching process		ML problems and applications should be used in lessons	6	4.1	26	17.9
		Planning lessons that take into account the individual differences of students	5	3.4		
		Helping student gain a critical perspective	2	1.4		
		Watching for appropriate environmental conditions	2	1.4		
		Developing and using materials and practices that will make the lessons interesting	2	1.4		

Table 12.1. Continued

Theme	Category	Code	f	%	f	%
Suggestions to the teacher in the teaching process		Being aware of the vital benefits of developing ML	1	0.7		
		Guiding the students who are open to communication and cooperation to choose ML courses	1	0.7		
		Taking into consideration pre-learning of students	1	0.7		
		Taking into account learning style of students	1	0.7		
		Initiating various actions based on mathematical analysis for children with low socio-economic status	1	0.7		
		Helping students to recognize the strengths and weaknesses of mathematics	1	0.7		
		Guiding students to the structuring of mathematical arguments and carry out research to determine whether they are successful.	1	0.7		
		Analyzing the difficulties experienced by the students	1	0.7		
		Providing opportunities to the high school students to create graphical representations while solving algebra problems	1	0.7		
Teacher training suggestions		Adding ML courses to undergraduate programs	8	5.5	14	9.7
		Getting the teacher candidates in undergraduate education to perform ML activities	3	2.1		
		Adopting the current ML approach in undergraduate courses	2	1.4		
		Integrating the related subjects in science and mathematics teaching programs	1	0.7		
Program development suggestions	Suggestions for program creation process	The concept of "universal curriculum" should be adopted for ML	1	0.7	14	9.7
		One of the main aims of basic education should be that students are mathematically literate	1	0.7		
		The relationship between mathematics and the real world should play a “more central role” in programs	1	0.7		
		"Basic and advanced ML" objectives should be defined in detail for individuals	1	0.7		
		Mathematical application and modeling process should also be reflected in primary school level	1	0.7		
		The curriculum should clearly show the use of context in mathematics	1	0.7		
	Suggestions for the implementation of the program	Seminars should be given to mathematics teachers and students' families	2	1.4		
		More clear problems should be used intensively with real world contexts and meta-cognitive competences should be paid more attention	1	0.7		
		Additional math courses, math competitions and projects should be disseminated to all schools	1	0.7		
	Suggestions for the assessment process	Literacy problems should be augmented in the national exams	2	1.4		
		The results of the PISA, TIMSS and PIRLS projects should be used to eliminate shortcomings in the program.	2	1.4		
No suggestions for ML			12	8.3	12	8.3
Teaching method suggestions for ML applications		RMT should be used	1	0.7	3	2.1
		Problem-based learning approach should be used	1	0.7		
		Teaching environments where students can make concrete and intuitive judgments should be created	1	0.7		
Total			145	100	145	100