

Secondary Mathematics Teachers' Conceptions of the Barriers to the Development of Mathematical Literacy

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The purpose of this study was to investigate secondary mathematics teachers' conceptions of the barriers to the development of mathematical literacy. The data were collected through semi-structured interviews with sixteen in-service mathematics teachers from nine secondary schools of five different school types. The data analysis consisted of an inductive analysis process for identifying and labeling the patterns or themes through examining interview data with the help of NVivo qualitative data analysis software. The results indicated that teachers' conceptions regarding the barriers to mathematical literacy development could be categorized under: (i) conceptual challenges (What is mathematical literacy?); (ii) educational challenges (How can we develop mathematical literacy?); and (iii) systemic challenges (Where is mathematical literacy (to be) located?). The teachers' identification of different obstacles to the development of mathematical literacy can account for the fact that each teacher in this study has diverse but convergent conceptions of mathematical literacy. This fact also promises hope for assisting teachers in resolving these obstacles that have been raised from various angles.

The development of mathematics education aiming at producing mathematically literate citizens who are mathematically competent in every way to engage with life's complex and diverse problems is of concern in many countries (Organization for Economic Co-operation and Development [OECD], 2013a). Although mathematical literacy is considered important for people to achieve their full potential, many do not feel prepared to use their mathematical literacy skills in their personal, working, or social life (Roohr, Graf, & Liu, 2014). The literature shows that any description of the competence in different levels of mathematical literacy partially depends on the individuals' level of mathematical knowledge and skills (Coben, 2000; Manaster, 2001; Niss, 2015). In other words, with necessary mathematical knowledge and understanding, people can automatically acquire the desirable power to deal effectively with everyday problems (OECD, 2013a; Turner, Blum, & Niss, 2015). Mathematics is, therefore, powerful and crucial for future citizens (Hoyles & Noss, 2000). However, Benn (1997) reports that the majority of adults have probably had a traumatic school experience with mathematics. Thus, if a real-life problem is thought to involve mathematics, then it can be avoided, and rather than performing school mathematics confidently and competently, various alternative strategies can be employed (Ashcraft & Kirk, 2001). This avoidance can lead to math anxiety, and although it is seen as an essential factor in predicting the success of mathematics (Ashcraft & Moore, 2009), its excess is often associated with poor performance in mathematics (Galla & Wood, 2012). Indeed, Noss (1991) emphasizes that many people are motivated to learn mathematics to make life easier and gain different perspectives, but:

...mathematics, at least the mathematics of the school classroom, is typically seen as hard-edged, as a subject in which meaningless problems are posed at best about real but material objects but often about unreal and meaningless objects (pp. 81-82).

Willis (1992) argues that while the necessary call for higher levels of mathematical literacy relies on the assumptions about the intrinsic usefulness of mathematics, narrowly traditional ways of defining the subject and an implicit acceptance of the naturalness of the

mathematical meritocracy prevent any real change. That is, traditional school mathematics curricula, unfortunately, do not deal consistently with all aspects of mathematical literacy (Steen, 2001). Many argue that the traditional mathematics curricula fail learners because it underlines a kind of mathematics that differs radically from the one that is used at work (Hoyles, Noss, Kent, & Bakker, 2010; OECD, 2016). Even though the middle and high school curricula highlight the importance of developing students' ability to decide when and how mathematical concepts should be used, actual teaching practices emphasize traditional mathematics skills and understanding, and fail to develop learners' ability to implement mathematical knowledge for handling authentic problems in a broad range of contexts (Stacey et al., 2015). According to Hope (2007), the traditional way of mathematics teaching at school is more formal, less intuitive, more abstract, less contextual, more symbolic, and less practical than the type of teaching that encourages student thinking and mathematical literacy.

Embedding the skills required to be mathematically literate into the existing mathematics curriculum is essential. However, it is more important for teachers to foster those skills within their teaching practices as the implementation of these practices in the classroom is the major factor influencing learning outcomes of being mathematically literate (OECD, 2009; OECD, 2010). This brings us the importance of how crucial is the role of teachers in the planning and implementation of the mathematics curriculum for cultivating the knowledge of mathematical literacy (OECD, 2005). There is, therefore, a great expectation from teachers to have an adequate understanding of how to incorporate mathematical literacy understanding into their instructional practices when and where necessary (Doyle, 2007) because their beliefs, knowledge, and their practices occurred within the classroom all significantly influence students' development of mathematical literacy (Askew, Brown, Rhodes, Johnson, & William, 1997).

Mathematics curriculum reforms in many countries around the world have been continuously gaining momentum to call for the development of mathematical literacy for all citizens (National Council of Teachers of Mathematics [NCTM], 2000). However, any innovation in curriculum or mathematics instruction has hardly been effectively implemented as intended, and most of the curriculum reforms have sadly failed to reach the desired success (Cuban, 1993; Fullan, 2007; Smith & Southerland, 2007; Sowell & Zambo, 1997). In other words, the success of any curriculum reform is mainly based on giving the necessary attention to teachers' conceptions of this reform or innovation movement (Handal & Herrington, 2003). However, policymakers and education authorities who are responsible for educational reforms and initiatives, unfortunately, fail to pay enough attention to teachers' conceptions about these reform movements (Kyeleve & Williams, 1996; Martin, 1993). Most of the innovations are introduced or enforced through a top-down approach without consultation with teachers who are required to implement these innovative strategies (Norton, McRobbie, & Cooper, 2002). It is therefore worth noting that teachers' conceptions of barriers on the way of developing mathematical literacy understanding are essential as they prepare students to become mathematically literate citizens of tomorrow by taking an important role in establishing and improving their mathematical literacy skills. Besides, teachers' conceptions are usually shaped and reinforced by their conscious or subconscious beliefs, and they are interpreted as "a more general mental structure, encompassing beliefs, meanings, concepts, propositions, rules, mental images, preferences, and the like" (Thompson, 1992, p. 130). Hence, teachers' conceptions play a significant role in forming their instructional behaviors and practices in the classrooms to reach the desired outcomes

and meet the requirements of mathematics education in the context of mathematical literacy in a substantial way. This study aims to examine the conceptions of mathematics teachers about the difficulties in the development of mathematical literacy. The following research question has guided the study: What are secondary mathematics teachers' conceptions of the barriers to the development of mathematical literacy?

Background and Literature Review

Learning about mathematics in the classroom is only meaningful if reflection upon mathematical rules and relations is accompanied by personally and socially relevant situations where, as in everyday situations, mathematics becomes a tool to achieve new relevant goals (Schliemann, 1999). Therefore, the fact that mathematics is used outside school gives it meaning, making mathematics outside of school a modeling process rather than a simple process of numerical manipulation (Nunes, Schliemann, & Carraher, 1993). However, mathematics curricula and pedagogy are often described as not responding adequately to the need of the citizens of today and tomorrow to meet personal and social goals (National Numeracy Review Report, 2008). That is, the process of schooling seems to encourage the idea that there is not supposed to be much continuity between what one knows outside the school and what one learns in school (Resnick, 1987). Therefore, here, the knowledge of mathematical literacy becomes essential, not just for utilitarian or abstract purposes or goals, but within the context of students' attempts to understand their individual and collective lives and to make their lives more meaningful and functional (OECD, 2014a).

The Quantitative Literacy Design Team (2001) argued that the problem of disconnection of school mathematics from meaningful contexts is particularly evident, and is one of the major impediments to mathematical literacy development in today's schools. However, one of the most important things that students should gain from school mathematics is the attitude that mathematics can help them to assure critical, effective, and full participation in real life as this builds the essence of mathematical literacy (Chapman, Kemp, & Kissane, 1990). It is actually in these situations where they will be required to use mathematics to function in today's modern society effectively and master the world around them (OECD, 2013b; Steen, 2001). There is an inevitable concern that the existing mathematics education in many countries inadequately equips their citizens to use and apply mathematics effectively in different phases of their lives (OECD, 2013c). This concern has resulted in a move away from a more elitist and traditional view of mathematics education to one assessing how well students can use school mathematics in realistic situations, which refers to mathematical literacy (OECD, 2003). Thus, there is substantial agreement among curriculum planners and educators to provide students with the most appropriate environment and program for mathematical literacy development (Ontario Ministry of Education, 2005).

Researchers hold varying, yet overlapping, perceptions of mathematical literacy ranging from informal mathematics involving basic mathematical skills to formal mathematics requiring higher-order thinking skills. While some researchers assert that mathematical literacy involves the formal application of mathematics to real-world contexts requiring a high level of mathematics knowledge and the competence to use and apply it (e.g., Gellert, Jablonka, & Keitel, 2001; Hope, 2007; Jablonka, 2003; Pugalee, 1999), other researchers contend that it involves some basic level of mathematics to empower people both personally and as citizens to make better-informed decisions when dealing with problem situations occurring in their daily living and the workplace (McCrone & Dossey, 2007; McCrone,

Dossey, Turner, & Lindquist, 2008; Powell & Anderson, 2007). All attempts to define mathematical literacy generally support the idea that mathematical literacy consists of the knowledge and skills required to efficiently respond to mathematical demands of individuals in life with the ability to adapt and conform easily to new demands and requirements in a constantly changing society that is entirely embedded by quantitative information and controlled by modern technology (Skovsmose, 2008; Venkat, 2013). According to the OECD (2013a), mathematical literacy is an individual's capacity to efficiently respond to mathematical demands of personal, social, and working life as well as the capacity to adapt and conform easily to new demands and requirements in a constantly changing society that is entirely embedded with quantitative information and controlled by modern technology. Thus, it requires the ability to formulate, employ, and interpret problem situations presented in a range of different contexts by analyzing, reasoning, and communicating mathematical ideas accurately and in a satisfactory manner as a constructive, engaged, and reflective citizen. The definition of mathematical literacy, as conceptualized by the OECD, is comprehensive and broad as it covers the main aspects of other notions of mathematical literacy. In other words, the emphasis is not just on the application of the basic principles and standard procedures, but also on the engagement of mental processes or cognitive functions through formulating, employing, and interpreting mathematics to solve various problems involving real-world situations representing a person's personal, occupational, and social lives to become a reflective, active and constructive citizen. Hence, being mathematically literate requires an understanding of the importance of mathematics in everyday life (Department of Education, 2003). In other words, connecting mathematics to real-life situations is essential for developing mathematical literacy skills and the confidence to use these skills in daily life. Therefore, teachers are expected to provide learning experiences to explore mathematical ideas and their applications in day-to-day life to ensure the ways for students to become mathematically literate critical members of society and contribute towards social prosperity (Coben, Colwell, Macrae, Boaler, Brown, & Rhodes, 2003).

Although introducing mathematical literacy to schools has created exciting opportunities, it has also posed several challenges, particularly concerning its conception by teachers and other stakeholders such as curriculum developers (Bowie & Frith, 2006). Genc and Erbas (2019) revealed that teachers held different, but interrelated and mutually reinforcing conceptions of mathematical literacy. Studies showed that some of the teachers considered mathematical literacy to be a watered-down version or easy mathematics and is meant for academically weak learners to perform at school, whereas some others viewed it as a type of mathematics with applications in everyday life to relate mathematics to real-life situations (Madongo, 2007; Mbekwa, 2006). In Sidiropoulos' study (2008), mathematics teachers expressed that mathematical literacy is an ability to perform basic arithmetic operations. They regarded it as lesser mathematics and stated that “‘it is not real maths’, ‘it is the beginning of maths’, ‘it is a maths only better than nothing’, ‘it is the maths of oranges and bananas’, and ‘it is a subject for the doffies’” (Sidiropoulos, 2008, p. 225). Graven and Venkatakrishnan (2006) stated that teachers had the understanding that mathematical literacy was intended for those learners who failed mathematics.

On the other hand, innovations and reforms in education are not carried out within the timeframe envisaged by the politicians and planners. Although reform-based principles and standards (NCTM, 1989, 2000) encourage teaching mathematics by including higher expectations such as problem-solving and mathematical reasoning, many teachers still use

mostly traditional learning and teaching methods in mathematics (Brew, 2001; Gresham, 2007). While teachers appear to have beliefs that are consistent with the reforms, they usually teach traditionally and resist to change familiar practices (Thompson, 1992). This resistance is due in part to their surface beliefs that are not deeply rooted within the belief system (Kaplan, 1991). Moreover, some factors that are beyond the control of teachers in the school system, such as parents, school administration, and classroom settings, can also influence their way of teaching as they believe (Handal, 2003). Furthermore, teachers' beliefs can be largely affected by their prior mathematics experiences and teachers, and their studies in undergraduate education. They tend to implement new reforms in their classrooms, but they do not know exactly how to do so (Toluk-Uçar & Demirsoy, 2010). Madongo (2007) also investigated teachers' perceptions about the causes that might prevent mathematical literacy development/teaching and reported some issues, including learners' lack of basic mathematical concepts, their difficulties in English language communication, and their negative attitudes towards mathematical literacy. Madongo (2007) added that several teachers have strongly felt that the time had not yet come to introduce this new curriculum with an emphasis on mathematical literacy. Some of the factors they put forward included: their lack of confidence to teach mathematical literacy; their lack of pedagogical content knowledge, their beliefs and conceptions of the nature of mathematics; high workloads; the large class sizes; lack of appropriate and sufficient teaching and learning support materials; lack of consistency in the forms of instructional textbooks; lack of support from the education department through regular training workshops; lack of funding to purchase the requisite educational resources; and difficulties in identifying or determining appropriate contexts, as well as implementing effective teaching strategies for mathematical literacy development. Accordingly, all these difficulties that may arise against the development/teaching of mathematical literacy can be grouped under three categories that Niss (2015) draws our attention to: conceptual challenges (What is mathematical literacy?); educational challenges (How can we develop mathematical literacy?); and systemic challenges (Where is mathematical literacy (to be) located?).

Method

Research Design

Qualitative research, in an exploratory vein, is usually preferred for characterizing, evaluating, and interpreting the complexity of beliefs or conceptions when 'what' questions are being posed as it allows for detailed descriptions and understanding of the phenomena under investigation (Yin, 2014). This research study lends itself well to the use of qualitative exploratory case study, where the case of interest is the secondary mathematics teachers' conceptions of the barriers to mathematical literacy, which entailed unfolding and reporting the complex interactions of teachers' beliefs about the challenges for mathematical literacy and other factors in unique and dynamic contexts (Cohen, Manion, & Morrison, 2007).

Participants

This study aimed to document secondary mathematics teachers' conceptions of the barriers to mathematical literacy. Sixteen mathematics teachers (four females and twelve males) from nine secondary schools of different types (Science High School ($n = 2$), Anatolian High School ($n = 7$), Vocational and Technical High School ($n = 4$), Anatolian Imam Hatip (Religious) High School ($n = 2$), and Private High School ($n = 1$)) located in an industrial-urban school district of Turkey participated in the study. Recruiting teachers from

different school types was considered important because students' performance and mathematical literacy, as revealed in the results of the Programme for International Student Assessment (PISA) across implementations, would vary among school types in Turkey (e.g., Alacacı & Erbas, 2010). Participants were briefed about the nature and purpose of the study before they gave consent.

Mathematics teachers of the ninth and tenth grades were targeted as the main population in these schools because these grades were considered foundational in terms of developing mathematical literacy for all students. The reason for this was twofold. First, about 93% of the Turkish students who participated in PISA 2012 were the ninth and tenth graders (Ministry of National Education [MoE], 2013a). Second, the national high school mathematics curriculum was structured differently in the ninth and tenth grades than in the eleventh and twelfth grades. By the time of data collection, even though the term mathematical literacy or other associated terms such as numeracy were not explicitly mentioned in the national high school mathematics curriculum the teachers in this study were expected to teach (MoE, 2013b), its importance was implicitly described and emphasized. For example, mathematical modeling and problem-solving were stated as essential skills and competencies that the curriculum aimed to develop. While the curriculum aimed to deliver the same core mathematical standards regardless of region and school type in the ninth and tenth grades, two sets of standards "Basic" and "Advanced" levels are recommended in the eleventh and twelfth grades based on students' choices, needs, and future career goals. The "Basic" level aimed at developing students' ability to use mathematics in their daily and professional lives, utilize it as an analysis tool for reasoning and decision making. In this context, standards for "Basic" level aimed to establish some of the fundamental mathematical concepts from the ninth and tenth grades through getting students engaged in real-life based problems so that the students who would not select careers or programs with mathematical emphasis could more effectively overcome the problems they face in daily life.

Since mathematical literacy is different in purpose, developing a sense of mathematical literacy and teaching for developing it could be challenging for teachers with little experience in teaching mathematics. The definition of an experienced teacher might be context-specific and even country-specific, considering the rules and regulations governing teachers' career stages. Yet, it seems that around five years of experience might be needed for teacher expertise, for example, to be counted as a senior teacher in Sweden (Grönqvist, Hensvik, & Thoresson, 2020) and a practitioner-teacher in Japan (Sakai, 2014), and an experienced teacher in Australia (Graham, White, Cologon, & Pianta, 2020). In Turkey, according to the "By-law regarding Promotion of Teacher Career Steps" (Legal Gazette, 13.08.2005/25905), seven years of teaching experience is expected to be able to apply for expert teacher status. Thus, in this study, it is assumed that teachers with at least five years of teaching experience would reveal more insight into teachers' conceptions regarding the barriers to mathematical literacy. Accordingly, in all upper secondary schools in the district, only the ninth and tenth-grade mathematics teachers with at least five years of experience were invited to participate in the study. Participants had been teaching from five years to twenty-four years ($M = 17.25$, $SD = 6.09$). Moreover, in Turkey, depending on the pathway teachers chose, teachers are certified through alternative routes to becoming teachers of mathematics. In this study, nine of the participants had their undergraduate degrees in mathematics education and thus had their certification as a mathematics teacher from the college of education as part of their degree program. Seven of the participants had

undergraduate degrees in mathematics and received their teacher certification through completing some additional pedagogical coursework after their graduation.

Data Collection

Data was collected through semi-structured interviews each lasted approximately one hour. All of the teachers preferred their respective schools as the interview site. All interviews were scheduled at the participants' convenience time during school hours. The teachers were asked to talk about their perceptions about the barriers to the development of mathematical literacy. The interview questions and probes (see Table 1) were developed based on the research questions together with an in-depth review of related literature.

Table 1

The Semi-structured Interview Guide used in the Interviews

Questions and Probes
What can be the challenges encountered in the development of mathematical literacy? <ul style="list-style-type: none">○ What can be student-oriented problems?○ What can be teacher-oriented problems?○ What can be the obstacles caused by the mathematics curriculum?○ What can be the obstacles caused by learning and teaching sources or materials?
What can be the teacher's role in the development of mathematical literacy? <ul style="list-style-type: none">○ What can be the teaching strategies teachers need to implement?○ What knowledge, skills, and competencies should the teachers have?○ What are your suggestions for teacher training programs?
What is the importance of having different conceptions on mathematical literacy for its development?

Prior to the data collection process, the instrument was piloted with two voluntary secondary mathematics teachers who were not involved in the actual study to assess the extent to which the interview questions could elicit responses that would address the research question of this study.

Data Analysis

The data analysis consisted of both inductive and deductive approaches for identifying, analyzing, and reporting patterns or themes within the data. An initial list of codes was developed based on the interview protocol and previous research (e.g., Graven and Venkatakrisnan, 2006; Madison, 2006; Madongo, 2007; Mbekwa, 2006; Niss, 2015; Sidiropoulos, 2008). Inductive codes generated by the data were added to this initial list in order to explore new insights and hidden patterns (Patton, 2002). For example, for the identification of the category 'Barriers associated with teachers' under the theme of 'Educational Challenges,' several codes were used, such as teachers' qualifications, rote learning, teaching practices, and routine problems. Similarly, for the creation of the category 'Difficulties in curriculum implementation' under the theme of 'Systemic Challenges,' several codes were generated, such as the intensity of curriculum, teachers' resistance, teachers' perspectives, and mathematical literacy emphasis.

NVivo qualitative data analysis software (QSR International, 2012) was also used in order to aid in coding and categorizing information to generate the common themes and patterns of practice. The use of this software allowed us to eliminate possible influences in the interpretations of the data by comparing it in the context of the interviewees' responses and ensure the accuracy of the research study. After assigning the initial list of codes to all transcripts, the audio recording of each interview was listened to again while reviewing the transcripts and codes. In this way, a content analysis of the transcripts was completed to identify common themes and ideas. The initial coding list with the emerging new patterns was then revised so that they could align with the actual data. This process enabled us to verify the accuracy and internal consistency of the coding system either by combining similar codes when redundancies occurred or by removing codes assigned to passages that were tangential to the study. Through member checks, the participants were also asked to elaborate or disagree with anything in the transcriptions in order to identify and minimize any possible bias. In this sense, fourteen of the teachers provided feedback orally and expressed no disagreements with their responses and interpretations of them.

It was necessary to verify that the codes assigned were meaningful, logical, and consistent with those that other readers could assign by inviting a researcher who was familiar with the same issue. The ratio of the number of agreements to the sum of the number of agreements and disagreements was used as a measure of inter-rater reliability (Miles & Huberman, 1994). In order to facilitate the inter-coder reliability, one mathematics education researcher with more than ten years of experience in analyzing qualitative data was asked to act as an external rater. Thus, during the final stage of analysis, in addition to the expert review, we (the authors) and this mathematics education researcher double-checked the codes on all transcripts and re-examined for emerging themes and categories. The comparison of the two coding outcomes showed a 92% agreement. The raters resolved all disagreements and revised the code definitions until a full agreement was reached for the categories and conferred the thoroughness and credibility of the data analysis. The number of the teachers talking about each distinct category was also reported for internal generalizability of the study referring to the generalization of conclusions within the collection of the teachers studied, and establishing that the categories identified are characteristic of this particular set of teachers as a whole (Maxwell, 2010).

Results

A cross-case analysis of the data from sixteen teachers revealed three themes that captured their conceptions of the barriers to the development of mathematical literacy: (i) conceptual challenges (What is mathematical literacy?); (ii) educational challenges (How can we develop mathematical literacy?); and (iii) systemic challenges (Where is mathematical literacy (to be) located?)

Conceptual Challenges: What is mathematical literacy?

A number of challenges associated with different conceptualization of mathematical literacy emerged across teachers' responses: (i) conceptualization of mathematical literacy as a necessity for all; (ii) conceptualization of mathematical literacy as a multifaceted notion; and (iii) conceptualization of mathematical literacy as a multidisciplinary construct. Figure 1 shows the teachers listed on a single chart in order to show the strength or intensity of each barrier regarding the conceptual challenges. The numbers in parentheses represent the corresponding total number of teachers talking about this particular barrier (see Table A1 in

the Appendix for more details). The following sections provide the findings concerning the challenges.

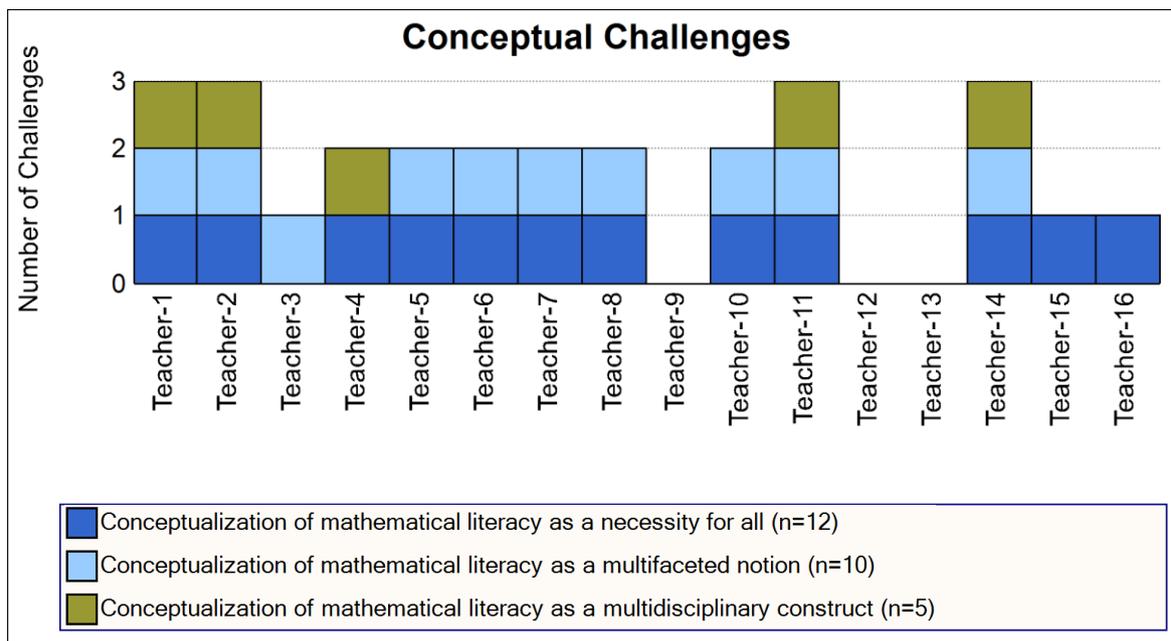


Figure 1. Conceptual challenges to the development of mathematical literacy

Conceptualization of mathematical literacy as a necessity for all

Most of the teachers ($n = 12$) in this study stated that mathematical literacy is not seen as a necessity for all students because some secondary mathematics teachers view mathematical literacy as watered-down or less mathematics that low-achievers are supposed to do while some others view it as more or advanced mathematics that only high-achievers should do. Firstly, as stressed by the teachers in this study, mathematical literacy is considered as a more accessible version of mathematics by several secondary mathematics teachers. According to these teachers, mathematical literacy is something that should be given only to those students whose mathematics achievement is not satisfactory. For example, one of the teachers expressed this as follows:

...whenever somebody mentions mathematical literacy, the first thing that comes to some mathematics teachers' mind is lower-level mathematical knowledge in order to tackle everyday problems...since it is viewed as an activity related to reading and writing about daily mathematics, students at this level are just expected to perform basic arithmetical operations including addition, subtraction, multiplication, and division. It is, therefore, only for students with poor mathematics achievement. (Teacher-2)

Second, the teachers assumed that for some other secondary mathematics teachers, the teaching of mathematics through emphasizing mathematical literacy is the teaching of mathematical definitions, rules, theorems, and proofs. According to these teachers, a good level of mathematical literacy is achieved only with those students having a higher level of mathematical knowledge and skills. One of the teachers put it that as follows:

...some teachers believe that learning mathematical theorems and proofs is indeed an important step in being mathematically literate. They claim that mathematical literacy is not basic mathematical knowledge. Anyone can learn this basic knowledge somehow but being mathematically literate requires something different. Only those students with higher-level

mathematical skills and understanding can reach the desired level of mathematical literacy. (Teacher-6)

Therefore, the teachers pointed out that since some secondary mathematics teachers sometimes do not see mathematical literacy as a phenomenon that everyone should achieve, this might serve as a challenge for the development of mathematical literacy of all students.

Conceptualization of mathematical literacy as a multifaceted notion

More than half of the teachers ($n = 10$) emphasized that some of the mathematics teachers do not understand that becoming mathematically literate is a multifaceted phenomenon that involves more than simply learning a set of mathematics knowledge and skills that are typically taught in schools. These teachers do not think that, in addition to mathematical knowledge, it also includes mastering a complex set of understandings, attitudes, expectations, and behaviors, as well as specific skills, related to the scientific, personal, social, professional, and cultural aspects of each person in various context. One of the teachers explained this as follows:

...sometimes it seems quite difficult for some mathematics teachers to see that mathematical literacy is not about learning a lot of decontextualized mathematical theorems, rules, operations, and algorithms nor about learning mathematics knowledge for its own sake. It is indeed about understanding and transferring mathematics knowledge to other domains of learning, real-life and work to get involved effectively in the community and civic life..., but it is sad to say that some mathematics teachers do not view mathematical literacy that way as a complex, multifaceted and sophisticated construct. (Teacher-10)

The teachers noted that teachers' failure to conceive mathematical literacy as a broad and multifaceted concept could cause their students not to develop mathematical literacy skills in all aspects.

Conceptualization of mathematical literacy as a multidisciplinary construct

About one-third of the teachers ($n = 5$) mentioned that some of the secondary mathematics teachers do not recognize that mathematical literacy should be closely related not only to mathematics but also to other fields of science such as biology, chemistry, physics, etc. They think that mathematical literacy only focuses on the use of mathematical knowledge and it requires a high level of mathematical skills. The teachers asserted that this way of thinking puts their view of mathematical literacy into a narrow perspective and prevents the development of mathematical literacy skills of their students. One of the teachers highlighted this point as follows:

...for some mathematics teachers, mathematical literacy development is entirely based on the level of their students' knowledge of the subject area, which requires solving many challenging mathematics problems... According to them, a well-qualified and competent mathematics teacher is the teacher who effectively handles or solves as many math problems as possible in a given time. Therefore, these teachers do not usually need to integrate mathematics and other subjects like physics, biology, geography, economics in order to develop mathematical literacy skills of students through giving meaning to the mathematics learned. (Teacher-4)

Hence, the teachers believe that some secondary mathematics teachers are not aware of the importance of the interdisciplinary inquiry as a distinguishing feature of mathematical literacy and do not make progress in incorporating multidisciplinary mathematical activities into their lessons. However, this unawareness brings about a major obstacle for developing their students' understanding of mathematical literacy.

Educational Challenges: How can we develop mathematical literacy?

Teachers' responses revealed several barriers as educational challenges to developing students' mathematical literacy: (i) barriers associated with students; (ii) barriers associated with teachers; (iii) lack of differentiated instruction; (iv) time constraint in teaching mathematics; and (v) crowded classrooms. Figure 2 shows all teachers listed on a single chart in order to indicate the strength or intensity of each barrier regarding the educational challenges. The numbers in parentheses represent the corresponding total number of the participants talking about this particular barrier (see Table A2 in the Appendix for more details). The following sections provide the findings concerning the barriers.

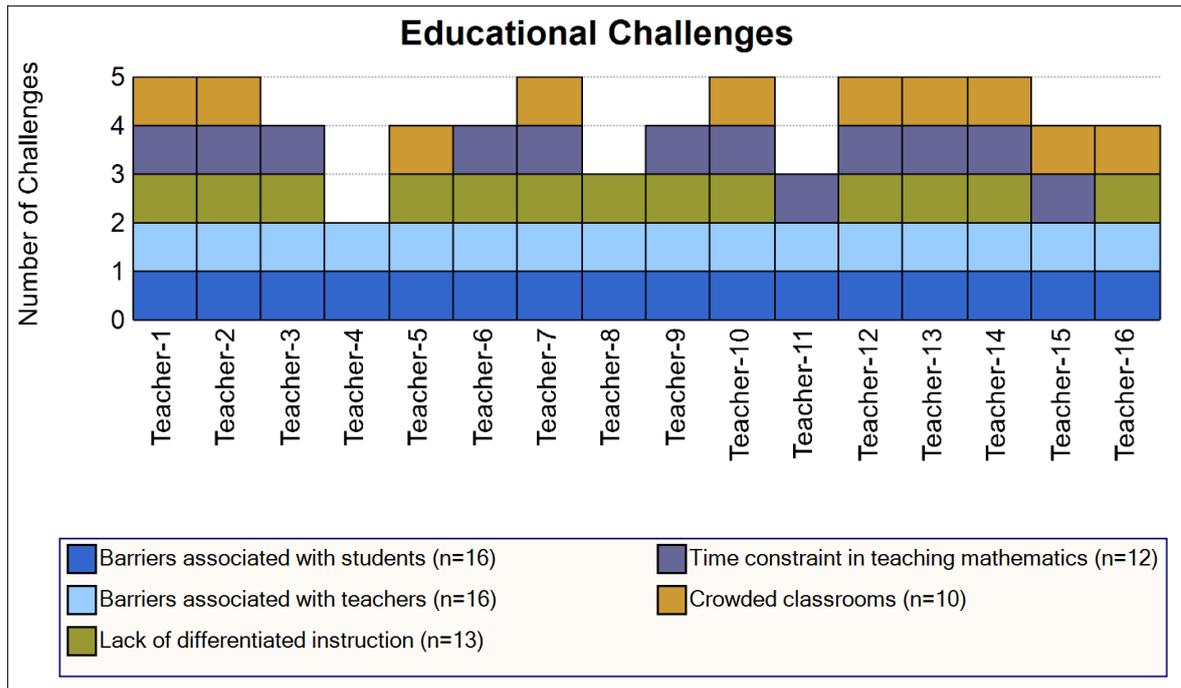


Figure 2. Educational challenges to the development of mathematical literacy

Barriers associated with students

The barriers associated with students were caused by the following obstacles: (i) math anxiety; (ii) students' lack of interest in mathematics; (iii) lack of basic arithmetic knowledge; (iv) excessive concern about mathematics grades; and (v) inability to search for information independently. For example, almost all of the teachers ($n = 15$) expressed rather sadly that many students believe that they are not capable of doing mathematics because they think that:

...mathematics is horrible, and success in it is unreachable since it is a very special subject. (Teacher-12)

These teachers stated that from the very beginning of their education, students are repeatedly told that mathematics is essential for their life, but this may lead to the creation of undue and undesirable pressure on students against studying mathematics or related fields. Hence, as one of the teachers pointed out,

...perhaps, we are not aware of it, but it gradually gives rise to math anxiety, which naturally affects their mathematical literacy development. (Teacher-13)

The teachers mentioned that math phobia could easily translate into negative thoughts about mathematics. This automatically leads to a low level of self-confidence in learning mathematics. However, one of the teachers stated:

...being mathematically literate requires people primarily to have self-confidence in their mathematical capability. (Teacher-1)

Nearly all of the teachers ($n = 15$) also stated that some of their students are quite indifferent to mathematics, and they usually say that teachers do not know their real concerns that are very distinct from those that their teachers expect from them.

...mathematics does not really make any sense for our students. They usually ask me questions like, "Where can I use it in my life?" (Teacher-7)

Hence, the teachers believe that students have very little or no interest in learning mathematics, as it was reported by one of the teachers:

...in the absence of curiosity about or interest in mathematics, how could we talk about the development of mathematical literacy skills? (Teacher-6)

Besides, most of the teachers ($n = 13$) declared that there is a noticeable deficiency in most of their students' core arithmetic skills,

...because they do not know basic mathematical operations, rules, or formulas used in everyday life, and even they recall the formulas, most of them are not able to implement them. (Teacher-7)

Thus, teachers noted that it is unfortunately hard for these students to gain mathematical literacy understanding unless they have basic arithmetic knowledge. Moreover, some of the teachers ($n = 5$) emphasized that when they practice any example in class,

...the first immediate question students are always curious about is that "Will you ask this kind of questions in the examination?" (Teacher-12)

The reason for this is explained by the fact that achievement in mathematics is always associated with earning higher grades in mathematics. Such associations cause extreme concern about receiving good grades, and everything else is worthless, including mathematical literacy. Several teachers ($n = 4$) also held the perception that:

...regretfully, most of the students lack the necessary skills in searching for information independently in today's age of technology. (Teacher-14)

They are simply accustomed to the transmission of ready-made knowledge. However, being mathematically literate requires people to know how to search for and reach the desired information independently for an accurate evaluation of events around them.

Barriers associated with teachers

The teachers' responses revealed that the barriers associated with teachers are due to the following reasons: (i) lack of teachers' qualifications about mathematical literacy; (ii) teaching mathematics by rote; (iii) difficulty of making major changes in teaching practices; and (iv) drawbacks of continuous use of routine problems. For example, almost all of the teachers ($n = 15$) commented that their qualifications and competencies about mathematical literacy are of great importance when the focus is on the development of mathematical literacy understanding. However, they frankly confessed that they do not usually set mathematical literacy acquisition higher priority in their lessons because, as put by one of the teachers:

“...teaching mathematics in the context of mathematical literacy is a completely different thing, and it requires qualified professionals to give” (Teacher-1), [but] “...we really lack in this regard.” (Teacher-8)

Moreover, most of the teachers ($n = 12$) emphasized that they all grew up in a rote education system, and even though some might be open to new teaching ideas and opinions, such prior education prevents them from producing creative and new ways to teach mathematics, emphasizing the development of mathematical literacy skills. Therefore, in teachers' words,

“...in class, we only teach mathematical rules and processes by rote, as well as practicing those rules and processes in order not to forget them very quickly” (Teacher-13), [thereby] “...many students continue to memorize a lot of mathematical rules and formulas without conceptual understanding as long as we have a sense of rote education in mathematics.” (Teacher-8)

Most of the teachers ($n = 12$) also asserted that they are naturally supposed to be much more dedicated to more challenging and diverse teaching activities in order to provide students with skills needed for mathematical literacy. However, in teachers' words,

“...nobody wants to bother with mathematics teaching practices emphasizing mathematical literacy” (Teacher-5), [because] “...math teaching emphasizing mathematical literacy requires a serious lesson preparation as well as many radical shifts in our teaching approaches.” (Teacher-16)

Furthermore, more than half of the teachers ($n = 9$) stated that although teaching non-routine everyday problems has much importance for students' mathematical literacy development, many students have difficulty and confusion with unfamiliar types of questions and they would rather ask traditional types.

...we always try to ask similar types of questions in order to make students practice or apply what they learn in class. (Teacher-11)

In fact, the teachers admitted the difficulty of organizing instruction using nontraditional activities.

...frankly speaking, preparing a non-routine pattern of instruction is rather difficult as it takes much time and energy after school. (Teacher-2)

Lack of differentiated instruction

The majority of the teachers ($n = 13$) mentioned that teaching the same mathematics to all students who are clearly of distinct levels in mathematics is a real obstacle to the mathematical literacy development of students. They said that the problem arises from the fact that:

...regardless of classes where students differ greatly in terms of mathematics level, we are requested to give all of the students the same mathematical skills. (Teacher-14)

These teachers further added that they are allowed minimal flexibility for changing their teaching in mathematics. However, as one of the teachers expressed it,

...when we try to teach students mathematics on a higher level than what they are actually able to achieve, we cannot create any willingness and desire for learning mathematics. (Teacher-4)

The teachers expressed that teaching mathematics in this way only results in a strong dislike and anxiety of mathematics rather than contributing to the development of students' mathematical literacy skills. Hence, they believe that:

...if we teach mathematics by considering classes consisting of students with varying levels of mathematical abilities, their mathematical literacy performance will be much higher than before. (Teacher-8)

Time constraint in teaching mathematics

Most of the teachers ($n = 12$) expressed that what mathematical literacy requires students is the understanding, formulation, and modeling of the real-life problems and then a comprehensive evaluation of the results. They remarked that all these steps take so much time and dedication. Hence, the teachers assumed that:

...mathematics teaching based on mathematical literacy understanding will challenge mathematics teachers as never before as it takes much of their time. (Teacher-10)

The teachers said that the time allocated to them in the curriculum is not enough for engaging students in a wide range of activities in the context of mathematical literacy, such as building and testing models of real-life situations. Such activities usually require teachers to allocate a separate time for each student. However, they implied that it is hard for them to devote enough time to each student in order to ensure satisfactory progress in these activities. Otherwise, there is an absolute risk of slowing down the teaching pace. In other words,

...the possible consequence of this is that we may stay behind the timeline of the mathematics curriculum. Of course, no teacher wants to take that risk. (Teacher-15)

Therefore, these teachers believe that time constraints in mathematics teaching harm students' mathematical literacy performance.

Crowded classrooms

Over half of the teachers ($n = 10$) highlighted that crowded classrooms serve as a challenge to convey mathematical literacy. They stated that in such classrooms, it is not easy to implement discovery, inquiry, and problem-based approaches to develop appropriate learning opportunities for mathematical literacy, as they all require individual encouragement and support for each student. As one teacher expressed that:

...it is certainly impossible to deal with everyone separately in classes consisting of about forty students...although group work is a necessity for mathematical literacy development, how can I efficiently manage any group activity in a crowded class? (Teacher-12)

They stated that although teaching in the context of mathematical literacy requires them great effort and determination to perform, crowded classrooms lower their performance in teaching mathematics.

...frankly speaking, I do not have such dedication and energy in crowded classrooms. I cannot observe each student's learning style and behavior carefully in order to develop appropriate learning opportunities for mathematical literacy. (Teacher-5)

Hence, the teachers usually pointed out the importance of class-size in providing students with opportunities for developing mathematical literacy:

...class size surely affects the teaching approaches that we offer for mathematical literacy development. (Teacher-16)

Systemic Challenges: Where is mathematical literacy (to be) located?

Several systemic challenges emerged in teachers' responses, including the following: (i) difficulties in the curriculum implementation; (ii) drawbacks of the university placement examination; (iii) shortcomings of undergraduate teacher education programs; (iv) lack of appropriate mathematics textbooks for mathematical literacy; and (v) lack of mathematical

literacy understanding in primary education. Figure 3 demonstrates all teachers listed on a single chart in order to indicate the strength or intensity of each barrier regarding the systemic challenges. The numbers in parentheses represent the corresponding total number of teachers talking about this particular barrier (see Table A3 in the Appendix for more details). The following sections provide the findings concerning the barriers.

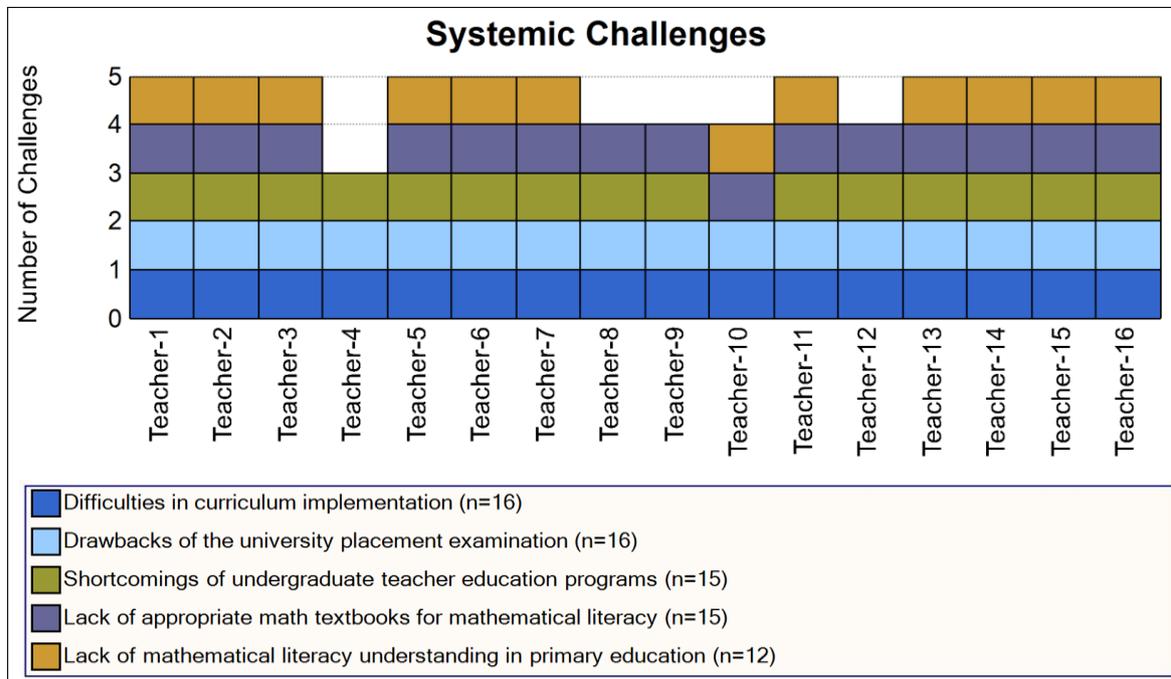


Figure 3. Systemic challenges to the development of mathematical literacy

Difficulties in curriculum implementation

It was stated that the challenges in the curriculum implementation in the context of mathematical literacy were linked to the following barriers: (i) intensity of mathematics curriculum; (ii) teachers’ perspectives and practices; and (iii) lack of mathematical literacy emphasis in the mathematics curriculum. For example, all of the teachers in this study ($n = 16$) mentioned that the congested mathematics curriculum is one of the significant factors that negatively influence the mathematical literacy development of students. Although many teachers believe that mathematical literacy understanding is essential for all students, most of the teachers are not able to achieve to provide it because there is no time or energy. They reported that mathematical literacy skills could be gained in a flexible and extended period of learning time. However, teachers’ class schedules are quite busy to implement necessary teaching and learning techniques for mathematical literacy. As one of the teachers pointed out:

...we have a very intensive and rigorous mathematics curriculum, which makes it very difficult for us to teach anything outside the curriculum content. (Teacher-10)

Teachers are said to be forced to teach or deliver too fast in order to cover all the curriculum topics. They have no other choice than to struggle to keep pace with the intensive curriculum targets. In other words,

...we just try to keep up with other math teachers with respect to the curriculum topic being taught next. (Teacher-15)

Indeed, as stated by one of the teachers:

...we seemingly teach many things to our students, but the fact is that we teach nothing. (Teacher-7)

Almost all of the teachers ($n = 15$) argued about teachers' perspectives and practices for the applicability of the curriculum with an emphasis on mathematical literacy. Two key arguments were developed. The first argument suggested the resistance of teachers to some changes, while the second suggested the possible ways for acceptance of a new curriculum among teachers. First of all, for most of the teachers, any curriculum revision or change in accordance with mathematical literacy understanding will probably bring teacher resistance as well. They asserted that many teachers resist curriculum changes because they would always like and prefer to keep doing things in the same way as they have in their past mathematics teaching. For example, one of the teachers explained that it might be more comfortable and easier to maintain teaching in familiar ways rather than striving to develop new teaching practices and skills. Therefore,

...some will certainly demonstrate resistance to any change in the curriculum with an emphasis on mathematical literacy. (Teacher-11)

Secondly, some of the teachers contended that if the mathematics curriculum is changed and revised to align with mathematical literacy understanding, its acceptance should be expected in the long run through the persuasion of teachers to such change and revision. For example, one of the teachers noted that the effects of curriculum change according to mathematical literacy understanding should not be expected in the short term. Otherwise, as he posited:

...the possibility of the applicability of such a curriculum is almost close to zero because it does not make any sense to put it in front of us to implement. (Teacher-1)

Thus, the participants believe that despite some difficulties in implementing it in the first few years, any curriculum modification towards mathematical literacy understanding will at least create awareness among teachers about the importance of mathematical literacy. In other words, as one of the teachers expressed,

...the first thing to be done is to convince teachers of the importance of such a curriculum for people to be productive and informed citizens. (Teacher-5)

Moreover, a slightly higher number of the teachers ($n = 10$) reported that lack of mathematical literacy emphasis in mathematics curriculum is the other significant obstacle that prevents the development of mathematical literacy understanding. According to them, as one of the teachers expressed it,

...it is difficult for us to find real-life teaching and learning activities or examples that require reasoning and logical thinking skills in the curriculum. (Teacher-6)

They stated that mathematics teachers generally stay at the level of knowing and applying mathematical rules and formulas when teaching mathematics.

...the level of reasoning and argument is usually ignored and is of secondary importance to us as they are not rigorously and sufficiently imposed by the curriculum. (Teacher-12)

Thus, the teachers pointed out that although the mathematics curriculum enforces teachers to give a lot of mathematics knowledge to their students in a short time, it does not precisely describe and emphasize where students will or must use this knowledge of mathematics in daily life. They honestly stated that the mathematics curriculum lacks in this regard.

Drawbacks of the university placement examination

It was said that the drawbacks of the university placement examination were related to the following causes: (i) university entrance exam-oriented education; (ii) lack of mathematical literacy emphasis on the university entrance exam; and (iii) university entrance examination anxiety. For example, nearly all of the teachers ($n = 15$) believe that the implementation of instruction emphasizing mathematical literacy is quite difficult for any education system in which the student selection and placement examination for higher education is a well-known and major fact.

...the only thing we do in class is just to prepare our students like a racehorse to compete with others for the upcoming university entrance exam. (Teacher-6).

Students are forced to solve as many (multiple-choice) questions as possible in the allotted time interval, and success depends on being practical and quick thinking. However, acquiring mathematical literacy understanding requires much time and effort as well as in-depth and lengthy contemplation.

...right now, my responsibility is not to teach mathematical literacy, but to show all types of questions that will possibly be asked in the university placement examination. (Teacher-11)

On the other hand, many teachers ($n = 12$) also argued in the following sense:

...the emphasis of our university placement examination has been gradually shifting towards mathematical literacy, but it is still not as it should be. (Teacher-14)

They added that, at least for the last few years, there have been some questions in the context of mathematical literacy in the university admission examinations. However, they also claimed that there is still no clarity about this issue because almost everybody, including parents, students, and educators, is confused about predicting how much weight would be given to mathematical literacy in the content of the next examinations. Over half of the teachers ($n = 9$) maintained that the university entrance examination also has a negative impact on students. This multiple-choice exam has five possible alternatives for each question, and the students are equally likely to choose any of the five choices. Teachers assumed that unless students overcome this exam anxiety or unless there is another way to enter university, students will continue to approach the solution of the problems they face in real life with the logic that only one of the many options in front of them is correct. Thus, as expressed by one of the teachers,

...the important thing is not to develop mathematical literacy, but to increase the total number of correct answers from the mathematics section of the test. (Teacher-6)

The more correct answers they have, the higher the score they receive from the test. Then, the higher the score they have, the better university they can enter. Therefore,

...nobody cares so much about real-life problems or let say mathematical literacy understanding. (Teacher-8)

Shortcomings of undergraduate teacher education programs

It was expressed that the shortcomings of undergraduate teacher education programs were associated with the following barriers: (i) lack of mathematical literacy understanding in undergraduate programs; and (ii) lack of mathematical literacy course in undergraduate programs. For example, almost all of the teachers ($n = 13$) emphasized that mathematical literacy is certainly not in the foreground in undergraduate teaching. One of the teachers puts it that as follows:

...I did not see anything about mathematical literacy in my undergraduate education. I also think that there is probably now nothing much about it in teacher education programs. (Teacher-12)

They maintained that pre-service mathematics teachers were generally not encouraged to learn by discussion and discovery learning at the university. Instead, as expressed by two of the teachers,

“...we were given whole math knowledge ready at the university, and we were only responsible and asked from this knowledge” (Teacher-11). [Actually], “...we were very busy with theorems and their proofs during the four years of university life. I wish I could also be given other things in the context of mathematical literacy.” (Teacher-15)

Hence, many teachers ($n = 11$) remarked that:

...it is, of course, very disadvantageous for pre-service teachers not to have any elective mathematical literacy course at the university in order to acquire mathematical literacy skills needed for effective mathematics teaching. (Teacher-9)

Therefore, teachers asserted that must or at least elective mathematical literacy courses would be supportive for prospective mathematics teachers as they provide them new visions and perceptions for developing some principles of and creative approaches to teaching and learning mathematics in the context of mathematical literacy.

Lack of appropriate mathematics textbooks for mathematical literacy

Almost all of the teachers ($n = 15$) stated that mathematics textbooks are not helpful for students to develop their mathematical literacy skills. They alleged that the textbooks are very symbol-laden and complicated to understand. They criticized that mathematics textbooks do not meet the needs of teachers about the mathematical literacy development of their students. As expressed by one of the teachers:

...I have big trouble to find an appropriate book to help me give motivating real-life examples in class. ...Our math textbooks still lack in this regard. (Teacher-9)

They said that the mathematics textbooks indeed provide necessary pure mathematics knowledge for teaching, but:

...the examples given in them are not only insufficient in number but also inappropriate in level for mathematical literacy acquisition. (Teacher-1)

They added that even they find some examples from everyday life in the books, most of them are not authentic mathematics problems. The events described in the problems are impossible to occur or take place in real life. That is,

I am sorry, but you cannot create or develop authentic or real-life examples by putting a few pictures or photographs at the top or bottom of the problem. (Teacher-5)

Hence, the teachers thought that there is regrettably nothing satisfactory in the content of the present mathematics textbooks concerning mathematical literacy.

Lack of mathematical literacy understanding in primary education

Most of the teachers ($n = 12$) pointed out that if they are expected to give their students a lesson emphasizing mathematical literacy,

...the principal basis of mathematical literacy understanding of our students should begin to be built in their elementary school years. (Teacher-3)

They said that by engaging students in learning mathematics through a process of inquiry and discovery in the early years of education, mathematical literacy understanding could be basically introduced to students. Otherwise, as is now, it is quite challenging to begin to implement such a lesson approach in high school education. Teachers, as well as students, all become stuck and do nothing about it. In other words,

...our students should be prepared, organized, and familiar with a lesson in the context of mathematical literacy when they come to high school. (Teacher-11)

For this reason, teachers believe that if mathematical literacy is thought to be essential for an individual and society, the importance of students' early mathematical literacy development cannot be underestimated, and it needs to be further supported in later years of life. The teachers noted that this would accordingly help many students not only eagerly learn a more advanced level of mathematics but also automatically gain a higher level of mathematical literacy understanding.

Discussion and Conclusion

The results of the current study revealed various conceptions of barriers to the development of mathematical literacy in students. First of all, some of the teachers in this study expressed that teachers' conceptualization of mathematical literacy as a necessity for all students is an obstacle. However, mathematical literacy has several dimensions as its meaning varies according to the purpose and context being used (Sfard, 2014). That is to say, not everyone needs to be mathematically literate at the same level, but they can all be more or less mathematically literate in accordance with their own needs and interests (Gardiner, 2004). To achieve this goal, teachers first need to believe that, through appropriate instructional strategies, it is possible to promote mathematical literacy for all. This also requires mathematics teachers to present interdisciplinary teaching and learning that allows them to conceptualize mathematical literacy as a multidisciplinary structure. On the other hand, the practice of multidisciplinary inquiry also brings with it challenges that teachers often struggle to address when attempting to move away from mathematics to other fields of inquiry (Geiger, Goos, & Forgasz, 2015). However, considering that most real-world issues are multivariate in rich contexts, people should typically rely on more than one discipline in the daily handling of these issues. Therefore, mathematics teachers also need to develop an awareness of the multidimensional and comprehensive nature of mathematical literacy. The fact that having multiple and diverse conceptions of mathematical literacy may reflect richness in one's understanding of the various aspects of mathematical literacy (Genc & Erbas, 2019). Hence, the challenge of conceptualizing mathematics literacy as a multifaceted concept by mathematics teachers is also avoided in this way.

Secondly, all of the teachers who participated in this study regarded certain educational challenges as a significant barrier to the effective development of mathematical literacy. Nearly all of the teachers reported that mathematics anxiety in students is one of the challenges that prevent acquiring mathematical literacy. Ashcraft and Moore (2009) state that once mathematics anxiety is activated, it is challenging to overcome it, and it adversely affects students' learning of mathematics, as well as mathematical literacy development. In this respect, perhaps the first prerequisite for gaining mathematical literacy is to defeat mathematics anxiety and develop the confidence needed for learning mathematics (Parsons, Croft, & Harrison, 2009). Coben (2003) attributes the inadequate level of mathematical literacy development to low self-confidence and negative prejudices against learning mathematics. Students' lack of interest in mathematics was also reported as another

educational challenge associated with students for the development of mathematical literacy. Hence, increasing learners' interest in mathematics seems to be essential for developing mathematical literacy (Parsons et al., 2009).

The teachers also reported that some students exhibit an apparent deficiency in basic arithmetic skills. They are even unable to implement the most basic mathematical operations used in everyday life. However, the knowledge of basic arithmetic facts is seen as an essential priority for mathematical literacy development (Department of Education, 2003; UNESCO, 2012). Here, teachers' view of mathematical literacy as a basic level of mathematical knowledge and skills to handle daily life problems may account for their conception of seeing students' lack of basic arithmetic knowledge to be the critical educational challenge on the way of mathematical literacy acquisition. On the other hand, instead of assigning responsibility for systemic structures and long-established traditional practices that can interfere with the learning of students, the teachers' deficient beliefs may also tend to blame these students for failure (Valencia, 2010). Moreover, students' extreme concern about their mathematics grades and their lack of ability to search for information independently also seems to be the other significant educational challenges that prevent the development of mathematical literacy. Teachers asserted that it seems hard to find someone who tries to learn mathematics in order to use or apply it effectively in everyday situations. Instead, many students are simply accustomed to the transmission of ready-made knowledge. However, mathematical literacy begins with knowledge of how to find information for accurate assessment of events in daily life (Department of Basic Education, 2011).

Most of the teachers of this study acknowledged that they are quite aware of their lack of qualifications for teaching mathematics emphasizing mathematical literacy. It seems very difficult for many teachers to teach in the context of mathematical literacy because they are all used to rote-learning and expository teaching starting from the beginning of primary school years (Colwella & Enderson, 2016; Draper, 2008; Hill, Bowan, & Ball, 2005; Julie, 2006; Schoenfeld, 2001). Their qualifications and competencies about mathematical literacy are of great importance when the focus is on the efficient implementation of the curriculum with an emphasis on mathematical literacy (OECD, 2009, 2014b). However, most of them do not see themselves as having such qualifications and remain stuck in teaching in ways that emphasize mathematical literacy (Shanahan & Shanahan, 2008; Westwood, 2008). Hence, teachers need training about how to give mathematical literacy understanding to their students in parallel with revising or designing mathematics curriculum requirements and standards according to such understanding. They must be prepared for this revision or change in advance through teacher training seminars, conferences, and workshops. On the other hand, a lack of consultation with mathematics teachers over the design and the implementation of new educational policies concerning mathematical literacy seems to be another critical educational challenge for mathematical literacy development associated with teachers. That is, any approach to reform implementation that does not consider teachers' opinions is not viable or sustainable for a long time (Martin, 1993).

The teachers in this study also noted that the mathematics teaching profile in the education system depends mostly on strict memorization and rote learning. However, as argued by Lortie (1975), the apprenticeship of observation is largely responsible for many of the preconceptions that teachers hold about their teaching, and consequently prevent many teachers from implementing creative and new ways to teach mathematics that emphasizes mathematical literacy. In such a case, what teachers are generally expected to do in class is to teach mathematics by drill and computation without conceptual understanding, if they all

grew up in a rote education system (Draper, 2002; Siebert & Draper, 2012; Stigler & Hiebert, 2004). Hence, most of the students generally tend to memorize many mathematical theorems, formulas, and rules but might not have any idea about how to use them in real life. Within such an educational system, unfortunately, it seems very hard for any individual to become mathematically literate enough. Hence, as reported by the Ontario Ministry of Education (2005), teachers with mathematical literacy emphasis should try to implement diverse teaching approaches in their classes, including problem-based learning, discovery learning, mathematical modeling, and cooperative learning. However, as many teachers underlined, the challenge of making major changes in teaching practices is the other significant educational challenge that inhibits the development of mathematical literacy. Most of the teachers generally apply traditional teaching approaches in their classes. They are not very much willing to have a teaching style laying particular stress on mathematical literacy as they need to make a serious effort to develop or change their existing teaching practices toward this new teaching style. Many teachers prefer to use traditional types of problems involving routine calculations and procedures in class because non-routine problems daunt or confuse their students a lot (Madison, 2004). Preparing non-routine problem activities for mathematical literacy is a challenge for most of the teachers because such activities can usually take up a significant amount of time, often an entire mathematics lesson (Romberg, 2001).

Another point to note is that developing problem-solving skills to formulate any problem situation from a real-life context to the domain of mathematics for evaluation requires a significant amount of time and effort to plan and implement. Teachers need to pay more attention to each student and to monitor his or her progress during instruction. However, teachers often find it difficult to implement inquiry-based and investigative classroom activities with formulation and modeling of real-life problems through a comprehensive evaluation of the results, as they typically need more time and dedication for both teachers and students. In crowded classrooms, such teaching practices and learning activities become much more difficult (Darling-Hammond, 2014; Ehrenberg, Brewer, Gamoran, & Willms, 2001; Lee & Smith, 1995). It is very difficult to plan and manage group work without it being a waste of time in crowded classrooms. Teachers cannot monitor and assess each student's learning style and need carefully to develop appropriate learning opportunities for mathematical literacy in such classes. Hence, in addition to the challenges associated with students and teachers, the time constraint and the crowded classrooms seem to be other possible educational challenges having negative impacts on students' mathematical literacy performance.

What mathematical literacy requires is for teachers to teach mathematics according to the students' expectations and capabilities starting from early school years. Therefore, teaching mathematics by considering classes consisting of students with varying levels of mathematical abilities is important (Murray & Jorgensen, 2007; Olson & Larsen, 2012; Tomlinson, 1999, 2003), as this would create much willingness and desire for learning mathematics. Otherwise, any lack of willingness or desire for learning mathematics automatically results in ineffective development of mathematical literacy. However, teachers emphasized that despite the differences in students' level of proficiency in mathematics, they struggle to teach everyone the same mathematics. Often, what teachers do in class is to teach mathematics to the "average" student. In this case, while students who are good at mathematics and enjoy solving challenging mathematics problems may feel bored and hold back, students who need additional help in mathematics may feel hopeless and frustrated.

Teaching mathematics in this way may only result in a strong dislike and anxiety of mathematics rather than contributing to the development of students' mathematical literacy skills.

Lastly, there is a general sense that systemic challenges also pose significant barriers to the effective development of mathematical literacy. In this regard, the congested mathematics curriculum was considered as one of the significant systemic challenges that negatively influence the successful implementation of the learning outcomes and goals emphasizing mathematical literacy. The teachers in this study stated that the curriculum they need to follow is very intense and requires a substantial commitment of time and effort to meet its requirements. This would automatically produce considerable stress for teachers, which would naturally harm the development of students' mathematical literacy skills. However, the successful implementation of any curriculum reform is primarily based on establishing more realistic time frames for teaching and learning (Adler, Pournara, & Graven, 2000). Moreover, as also reported by many teachers, even if the curriculum is changed and adapted through mathematical literacy understanding, most of the teachers may not appreciate and welcome it unless their beliefs and perceptions about teaching mathematics change. In such a case, teachers usually intend to maintain their existing teaching practices and enact different curricula in their classrooms, and as a result offer students and themselves considerably different learning opportunities (Fullan & Stegelbauer, 1991; Handal & Herrington, 2003; Remillard, 2005; Remillard & Bryans, 2004). Unless a supportive environment is created to improve the professional qualities of teachers in order to enhance their knowledge and skills needed by the modified curriculum, it always becomes more comfortable for many teachers to resort to old knowledge and familiar teaching and learning methods (Clarke, 1997). Hence, even if the mathematics curriculum is changed and revised to align with mathematical literacy understanding, its acceptance should be expected in the long run through the persuasion of teachers to such change and revision.

The (university entrance) exam-oriented education was also seen as a critical systemic challenge for mathematical literacy development by the teachers. The university placement test is one of the well-known facts in Turkey. Teachers are just forced to prepare their students for the university admission test, as many students' concentration is on this entrance examination. However, according to the Standards for Educational and Psychological Testing (2014), this may result in unintended consequences of testing. For example, statewide placement testing based on ranking may lead teachers to focus on solving as many standard questions as possible at the expense of giving mathematical literacy problems. Moreover, such student placement testing eventually leads to the development of test anxiety. Unless students handle this anxiety or there is another way to enter university, they continue to think that the right answer to the problems they face in real life will be just one of many other possible available options. The important thing is not to develop mathematical literacy, but to increase the total number of correct answers in the admission test (Firestone & Mayrowetz, 2000). The more correct answers they have, the higher the score they receive on the test. The higher the score they have, the better the university they can enter. Therefore, the primary purpose of mathematics teaching has become to prepare the students for the university admission test rather than focusing on mathematical literacy. However, the essential point missed here is that the university admission test indeed could be one of the means for providing necessary mathematical literacy skills. Indeed, as teachers in this study reported, although there have recently been seen some questions in the context of mathematical literacy understanding in the tests, they have been so few to encourage

mathematics teachers to give much importance to this understanding. The content of the test also still does not seem to be helpful for the development of mathematical literacy understanding. Elmore (1996) mentioned that these types of tests often lack intellectual challenges and real-life applications of knowledge and skills for students. Various rules and similar procedures are practiced by students many times with little or no understanding (Schorr, Firestone, & Monfils, 2003). However, to improve mathematical literacy, the content of the exam should encourage discovery learning and inquiry-based teaching approaches that would allow an opportunity for students to establish deeper understanding by exploration and investigation (Baron & Wolf, 1996; Corbett & Wilson, 1991; McNeil, 2000; Resnick & Resnick, 1992). Thus, as teachers recommended, the university placement examination content should be modified to make it more relevant to mathematical literacy if teachers are required to focus their emphasis much on the development of mathematical literacy understanding.

The lack of mathematical literacy understanding in undergraduate teacher education programs also seems to be another critical systemic challenge that adversely affects the development of mathematical literacy. Many teachers in this study expressed that education given in their undergraduate programs had nothing much to use mathematics in the context of mathematical literacy. Additionally, the lack of research or discovery-oriented undergraduate teacher education was also stated as another contributory factor for the lack of mathematical literacy understanding. However, as voiced by Laursen, Hassi, and Hough (2016), inquiry-based learning in mathematics is well suited to produce prospective teachers who are inclined to emphasize research or discovery-oriented mathematics education. Furthermore, the lack of mathematical literacy courses in undergraduate programs is considered as the other major factor that negatively influences the development of mathematical literacy skills. Therefore, it is expected that such elective and compulsory courses on mathematical literacy in pre-service teacher education would help to equip prospective teachers with the basic principles and skills in designing and developing mathematics teaching in the context of mathematical literacy.

In addition to mathematical literacy understanding in pre-service teacher education programs, teachers often supported the view that the development of the essential basis for mathematical literacy, such as having basic arithmetic and problem-solving skills and conceptual understanding, should indeed start from elementary school. However, the education given in primary schools does not seem to underline sufficiently the importance of mathematical literacy development. In other words, basic mathematical skills that students need in real life are not exactly established in elementary school years (Treacy & Willis, 2003). Most of the students cannot understand new mathematical ideas and structures by relating them to what they already know and understand. They also have much difficulty in understanding, formulating, and solving basic mathematics problems presented in high school, as they probably inadequately receive necessary problem-solving skills in primary education (NCTM, 2000). Accordingly, many students suffer from discontinuity problems between primary and secondary schooling (Clarke, 2000), and this inevitably prevents the development of mathematical literacy understanding of students.

Mathematics textbooks are also supposed to be essential to meet the mathematical literacy demands of both teachers and students. However, teachers generally do not find the textbooks sufficient for mathematical literacy development in terms of both their content and the number of appropriate examples. They highlight the fact that even though they involve a few examples from everyday life, most of them, unfortunately, are not authentic problems.

Besides, they are seen as very symbol-laden and complicated to understand to build problem-solving skills (Pia, 2015), which prevents the development of mathematical literacy understanding.

As a result, if mathematical literacy is to be well embedded into all aspects of mathematics teaching and learning, it should be ensured that teachers have a rich understanding of mathematical literacy and belief that it is an integral part of students' learning process, along with relevant mathematical, pedagogical and curriculum knowledge (Bennison, 2015). Accordingly, educators need help in understanding the idea of mathematical literacy itself in the process of implementing mathematical literacy and what it means in terms of how teachers can organize mathematical activities and how to resolve the interplay between content and context within those activities and their inclusion in the classroom. Many of the participants have expressed their lack of confidence in effectively teaching mathematical literacy as well as little confidence in their ability to develop teaching materials regarding mathematical literacy. Teachers are not only required to understand mathematics but also make the contexts relevant to all learners, and that is where the root of the problem lies. If mathematical literacy learners are expected to be able to use mathematics, they must be sufficiently familiar with the contexts and have sufficient understanding of the contexts to use their mathematical knowledge to evaluate them. However, teachers are unlikely to be able to manage all the appropriate contexts for all students during their lesson, let alone a large amount of teaching time needed to meet just one of the curriculum standards. This may mean two things: either they lack sufficient content knowledge and the comprehension of mathematical concepts or they have no pedagogical content knowledge of the subject. In order to acquire the skills necessary for effective teaching of mathematical contents in service for the development of mathematical literacy, continuous professional development support is thus needed immediately. Two critical areas of professional development require proper attention. Firstly, the existing teacher education programs need to be improved by structuring them to provide awareness of mathematical literacy. Secondly, in line with current curricular and pedagogical changes, all mathematics educators need to be formally retrained in the light of mathematical literacy. Also, continuous professional assistance is required that could help mathematics educators understand how instruction for mathematical literacy development looks like.

Overall, what is remarkable is that the teachers in this study identified some obstacles to the development of mathematical literacy from different perspectives. The emergence of many different views about this issue could indeed be explained by the fact that each teacher in this study already had almost all of the diverse but convergent conceptions of mathematical literacy (Genc & Erbas, 2019). This fact could serve as an opportunity to assist in resolving the obstacles identified from various perspectives. Hence, the role of teachers' conceptions as a tool for promoting mathematical literacy is perhaps the most important from a pedagogical perspective that would shed further light on this matter. Accordingly, the next step could be to investigate the teachers' conceptions for the effective development of mathematical literacy understanding in the classrooms. This investigation could also be extended to shed light on the matter of the nature of the conceptions of mathematical literacy that students are likely to develop as a result of the learning experiences in the context of mathematical literacy. It is hoped this can also be enlightening for policymakers to make the necessary efforts in order to offer appropriate activities, resources, and ideas to teachers and educators that could address some of the issues and challenges raised.

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Appendix. Crosstab of various challenges to the development of mathematical literacy by teachers

Table A1. Crosstab of conceptual challenges to developing students' mathematical literacy by teachers

Conceptual Challenges: What is mathematical literacy?		Teacher-1	Teacher-2	Teacher-3	Teacher-4	Teacher-5	Teacher-6	Teacher-7	Teacher-8	Teacher-9	Teacher-10	Teacher-11	Teacher-12	Teacher-13	Teacher-14	Teacher-15	Teacher-16	Total (16)	
Categories																			
Conceptualization of mathematical literacy as a necessity for all	Total (unique)	1	1	0	1	1	1	1	1	0	1	1	0	0	1	1	1	1	12
Conceptualization of mathematical literacy as a multifaceted notion	Total (unique)	1	1	1	0	1	1	1	1	0	1	1	0	0	1	0	0	0	10
Conceptualization of mathematical literacy as a multidisciplinary construct	Total (unique)	1	1	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	5

Note. While a score of 1 denotes that the teacher response included the related obstacles, and 0 indicates otherwise.

Table A2. Crosstab of educational challenges to developing students' mathematical literacy by teachers

Educational Challenges: How can we develop mathematical literacy?		Teacher-1	Teacher-2	Teacher-3	Teacher-4	Teacher-5	Teacher-6	Teacher-7	Teacher-8	Teacher-9	Teacher-10	Teacher-11	Teacher-12	Teacher-13	Teacher-14	Teacher-15	Teacher-16	Total (16)	
Categories	Subcategories																		
Barriers associated with students	(i) Mathematics anxiety	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	15
	(ii) Students' lack of interest in mathematics	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	15
	(iii) Lack of basic arithmetic knowledge	1	1	1	1	0	1	1	0	1	1	1	0	1	1	1	1	1	13
	(iv) Excessive concern about mathematics grades	0	1	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	5
	(v) Inability to search for information independently	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	1	1	4
	Total (unique)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
Barriers associated with teachers	(i) Lack of teachers' qualifications in mathematical literacy	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	15
	(ii) Teaching mathematics by rote	1	1	1	1	1	1	1	1	0	1	1	0	1	0	0	1	1	12
	(iii) The difficulty of making major changes in teaching practices	1	1	1	0	1	1	1	1	0	1	1	1	0	1	0	1	1	12
	(iv) Drawbacks of continuous use of routine problems	0	1	1	0	1	1	1	1	1	1	1	0	0	0	0	0	0	9
	Total (unique)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
Lack of differentiated instruction	Total (unique)	1	1	1	0	1	1	1	1	1	1	0	1	1	1	0	1	1	13
Time constraint in teaching mathematics	Total (unique)	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	0	1	12
Crowded classrooms	Total (unique)	1	1	0	0	1	0	1	0	0	1	0	1	1	1	1	1	1	10

Note. While a score of 1 denotes that the teacher response included the related obstacles, and 0 indicates otherwise.

Table A3. Crosstab of systemic challenges to developing students' mathematical literacy by teachers

Systemic Challenges: Where is mathematical literacy (to be) located?		Teacher-1	Teacher-2	Teacher-3	Teacher-4	Teacher-5	Teacher-6	Teacher-7	Teacher-8	Teacher-9	Teacher-10	Teacher-11	Teacher-12	Teacher-13	Teacher-14	Teacher-15	Teacher-16	Total (16)	
Categories	Subcategories																		
Difficulties in the curriculum implementation	(i) The intensity of the mathematics curriculum	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
	(ii) Teachers' perspectives and practices	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	15
	(iii) Lack of mathematical literacy emphasis in the mathematics curriculum	0	1	0	1	0	1	0	1	1	1	1	1	0	1	0	1	1	10
	Total (unique)	1	1	1	1	1	1	1	1	16									
Drawbacks of the university placement examination	(i) University entrance exam-oriented education	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15
	(ii) Lack of mathematical literacy emphasis on the university entrance exam	1	1	0	1	0	1	1	1	1	1	1	1	0	1	0	1	1	12
	(iii) University entrance examination anxiety	1	0	0	1	0	1	0	1	1	1	1	0	1	0	0	1	1	9
	Total (unique)	1	1	1	1	1	1	1	1	16									
Shortcomings of undergraduate teacher education programs	(i) Lack of mathematical literacy understanding in undergraduate programs	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	0	1	13
	(ii) Lack of mathematical literacy course in undergraduate programs	1	1	1	0	1	0	1	1	1	0	1	1	1	0	0	1	1	11
	Total (unique)	1	0	1	15														
Lack of appropriate mathematics textbooks for mathematical literacy	Total (unique)	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	15
Lack of mathematical literacy understanding in primary education	Total (unique)	1	1	1	0	1	1	1	0	0	1	1	0	1	1	1	1	1	12

Note. While a score of 1 denotes that the teacher response included the related obstacles, and 0 indicates otherwise.