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Abstract

The purpose of this study was to investigate secondary mathematics teachers' conceptions of mathematical literacy, which are important to consider when is essential to address in designing and implementing effective approaches. Data sources included semi-structured interviews with 16 in-service mathematics teachers from different types of secondary schools. Data analysis utilized open coding in order to identify and label patterns and themes. Results indicated that teachers' conceptions of mathematical literacy could be categorized into seven groups: (i) Possession of mathematical knowledge and skills, (ii) Functional mathematics, (iii) Problem solving, (iv) Mathematical thinking, reasoning and argumentation (v) Innate mathematical ability, (vi) Conceptual understanding, and (vii) Motivation to learn mathematics. The teachers participated in this study often expressed multiple and simultaneously held conceptions of mathematical literacy. Even though this would suggest that teachers may have confusing and ambiguous understandings of the nature of mathematical literacy, it may also reflect richness in teachers' understanding of various aspects of mathematical literacy.

Introduction

Recent arguments have presented the view that people need to develop mathematical literacy to process, communicate, and interpret mathematical information in a variety of contexts in order to survive in today's modern society (Organization for Economic Co-operation and Development [OECD], 2013a; Stacey & Turner, 2015). This growing interest in mathematical literacy calls for an inclusive mathematics education for all students. However, there seems to be little or no general agreement among educators and researchers as to what mathematical literacy actually means (Coben et al., 2003; Goldenberg, 2014; Jablonka, 2003; National Institute of Adult Continuing Education [NIACE], 2011; Sfard, 2014; Steen, 2001; Withnall, 1995).

Mathematical literacy provides people with awareness and understanding of the role that mathematics plays in the world. Although mathematics and mathematical literacy do not overlap exactly, they do support the development of each other (Quantitative Literacy Design Team, 2001; Steen, 2001). Since mathematical literacy involves using mathematics to act in real life, people need to be mathematically literate in a wide variety of settings. In addition to knowing and using efficient methods for problem-solving, mathematically literate people need to assess whether the result obtained makes sense and to be aware of the appropriate and inappropriate uses of mathematical knowledge to analyze situations and draw conclusions. Mathematical literacy is, therefore, useful not only for citizens individually but also for society as a whole for fostering democracy and civilization in society. It enables people to develop both competence and confidence to interpret and critically analyze everyday situations (Steen, 2001). In that respect, it has been argued that the development of students' mathematical literacy skills should take place throughout the curriculum and is the responsibility of all teachers (Thornton & Hogan, 2004).

Even though the concept of mathematical literacy has become a personal attribute very much dependent on the context in which the individual operates and might mean different things to different people including teachers, it lays particular stress on inclusion of learners in relation to access important mathematics and improving students' capacity to make use of mathematics in different contexts. It is thus essential that instruction in schools must be significantly revised so that students can have rich experiences to be able to deal with a range of problems and situations encountered in daily life to become mathematically literate (OECD, 2013a). This certainly requires moving away from an elitist and exclusive perspective that considers mathematics as something at which only the more talented few can be successful, to one in which mathematics is a subject at which everyone needs to become proficient to some degree (Mavugara-Shava, 2005). Indeed, knowledge and skills needed to be mathematically literate are often embedded into the existing school mathematics curriculum. Teachers are expected to be able 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 (Askew, Brown, Rhodes, Johnson, & William, 1997). On the other hand, teachers do not only implement the curriculum, but they also develop, define, and reinterpret it (Thompson, 1992). Hence, 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 and most of the innovations have been introduced or enforced through a top-down approach without consultation with teachers who are required to implement these innovative strategies (Norton, McRobbie, & Cooper, 2002). There is, therefore, a great expectation from teachers to have an adequate understanding and know how to incorporate mathematical literacy understanding into their instructional practices when and where necessary (Milton, Rohl, & House, 2007).

Accomplishing mathematical literacy for all naturally involve challenges due to the instructional practices, knowledge, beliefs and, in general, understanding of teachers who for a long time have considered the teaching of mathematics to be the competence of a few. Since teachers' conceptions of mathematical literacy have a significant role in forming their instructional behaviors or practices in the classrooms in the context of mathematical literacy, any discussion on teachers' instructional practices regarding mathematical literacy cannot be viewed differently from the discussion on teachers' conceptions about mathematical literacy (Askew et al., 1997; Thompson, 1992). For example, early indications of teachers' understanding suggest that mathematical literacy is being seen as downgrading or inferior to mathematics (Steen, Turner, & Burkhardt, 2007; Tout, 2001) or as equivalent to less mathematics (Gal, 2000). Such positions and perceptions would serve as a barrier for advancing inclusive mathematics education because "the major issue in exclusion from mathematics is the way in which its central practices are hidden from many students, causing them to remain on the margins, lacking the means of ownership" (Solomon, 2009, p. 163). Therefore, teachers should have an adequate understanding and know how to incorporate mathematical literacy understanding into their instructional practices when and where necessary (Milton et al., 2007). As teachers' beliefs, knowledge and their practices occurred within the classroom will significantly influence students' development of mathematical literacy (Askew et al., 1997), ensuring an inclusive classroom and thus opportunities for all students to become mathematically literate requires teachers who can make sense of the concept of mathematical literacy and its importance for an inclusive mathematics education. Moreover, understanding teachers' conceptions of mathematical literacy in terms of its importance to personal and social lives as well as the requisite mathematical knowledge and skills are important for providing teachers with opportunities to develop a richer personal conception of mathematical literacy for embedding relevant practices into their lessons (Bennison, 2015a; Goos, Geiger, & Dole, 2014). For this, it is of significance to investigate what teachers interpret and understand about the term mathematical literacy in order to better equip and prepare them for implementing appropriate mathematical literacy practices. Thus, the purpose of this study was to investigate what secondary mathematics teachers think and understand about mathematical literacy. The following research question has guided the study: What are the conceptions of mathematical literacy held by secondary mathematics teachers?

Literature Review and Theoretical Background

The concept of mathematical literacy has been debated over many years by educators and researchers because there is an issue of meaning, that is to say, it is not yet clear that what we mean when we talk about mathematical literacy (American Institutes for Research, 2006; Coben et al., 2003; Goldenberg, 2014; Jablonka, 2003; NIACE, 2011; Sfard, 2014; Steen, 2001; Westwood, 2008; Withnall, 1995). There are a number of different approaches to mathematical literacy that vary in accordance with "the culture and the context of the stakeholders who promote it", and it can be considered "as the ability to use basic computational and geometrical skills in everyday contexts, as the knowledge and understanding of fundamental mathematical notions" or "as the ability to develop sophisticated mathematical models or as the capacity for understanding and evaluating another's use of numbers and mathematical models" (Jablonka, 2003, p. 76). However, in a constantly changing world demanding increasingly complex skills and competences, the operationalization of the term 'mathematical literacy' to be used by all poses a challenge. In fact, according to Withnall (1995), mathematical literacy "must remain a fluid term capable of re-conceptualization according to the contexts in which it is used and by whom" (p. 16). This is particularly important for the teachers who are expected to be familiar with the context (i.e., students, schools, curriculum, policy, etc.) where the term is used or needs to be operationalized.

The term 'mathematical literacy' is commonly used synonymously with the terms 'numeracy' and 'quantitative literacy' in different countries and/or contexts with different interpretations (Goos, Dole, & Geiger, 2012; Jablonka, 2003). Although Coben et al. (2003) argued that the concept of numeracy is "a deeply contested and notoriously slippery concept" (p. 9), it is mostly used in adult mathematics education programs and often refers to an individual's ability to cope with the practical mathematical demands of everyday life (Cockcroft, 1982). It encompasses an individual's familiarity with basic ideas in everyday mathematics and adequate number sense in order to recognize, comprehend, represent, and handle data and to interpret problem statements involving mental processing in real-world contexts (de Lange, 2003; Jablonka, 2003). The term numeracy also connotes more than functional use of numerical skills to process, communicate, and evaluate the numerical information (Benn, 1997; Gal, 2000). On the other hand, the National Council on Education and the Disciplines (Steen, 2001) favors to use the term 'quantitative literacy' rather than mathematical literacy. Quantitative literacy is represented by "a cluster of phenomenological categories: quantity, change and relationships, and uncertainty" (de Lange, 2003). However, mathematical literacy indeed can be thought of as the encompassing literacy that consists of both numeracy and quantitative literacy (de Lange, 2003). For example, Jablonka (2003) speaks of the term 'mathematical literacy' "to focus attention on its connection to mathematics and to being literate" (p. 77), especially it pertains "to a mathematically educated and well-informed individual" (p. 77).

According to Steen (1997), mathematical literacy has five dimensions: practical, civic, professional, recreational, and cultural. He highlights that mathematical literacy can be seen in every issue that is related to people's personal, social, and working life because context and mathematical literacy are indivisible and highly interrelated. Steen further suggests more straightforward and comprehensive portrait of mathematical literacy involving the following elements: (i) Confidence with mathematics, (ii) Cultural appreciation, (iii) Interpreting data, (iv) Logical thinking, (v) Making decisions, (vi) Mathematics in context, (vii) Number sense, (viii) Practical skills, (ix) Prerequisite knowledge, and (x) Symbol sense. On the other hand, Skovsmose (2008) categorizes mathematical literacy as critical and functional literacy. While the latter is described by competencies that an individual possesses to perform a particular job function, the former is defined through skills in order to identify and assess the issues such as working conditions and political issues. Skovsmose emphasizes that the functional and critical literacy could take on very different meanings and interpretations depending on the context of the learner. He also mentions reflective knowledge as for mathematics instead of critical literacy. Reflective knowledge pertains to competence in figuring out how mathematics is used or could be used in simple and complex procedures or systems.

Similarly, Sfard (2014) suggests that mathematical literacy can be of various levels depending on the people's needs and requirements. This means that not everyone may necessarily be mathematically literate at the same level, but can be more or less mathematically literate according to his or her demands and necessities. However, it is not clear what mathematical knowledge and skills people should possess in order to become mathematically literate because everyone's interests and desires in daily life is different from each other (Gardiner, 2004). Nonetheless, what is clear is that a satisfactory knowledge of mathematics is essential for mathematical literacy development (Niss, 2015).

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 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 et al., 2008; Powell & Anderson, 2007). For example, the model of mathematical literacy constructed by Pugalee (1999) is sharply based on students' level of mathematical knowledge, which is "valuing mathematics, becoming confident in one's ability to do math, becoming problem solvers, communicating mathematically, and reasoning mathematically" (p. 19). Similarly, Gellert et al. (2001) argue that mathematical literacy is sometimes viewed just as 'survival mathematics', but "this view underestimates the importance and the power of the concept of abstraction" (p. 62). They also express that mathematical literacy cannot be explained in terms of basic skills only as it consists of mathematical problems in contexts that require attributes such as conceptual understanding of formal mathematical knowledge and problem-solving skills. Gellert et al. believe that mathematical literacy involves "a level of mathematical understanding that goes beyond the minimal abilities of calculating, estimating, and gaining some number sense, and basic geometrical understanding" (p. 59). They point out that such abilities can be promoted "by experiencing mathematical modes of thinking, such as searching for patterns, classifying, formalizing and symbolizing, seeking implications of premises, testing conjectures, arguing, and thinking propositionally, and creating proofs” (p. 59), which all require sufficiently advanced levels of mathematical abstraction. In a like manner, Jablonka (2003) accepts mathematical literacy in terms of higher-order mathematical skills that are applicable to all kinds of contexts. According to her, “it emphasizes higher-order thinking (developing and applying general problem-solving skills) rather than basic mathematical skills” (p. 81). However, she also argues that when we try to define mathematical literacy, it is certain that “it cannot be conceptualized exclusively in terms of mathematical knowledge because it is about an individual’s capacity to use and apply this knowledge” (p. 78). This conception of mathematical literacy helps to create predisposition towards seeing the world through mathematical eyes. In this sense, there are also some researchers asserting that mathematical literacy is essential for all individuals to meet the basic demands of everyday living. For example, McCrone and Dossey (2007) argue that the focus of mathematical literacy is on “bringing relevance and deeper understanding to mathematical learning situations that empower individuals relative to their present and envisioned needs” (p. 32) rather than studying higher levels of more formal mathematics. They also argue that this emphasis of mathematical literacy applies to all people, not just to those who are expected to become scientists, bankers, or engineers. Similarly, Powell and Anderson (2007) contend that mathematical literacy is important and necessary for every individual to sustain informed, functional, and effective daily living.

Clearly, there has been a wide range of discussions and debates about mathematical literacy in the literature. Indeed, “we have a definition, but no clear meaning” (Goldenberg, 2014, p. 140). Whilst recognizing that currently the concept of mathematical literacy is heavily contested, all attempts to define mathematical literacy support the idea that mathematical literacy consists of the knowledge and skills required to deal effectively with people’s everyday mathematical needs, including the ability to readily relate to different expectations in this ever-changing society that is fully exposed to numerical information and driven by recent technological innovations (Gellert et al., 2001; OECD, 2013a; Skovsmose, 2008; Venkat, 2013). Concerns that existing mathematics education in many countries inadequately equips their citizens to use and apply mathematics effectively in different phases of their lives have 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 is referred as mathematical literacy (OECD, 2003). According to OECD (2013a), mathematical literacy is an individual’s capacity to efficiently manage and respond to mathematical demands of personal, social and working life as well as the capacity to easily adapt and conform to new requirements in a constantly changing society that is entirely embedded with quantitative data and controlled by modern technology. Thus, it requires 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 (OECD, 2013a). Hence, the definition of mathematical literacy as conceptualized by OECD is comprehensive and broad as it covers the main aspects of other notions of mathematical literacy. Among others, it clearly resorts to Freudenthal’s (1983) realistic mathematics education approach and describes mathematical literacy in high relation to the authentic real-world contexts in which mathematics is applied and thereby contributing to a better understanding of mathematics (OECD, 2013a). 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 people’s personal, occupational, and social lives in order to enable them to become constructive, concerned, and reflective citizens of now and future generations.

Although the existing definitions of mathematical literacy, quantitative literacy, and numeracy have many features in common and can provide useful information about curriculum development and national or international evaluations of students’ educational achievement, they do not provide teachers with direct guidance on how to plan a rich mathematics literacy-oriented teaching (Goos et al., 2014). Using the common elements of these definitions, Goos et al. (2014) developed a multi-faceted model of numeracy in order to elaborate the skills needed to be numerate in the twenty-first century. According to this model, being numerate requires the application of mathematical knowledge including concepts and skills as well as problem solving strategies and the capability to make rational estimations; the use of this mathematical knowledge in a range of contexts involving personal, social, and work life; the use of representational, physical, and digital tools; and positive dispositions towards mathematics by being confident and willing to apply mathematical knowledge flexibly. By placing the context dimension at the center, the numeracy model incorporates these four dimensions, including mathematical knowledge, contexts, tools, and dispositions, and embeds them into a critical orientation dimension for the use of mathematics to assess, defend or provide a justification for mathematical arguments or results (Goos, et al., 2014). Bennison (2015a) argued that if teachers are to effectively exploit this model to plan and implement numeracy strategies across the school curriculum, they need to see themselves as teachers of numeracy and develop effective ways of embedding numeracy into their lessons. In this sense, Bennison (2015a) developed a conceptual framework for identity as an embedder of numeracy, which is structured around five domains of influence (i.e., knowledge, affective, social, life history and context). The framework is based on the numeracy model (Goos, et al., 2014) and the orientation to numeracy as an embedder who believes that "every teacher is a teacher of numeracy …, and has a responsibility to vigorously intervene in students' learning of mathematics in that context" (Thornton & Hogan, 2004, p. 318). Bennison (2015a) highlighted that as long as teachers' personal conceptions of numeracy are of the kind described in Goos et al.'s (2014) model of numeracy, they will not be able to fully develop an identity as an embedder of numeracy to promote the numeracy capabilities of their students. Therefore, effective numeracy or mathematical literacy teaching requires that teachers have a rich conception of numeracy or mathematical literacy to better able to improve students' learning across the curriculum (Bennison, 2015a, 2015b).

Method

Research Design

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 mathematical literacy, which entailed unfolding and reporting the complex interactions of teachers' beliefs about mathematical literacy and other factors in unique and dynamic contexts (Cohen, Manion, & Morrison, 2007).

Participants and Their Context

This study aimed to document secondary mathematics teachers' conceptions of mathematical literacy at various school types in Turkey. Sixteen mathematics teachers (4 females and 12 males) from nine secondary schools of five different types [i.e., 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 participated in the study on voluntary basis.

When recruiting the participants, including teachers from different school types was considered important as students' performance and mathematical literacy as defined in the PISA vary among school types. In fact, Alacacı and Erbaş (2010) reported that, in PISA 2006, while the students in Science High Schools, Anatolian High Schools, and Foreign Language Intensive High Schools performed above OECD average in PISA 2006, students in General[*] and Vocational High Schools (including Religious High Schools) have significantly lower overall performance. On the other hand, by the time of data collection even though the same national mathematics curriculum is intended to be applied in all school types, students' differing performance in different types of high schools may be intervened by the actual curriculum implemented in these schools and differences in the weekly number of mathematics lessons in the programs of different school types (Alacacı & Erbaş, 2010). The school types from which the participants were recruited for this study were representative of the general and vocational upper secondary education institutions in the area and in the Turkish education system in general.

Teachers of 9th-grade and 10th-grade mathematics 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 9th and 10th graders (Ministry of National Education, 2013a). Second, the national high school mathematics curriculum was structured differently in 9th and 10th than 11th and 12th 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 (Ministry of National Education, 2013b), its importance was implicitly described and emphasized. For example, mathematical modeling and problem solving were stated as the most essential skills and competencies that the curriculum aimed to develop. While the curriculum aimed to deliver the same core mathematical standards regardless of region, school type, and student in grades 9 and 10, two sets of standards, referred to as "basic level" and "advanced level," are recommended in grades 11 and 12 based on students' choices, needs, future career goals, etc. The "basic level" aimed at developing students' ability to actively use mathematics in their daily and professional lives, utilize it as an analysis tool for reasoning and decision making. In this context, standards for the "basic level" aimed to establish some of the fundamental mathematical concepts from grades 9

[*] Starting from 2010, all general high schools in Turkey were converted to either Anatolian high schools or vocational high schools including Anatolian Imam Hatip (Religious) high schools by 2014.

and 10 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.

On the other hand, 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. In this study, it is assumed that experienced teachers, as we considered those with at least five years of experience in teaching mathematics, would reveal more insight into teachers' conceptions regarding mathematical literacy. Thus, in all types of upper secondary schools in the district, only 9th and 10th grade mathematics teachers with at least five years of experience were invited to participate in the study. Participants had been teaching from 5-year to 24-year (M = 17.25, SD = 6.09). Moreover, while nine of the participants had their undergraduate education and thus certification as mathematics teacher in college of education, seven of the participants received their teacher certification through pedagogical coursework after having a degree in mathematics.

Data Collection

The conceptions are considered as "a more general mental structure, encompassing beliefs, meanings, concepts, propositions, rules, mental images, preferences, and the like" (Thompson, 1992, p. 130). Teachers' conceptions of mathematical literacy, in this study, are characterized as what teachers regard to be the purpose and importance of mathematical literacy as an outcome of the school mathematics curriculum, skills and competencies integral to mathematical literacy, and the connections between mathematics and its literacy. Data was collected through one-to-one semi-structured interviews lasting approximately one hour. All of the teachers preferred their respective school as the interview site. All interviews were conducted at the leisure time of each participant during school hours. The teachers were asked to talk about their perceptions and understandings of the notion of mathematical literacy. Questions and sample probes in the interview guide were as follows:

- What do you understand from the term 'mathematical literacy?'
  - What can be the purpose of mathematical literacy?
  - To what extent is it important?
  - How does mathematical literacy contribute to the individual and the society?
- What are the fundamental skills and competencies that a person with mathematical literacy possess?
  - What does it require to be mathematically literate?
  - What would be the essential constituents of mathematical literacy?
- How do you think mathematics and mathematical literacy is related?
  - How does mathematical knowledge shape mathematical literacy?
  - How does mathematical literacy shape mathematical knowledge?

Prior to the data collection, a pilot study was also conducted with two voluntary secondary mathematics teachers who were not involved in the actual study in order 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 open coding the data in order to identify and label the patterns and themes. In this sense, an initial list of codes was developed based on the interview protocol and previous research. Inductive codes generated by the data were added to this initial list in order to explore emergent insights and hidden patterns (Patton, 2002). The qualitative data analysis software NVivo 10 was 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. Interviews were transcribed verbatim and coded using a grounded theory approach. After assigning the initial list of codes to all transcripts, the audio recording of each interview was listened 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 were 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, 14 of the teachers provided feedback orally and expressed no disagreements with their responses and interpretations of them. Furthermore, it was important 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. In that respect, 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). To facilitate inter-coder reliability, one mathematics education researcher with more than 10 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 expert review, this mathematics education researcher and we double-checked codes on all transcripts and re-examined emerged themes and categories. The comparison of the two coding outcomes showed 92% agreement. The raters resolved all disagreements and revised the code definitions until a full-agreement was reached for the categories and conferred thoroughness and credibility of the data analysis. The number of the teachers talking about each distinct category was also reported in order to contribute internal generalizability of the study which refers not to the generalizability of conclusions of this study to other settings, but to generalization within the collection of the teachers studied, establishing that the categories identified are in fact characteristic of this particular set of teachers as a whole (Maxwell, 2010).

Results

A cross-case analysis of the data from 16 teachers revealed seven emergent categories for teachers' conceptions of mathematical literacy: (*i*) Possession of mathematical knowledge and skills, (*ii*) Functional mathematics, (*iii*) Problem solving, (*iv*) Mathematical thinking, reasoning and argumentation, (*v*) Innate mathematical ability, (*vi*) Conceptual understanding, and (*vii*) Motivation to learn mathematics. Figure 1 shows all teachers listed on a single chart in order to indicate the strength or intensity of each category regarding the concept of mathematical literacy. The numbers in parentheses next to each category represent the corresponding total number of the participants talking about this particular category. The following sections provide the findings with respect to these emergent categories.

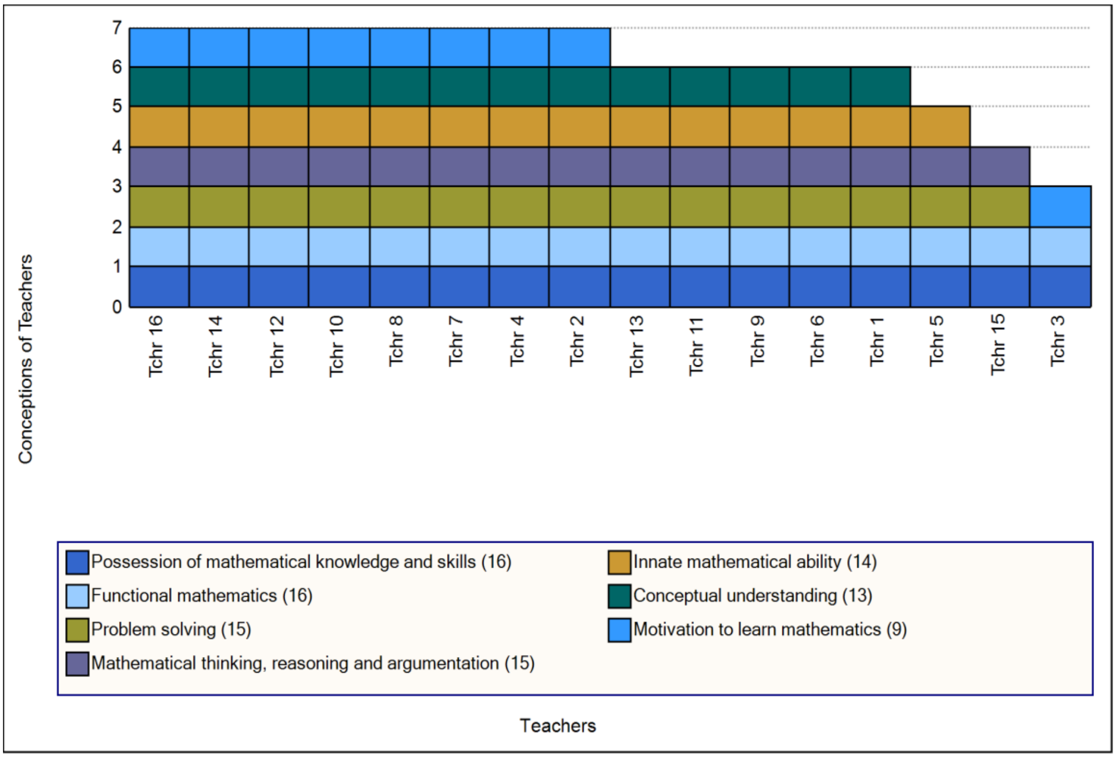

Figure 1. Teachers' conceptions of mathematical literacy

Mathematical Literacy as Possession of Mathematical Knowledge and Skills

All of the teachers in this study considered the nature of mathematical literacy as the possession of mathematical knowledge and skills. Six teachers held the view that mathematical literacy is the possession of a basic level of mathematical knowledge and skills necessary to meet the general demands of daily living. What they mean by the basic level is the ability to employ basic mathematical algorithms and procedures. For example, one of the teachers commented that "*...it would be enough to know basic mathematical operations to become mathematically literate…there is no need to know advanced mathematical knowledge*" (Teacher-3). On the other hand, only two teachers commented that mathematical literacy is the possession of an advanced level of mathematical knowledge and skills. They expressed that instead of the basic level of mathematics, mathematical literacy is a different area of expertise in advanced mathematics. As one teacher remarked, "*...mathematical literacy is the ability to translate advanced mathematical structures into mathematical expressions by setting up complex mathematical equations*" (Teacher-13). The rest of the teachers (n = 8) stated that mathematical literacy is indeed the possession of mathematical knowledge according to people's interests and needs in personal, vocational and social lives. They thought that sometimes it is considered as a basic level of mathematics required for the continuation of life, but other times it can be perceived as a higher level of mathematics needed for scientific and technological developments. Depending on the usage, it can be basic or advanced level of mathematical knowledge and skills. This is related to the diversity of problems that people face in their life. One of the teachers stated that there is surely not a certain level of mathematical literacy for everyone. That is to say, "*…everyone may not read the same number of books but they nonetheless have a level of literacy. Mathematical literacy is something like this*" (Teacher-12). In fact, what the teachers simply mean is that a mathematically literate individual needs to understand and develop satisfactory knowledge of mathematics to use in everyday problems according to their demands and necessities. On the other hand, some of the teachers (n = 7) also mentioned that although a certain level of mathematics is essential for a better mathematical literacy acquisition, there is nevertheless no linear relationship between them. Specially, being good at one does not necessarily mean being good at the other. For instance, one of the teachers pointed out that being mathematically literate anyway requires mathematical knowledge, but "*...there is no such thing that as the level of mathematics increases, mathematical literacy level also automatically increases*" (Teacher-6). They also took up the same issue from the opposite angle and added that using mathematics effectively in life without having studied much mathematics is also possible and it can be explained by a practical skill or a learned habit. The following extract is a typical comment made on this issue:

> …I think that despite having no mathematical education an old peasant woman who excellently weaves many carpets with complex geometric motifs can only be explained by a learned habit or a practical skill inherited from her parents or ancestors (Teacher-5).

Mathematical Literacy as Functional Mathematics

All participants in this study expressed that using mathematics in day-to-day activities is vital in order to function effectively in today's modern society. As one of those participants said, "*...I think math literacy is a knowledge of mathematics which is used functional in daily life*" (Teacher-14). They mentioned various perspectives concerning the use of mathematics functional in societal life. For example, many teachers (n = 14) indicated that mathematically literate individuals can look at things around them with a more critical eye. They emphasized that it is very easy to manipulate or mislead people that lack in mathematical literacy skills because, "*…they easily accept what someone says as just right…they do not have any strong criteria to assess what is being said*" (Teacher-5). Hence, the teachers maintained that mathematical literacy enables people to be informed citizens by taking their own decisions independently. It is their ability to manage themselves rather than someone else manages them. For the teachers, lack of mathematically literate people in any community gradually paves the way for underdeveloped societies and, that is why, "*…we can live in a society in a more prosperous way if most of us somehow gain mathematical literacy*" (Teacher-8). Thus, the teachers noted that mathematical literacy in a general sense is very important to improve the welfare and progress of the society as it makes a direct positive impact on the community development. Besides, several teachers (n = 6) reflected on the importance of mathematical literacy that plays a significant role in individuals' future education. For example, one of the teachers stated that "*...I personally believe that mathematical literacy moves our students to the upper levels in all branches of science*" (Teacher-16). Therefore, they thought that gaining mathematical literacy understanding in the early years would positively affect future education opportunities, especially those based on mathematics or related fields. Some of the teachers (n = 4) also argued that mathematical literacy is the functional use of mathematics in occupational or professional life. As one of the teachers asserted, "*...gaining mathematical literacy understanding certainly provides people with many facilities in their vocational life*"

(Teacher-2), and that is why there should be attached too much importance to the provision of the students with better mathematical literacy understanding for their success and efficiency in their future occupations.

Mathematical Literacy as Problem Solving

Almost all of the teachers (*n* = 15) in this study viewed the nature of mathematical literacy as problem solving. For example, they said that mathematical literacy is very conducive to both formulating the authentic problem situations and constructing its mental representation. It also provides us to create a most appropriate solution to the given problem by evaluating all possible ways. Mathematical literacy is also helpful for reflecting on our solutions to the given problem. One of the teachers stated this as follows: "*...mathematical literacy is, first, to understand the given problem, and second, to represent the problem situation mathematically, and then to interpret it, and finally to apply mathematical procedures for finding solutions*" (Teacher-15). Hence, the teachers in general defined mathematical literacy as the ability to analyze given information effectively and identify the best strategy to reach an appropriate solution for the given problem. Many teachers (*n* = 11) also held the view that in addition to solving pure mathematics problems, mathematical literacy is also the ability to transfer mathematics knowledge to everyday life in order to find solutions to daily life problems. The teachers thought that people with problem-solving skills could produce faster, more reasonable and more logical solutions to the challenges they face in life. The following excerpt illustrates one of these teachers' view on this issue:

> …for example, a doctor, a lawyer, a police officer or a judge need to decide quickly and produce the most appropriate and the most reasonable solution to problems faced in their working life…they can achieve this by the help of mathematical literacy understanding because such an understanding triggers and develops their problem-solving ability (Teacher-9).

Hence, the teachers emphasized that it is definitely mathematical literacy, which allows people to be successful in life. They thought that some people can be good at mathematics but if they do not use their mathematics knowledge to guide them through their life, their mathematics knowledge will mean nothing. Therefore, teachers alleged that if we communicate a proper understanding of mathematical literacy with our students, they could be empowered to overcome many troubles in their future lives. To put it differently, for example, when confronted with a problem, instead of waiting for somebody who would help (or deceive) them, they can at least attempt to produce several efficient solutions for themselves.

Mathematical Literacy as Mathematical Thinking, Reasoning, and Argumentation

Almost every teacher (*n* = 15) in this study expressed that mathematical literacy allows students to develop their mathematical thinking, reasoning and argumentation skills that involve the justification of the mathematical claims, calculations or inferences based on the information or instructions given in the problem. Teachers noted that mathematical literacy helps students make sense of their mathematical work and defend their thoughts about their mathematical inferences. It enables them to evaluate their conclusions and inferences obtained from the information given in the problem. For instance, one of the teachers reported that:

> …the first thing that our students should learn from math classes is to justify their arguments or solutions for any problem by creating their own reasoning or logical thinking process. In fact, the success of this process depends on their mathematical literacy level (Teacher-9).

The teachers considered that mathematical literacy is the ability to find a solution to any problem through reasoning. As one teacher mentioned, "*...mathematical literacy is a complex concept that requires reasoning and thinking skills in addition to basic mathematical knowledge and skills*" (Teacher-11). They supported the view that mathematical literacy fundamentally provides individuals with the competency to establish and develop logical relations for their everyday problems or to assess whether the given arguments put forward by others is correct and adequate. This accordingly allows them to think fast or practical about any issue in daily life. That is to say, "*...mathematical literacy teaches us how to think mathematically*" (Teacher-6). Additionally, some of the teachers (*n* = 4) also supported the view that mathematical literacy, in fact, involves higher-order thinking skills in mathematics. For example, one of the teachers noted that "*mathematical literacy fully supports the power of mathematical thinking and creative thinking skills at higher levels*" (Teacher-9). Therefore, these teachers asserted that mathematical literacy helps people to establish cause and effect relationships by thinking about the possible alternatives carefully and in detail to cautiously analyze all of the parameters of the cases from different angles.

Mathematical Literacy as Innate Mathematical Ability

A large number of the teachers (*n* = 14) in this study argued that mathematically literate people have some sort of innate mathematical intelligence. They commented that some people have numerical intelligence, whereas others have verbal intelligence. Thus, some students may clearly exhibit more talent in mathematics than others. The participants attributed this to genetic factors and held the view that everyone naturally has a certain level of inborn mathematical intelligence that is often inherited from his or her parents. They said that we could try to give higher level of mathematical literacy skills as much as we want to students with lower mathematical ability, but this is something like irrigating a plant that does not produce crops. Therefore, teachers pointed out that it is difficult for everyone to have the same mathematical literacy competence because individual genetic differences are claimed to be important for the issue of the development of mathematical literacy skills. For example, one teacher stated that "*...innate mathematical skills are something that should be considered for better mathematical literacy development*" (Teacher-1). Teachers reported that mathematical literacy is acquired faster with inborn mathematical competence. Similarly, another teacher put it that "*...the innate mathematical ability has a significant influence over the development of mathematical literacy. So, mathematically intelligent people can easily develop mathematical literacy*" (Teacher-4). Teachers supported the view that mathematical literacy is a kind of talent such as writing, drawing, singing, dancing, or playing any musical instrument. In other words, if a person does not have the necessary talent, he or she cannot be a talented drawer, writer, or singer. Similarly, *"if someone does not have any mathematical competence, he or she cannot also adequately become a mathematically literate person*" (Teacher-9). Thus, the teachers claimed that everyone may have different skills or talents, but inborn mathematical intelligence is inevitably needed for better mathematical literacy acquisition. They, therefore, considered that our mathematical literacy in one way is shaped by our genetic factors or by our intelligence.

Mathematical Literacy as Conceptual Understanding

For most of the teachers (*n* = 13) in this study, mathematical literacy involves understanding of mathematical concepts and making connections between these concepts. For example, one of the teachers stated that "*...mathematical literacy is to learn new mathematical concepts by connecting them to what you already know and understand*" (Teacher-13). Teachers perceived mathematical literacy as the organization of mathematical knowledge we already know and the integration of this knowledge into our understanding of new mathematical ideas and structures.

> …Can we effectively use our existing knowledge of mathematics or the knowledge we have already learned? Can we simply activate our prior knowledge? Can we easily transfer this knowledge to another learning? Can we efficiently apply what we have learned in mathematics? The answer to each of these questions is unfortunately not straightforward. Those are the biggest challenges we face in our math lessons. One of the things that our students tell us the most is, 'I know it, but I do not know how to use it'. In such a case, mathematical literacy can help to recognize and understand the mathematical concepts, and then being able to give life to these concepts by relating them to previous concepts (Teacher-12).

Teachers contended that mathematical literacy surely strengthens the conceptual understanding. They emphasized that students should firstly know what mathematics means to them in life. If their conceptual understanding is not good enough, the language used by the teacher when explaining the lesson seems like a foreign language, which is hard to understand for them. Therefore, the teachers claimed that once students get the knowledge of mathematics, they need to use, interpret and transfer it; otherwise, the internalization problem arises. They considered that mathematical literacy plays an important role here to remedy this problem.

Mathematical Literacy as Motivation to Learn Mathematics

Over half of the teachers (*n* = 9) commented that mathematical literacy is very conducive to enhancing motivation and interest in learning mathematics. For example, one teacher held the view that "*...mathematical literacy inspires your mind to love math and it then arouses your enthusiasm for studying mathematics*"

(Teacher-7). Similarly, another teacher noted that since mathematical concepts are usually presented in a more formal way, mathematical literacy understanding can simply facilitate students' understanding in mathematics. She stated, "*...we can make sense of mathematics through mathematical literacy, thereby making it easier to learn*" (Teacher-16). They expressed that mathematical literacy clearly provides students with the power to interpret problem situations and cautiously handle them for finding the most appropriate solutions. The teachers added that students could easily comprehend and develop mathematical knowledge that they use and apply in life. Otherwise, they do not accept the unused mathematical knowledge as their own knowledge and it does not become their own mathematical knowledge until they apply or use it. Therefore, teachers asserted that mathematical literacy could be a wonderful vehicle to teach mathematics effectively because it increases interest in learning mathematics and automatically pushes students to higher levels in mathematics. As explained by one teacher, "*...mathematical literacy certainly presents our students many opportunities for learning mathematics with deep understanding*" (Teacher-11). She stated that it might increase the number of people who like mathematics or the number of people who at least have positive attitudes towards mathematics. Additionally, one of the teachers who mentioned that mathematical literacy is useful for increasing interest and engagement in mathematics also supported the view that mathematical literacy is helpful for dealing with math anxiety or fear by building self-confidence. This teacher thought that when dealing with such anxiety, mathematical literacy is of paramount importance as it presents mathematics in more real, fun and diverse ways: "*...mathematical literacy is a kind of ability that prevents or reduces your math anxiety*" (Teacher-14).

Discussion and Conclusion

The results of this study revealed that teachers held various, but interrelated and mutually reinforcing conceptions of mathematical literacy. While some teachers regarded mathematical literacy as downgraded or inferior mathematics that low-performing students are expected to achieve, some others considered it solely as advanced mathematical thinking and reasoning that high-performing students are supposed to do. In this sense, although the teachers' conceptions of mathematical literacy seem to be divergent, they all thought that a mathematically literate person needs to understand and develop certain level of mathematics and more importantly relate mathematics to everyday experiences in order to deal with real-life problems for improving the overall quality of his/her life. In this context, the teachers' emphasis was on improving students' mathematical problem-solving skills through mathematical literacy which would not only require a clear understanding and simplification of the given problem situation, but also producing different ideas by evaluating the given information in order to set up an algorithm to solve the problem (Brown & Schäfer, 2006). This consequently also requires the problem solver to communicate the solution process and its outcome as well as its justification by actively expressing oneself to others through various means (Niss, 2015). However, the key point to note here is not about to what extent people develop problem-solving skills during their formal education. What is more important to recognize is that how much they can use these skills to solve problems in everyday life. The more they can use these skills, the more mathematically literate they are expected to be. Therefore, the teachers who thought that mathematical literacy mainly refers to problem solving skills in mathematics also held the view that mathematical literacy is in fact the ability to transfer mathematics knowledge to everyday life in order to tackle daily life problems.

This viewpoint is the underlying factor explaining why the teachers in this study considered mathematical literacy as useful or functional mathematics. For example, with respect to the use of mathematics in societal life, teachers asserted that people need to question and criticize events concerning the whole society as well as the events specifically in direct relation to their lives. They alleged that mathematical literacy is important both at individual level and societal level as it could bring wide-ranging benefits to the society and improve the community by enriching the quality of life. One of these benefits considers the functional use of mathematics in work life to increase the professional efficiency as fundamental mathematical skill and knowledge. This is often considered not only among the prerequisites needed in variety of workplaces but also would have an impact on people's employment prospects (Bynner & Parsons, 2000; Hoyles et al., 2002). Another benefit of mathematical literacy was related to individuals' future education, because no matter under what circumstances, if students are mathematically literate, they can be successful in the areas they would choose in the future (Kemp & Hogan, 2000). That is to say, mathematical literacy would make it easier for people to take them to the point where they desire for their future education (Quantitative Literacy Design Team, 2001).

Moreover, many teachers perceived in this study that one of the purposes of mathematical literacy is to encourage people to think mathematically. They put forward that mathematical literacy helps fostering mathematical reasoning and rational thinking skills and allows people to establish causal relationships between events in order to cope with the difficulties they encounter in their personal, vocational, and social life.

However, it is also important to bear in mind that in addition to mathematical thinking and reasoning in general, mathematical literacy in particular also promotes higher order thinking skills (e.g., Gellert et al., 2001; Hope, 2007; Jablonka, 2003). Only a few teachers in this study supported the view that mathematical literacy indeed involves higher-order thinking skills in addition to mathematical knowledge and skills. The difficulty to describe mathematical literacy through higher-order thinking skills for most of the teachers can be attributed to their conception of mathematical literacy that it involves a level of mathematical understanding that does not go beyond basic mathematical skills and knowledge.

Not expectedly, a large number of teachers in this study considered that a genetic predisposition for mathematics or inborn mathematical intelligence is a significant contributor of effective mathematical literacy development. For these teachers, mathematically intelligent people are always one-step ahead of others in terms of mathematical literacy acquisition or understanding because being mathematically literate requires some kind of innate mathematical intelligence. This finding contradicts with the results of PISA 2012 assessment dispelling the common thought that mathematics achievement is predominantly a product of innate ability rather than hard work (OECD, 2014a). Similarly, Boaler (2005) argues that nature of high achievement in mathematics is not a result of innate ability but hard work. Hence, although overall intellectual capacity is seen as influential over the mathematical ability that has the dominant influence on high achievement in mathematics (Orton, 2004), it does not literally mean that people without innate mathematical competence can never gain or develop mathematical literacy skills. This in fact means that the acquirement or development of mathematical literacy skills could be ultimately achieved through hard work and persistent effort even if it takes longer to accomplish this to happen (Hobden, 2007). Innate mathematical intelligence indeed facilitates the acquisition or promotion of mathematical literacy skills. However, an important point sometimes overlooked here is to recognize that mathematical literacy actually ensures people to use their inborn mathematical ability effectively and promotes inclusion by enabling better access to mathematics.

It is promising to find that many teachers in this study also considered conceptual understanding of mathematics as the nature of mathematical literacy. The teachers asserted that in order to comprehend why a mathematical idea is important, students need to connect this idea to what they already know. More importantly, they also need to know exactly where they can use their mathematical knowledge in life. However, the teachers acknowledged that most of their students have difficulty to make sense of their learning by establishing relationships between classroom learning and everyday experiences. Therefore, they considered that mathematical literacy is important in order to empower students to organize their mathematical knowledge into a coherent whole and transfer it to daily life as mathematical literacy offers students opportunities for effective and active learning of mathematics with deep conceptual understanding. Naturally, this understanding can be very conducive to increasing motivation and interest in learning mathematics because people easily comprehend and develop their own mathematical knowledge that they use and apply in real life. Mathematical literacy is indeed our capacity to understand the critical role of mathematics in the world around us and helps us endear mathematics to students (OECD, 2013b). It aims to show that mathematics is a subject that everyone can do regardless of his or her background (Martin, 2007), thereby being a valuable vehicle to teach mathematics through realistic, diverse, and effective ways (OECD, 2014b). However, interestingly, fewer teachers than expected considered that emphasis on mathematical literacy would increase students' interest towards mathematics. This might be due to teachers' lack of experience or necessary competencies about teaching mathematics emphasizing mathematical literacy because teaching or integrating mathematics with real-life applications in the context of mathematical literacy would demand different teacher qualifications in terms of educational preparation and training, professional knowledge and pedagogical skills (OECD, 2014c).

Overall, integrating mathematical literacy effectively into teaching mathematics requires teachers developing understanding and conceptions of mathematical literacy in classroom context as part of their professional capital or identity as regards to numeracy or mathematical literacy (Bennison, 2015a; Callingham, Beswick, & Ferme, 2015). Thus, understanding teachers' conceptions of mathematical literacy would provide insights into why teachers make particular instructional decisions regarding mathematical literacy (Goos, et al., 2014). In this study, varying but mutually supportive and sometimes overlapping conceptions of mathematical literacy seem to be held by the teachers. The fact that every teacher in this study presented almost all of the seven conceptions revealed from the data collected might be perceived that the teachers have confusing and ambiguous conceptions towards the nature of mathematical literacy. Mathematical literacy, however, has several dimensions as its meaning varies according to the purpose and context being used and it means different things to different people according to their interests and lifestyles (Hope, 2007; Jablonka, 2003; McCrone & Dossey, 2007; Sfard, 2014; Skovsmose, 2008; Steen, 1997; Westwood, 2008). Therefore, the fact that having multiple and simultaneous conceptions of mathematical literacy might actually reflect richness in one's understanding of the various aspects of mathematical literacy. In that respect, if mathematical literacy is to be best 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, 2015b). However, emphasis in policy documents and curriculum generally does not necessarily equip teachers with adequate conception of mathematical literacy or numeracy (Bennison, 2015b; Callingham et al., 2015). Even with much emphasis on the use of mathematics in everyday activities, it usually becomes difficult for most of the teachers to design a mathematics lesson in the context of the mathematical literacy due to a number of obstacles (Shanahan & Shanahan, 2008; Westwood, 2008). This may also explain why Turkish students have remained far behind other participating countries in terms of mathematics scores in PISA since its first participation in 2003. Therefore, a valuable pursuit for further research is to investigate teachers' conceptions about barriers to the development of mathematical literacy in order to develop relevant policy and take action. Some further work on constraints such as curriculum development and testing regimes are also worth exploring as raised by some of the teachers in this study. The successful integration of mathematical literacy throughout mathematics curricula is supported by teachers' adequate appreciation and continued reflection of these conceptions in their instructional practices. Thus, for possible interventions, how teachers' perceptions of mathematical literacy would play out throughout their teaching should be studied for understanding the relation between teachers' beliefs and actions in this context. Moreover, further research about how teachers perceive mathematical literacy and their instructional practices would be related in terms of inclusion—or exclusion—of learners in relation to access to certain mathematics would be a valuable follow-up to this study. A next step could be to examine how teachers' conceptions of mathematical literacy and their day-to-day classroom practices align and to design and assess professional development programs addressing these issues. In this regard, conducting observations and additional or follow-up interviews in actual classrooms could provide insight into the possible reasons for tensions between teachers' conceptions and mathematical literacy practices.

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