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# A Meta-Synthesis Study Identifying the Landscapes of Pre- and In-service Math Teachers' Knowledge in the Turkish Context*

# Matematik Öğretmenlerinin ve Öğretmen Adaylarının Bilgisi Üzerine Türkiye'de Yapılan Araştırmaları İnceleyen Bir Meta-Sentez Çalışması

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**ABSTRACT**: This study aims to present a synthesis of empirical studies conducted in Turkey on pre- and in-service math teachers' knowledge and to recapitulate the existing conceptualization in this particular line of research in the local context. Considering the interwoven and sophisticated nature of teachers' knowledge (Seidel & Shavelson, 2007), it sets out to enhance the understanding on what constitutes and should constitute these math teachers' knowledge by discovering the frequently studied research strands in the literature. To this end, this paper reviews 25 empirical research studies identified through Academic Search Complete, Education Source, ERIC, Humanities International Complete, ULAKBIM, and Google Scholar databases. Thematic analysis revealed two majorly studied strands in the field: (a) studies that identify teachers' knowledge levels in terms of certain mathematical concepts, and (b) studies that try to develop math teachers' knowledge through workshops, courses, and programs particularly designed to reach specific objectives. In addition, majority of research was seen to be carried out with pre-service teachers (N = 21); and qualitative methodology was the most commonly consulted research design (N = 22). With its findings, this study bears the potential to direct future research and contribute to pre-service mathematics teacher education programs and in-service trainings.

**Keywords:** math teachers' knowledge, content knowledge, pedagogical content knowledge, meta-synthesis

**ÖZ:** Bu çalışmanın amacı matematik öğretmenlerinin ve öğretmen adaylarının bilgileri üzerine yapılmış veriye dayalı araştırmaların bir meta-sentezini sunarak konu ile ilgili Türkiye bağlamındaki kavramsal altyapının bulunduğu noktayı belirlemektir. Öğretmen bilgisi kavramının iç içe geçmiş ve karmaşık yapısı düşünüldüğünde (Seidel & Shavelson, 2007) bu araştırma, sözü geçen öğretmenlerin bilgi yapılarınınTürk araştırmacılarca hangi boyutlarıyla ele alındığını ortaya koyması ve hangi alanlarda araştırmaya ihtiyaç duyulduğunu göstermesi bakımlarından ulusal alan yazına katkıda bulunmayı hedeflemektedir. Bu amaca ulaşmak üzere çalışma, Academic Search Complete, Education Source, ERIC, Humanities International Complete, ULAKBİM ve Google Scholar veri tabanları kullanılarak erişilen ve konuyla doğrudan bağlantılı olan 25 araştırma makalesinin bir incelemesini sunmaktadır. Yapılan tematik analiz, Türkiye'de yürütülmüş olan çalışmaların iki boyutta yoğunlaştığını göstermiştir: (a) Matematik öğretmenlerinin ve öğretmen adaylarının belli matematiksel kavrama dair bilgi düzeylerinin belirlendiği çalışmalar ve (b) katılımcıların matematik bilgisini düzenlenen eğitim programları, çalıştaylar ve geliştirilen dersler yoluyla geliştirmeyi hedefleyen çalışmalar. Bunun yanı sıra, incelenen araştırmaların büyük bir bölümünün öğretmen adayları ile gerçekleştirildiği (N=21) ve araştırma deseni olarak çoğunlukla nitel yöntemin izlendiği (N=22) de çalışmanın bulguları arasındadır. Sunduğu ve tartıştığı verilerle bu çalışmanın gelecekteki araştırmalara ışık tutması ve öğretmen yetiştirme programları ile hizmet-içi eğitime bilgi sağlaması bakımından faydalı olacağı düşünülmektedir.

**Anahtar sözcükler:** matematik öğretmenlerinin bilgisi, alan bilgisi, pedagojik alan bilgisi, meta-sentez

## 1. INTRODUCTION

Having roots in as early as almost one and a half centuries, although its theoretical lineage dates farther back in time, teacher component of the corps of teaching has been the subject of

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various studies under several headings as process-product, teacher effectiveness, and teacher behavior research (Shulman, 1986). This interest mainly derives its strength from the premise that a teacher's knowledge, widely embraced type being the command of the subject matter, is tightly germane to the achievement of his or her students.

As a result, be it through the 70s marked by industrialization which brought the prioritization of subject matter while ignoring pedagogy or the contrary arguments of 80s that discarded content knowledge due to being absorbed by pedagogical concerns (Shulman, 1986), the constituents of teachers' knowledge in all its parts have been entertained by curriculum scholars. Despite the post facto evidence showing that no one teacher characteristic alone verifies to have a direct and consistent impact on student success, early research appeared to profoundly concentrate on the domains of teacher knowledge seeking to discover the sets of knowledge, skills and personality traits of effective teachers (Medley, 1979). Thus, the research base for identifying what makes effective teaching effective and its connection to teacher characteristics has become fairly thick. Ball (1991) identifies this primal stage as the first phase of research on teachers, followed by second chapter studies aspiring to discover an association between teachers' actions and student learning, also known as the process-product research, and by a third and most recent trend to gain an insight into teacher thinking latently or explicitly operating in the background. Therefore, a shift has been observed in the research history on teachers from studies investigating what teachers are, to what they do, and finally to what they think.

In return, this accumulated lore in the literature lent itself to diverse categorizations of teachers' knowledge. The most acknowledged of all has been proposed by Shulman (1987) encompassing seven categories as (1) content knowledge, (2) general pedagogical knowledge, (3) curriculum knowledge, (4) pedagogical content knowledge, (5) knowledge of learners and their characteristics, (6) knowledge of educational contexts, and (7) knowledge of educational ends, purposes and values. These scholarly remarks parented a number of studies constituting the current corpus of research on teacher knowledge. These can roughly be labelled as studies (a) identifying the amount of knowledge teachers possess, (b) studies investigating the effect of teachers' knowledge on student achievement, (c) studies making novice-expert comparisons, and (d) studies relating teachers' knowledge to pre-service teacher education programs.

The nature of research in the field of mathematics education is also reported to evolve in a similar fashion. In terms of studies on subject matter knowledge in mathematics, researchers appear to have split into two sects, one interested in teachers' conceptions of beliefs about mathematics, the other focusing on teachers' understanding of mathematical concepts and procedures (Ball, 1991). The second focus resulted in construction of several quantitative and qualitative research studies. Baumert et al. (2009) suggests that while studies with quantitative methodology examine more distal indicators as teacher certification status and mathematics coursework completed, the qualitative line investigates teachers' conceptions of the content to be taught. It is further manifested that the quantitative track of research presents relation of teachers' test scores in national exams assessing content knowledge and number of mathematics courses they have been exposed to in pre-service training to student gains, whereas qualitative studies provide in-depth information on of teachers' conceptual understanding of the subject and its reflections on their professional practice in terms of the variety and breadth of teaching methods they implement in their classrooms. In terms of mostly utilized data collection techniques, early research was observed to make frequent use of questionnaires but later the field inclined to include interviews and observations; orienting from the quantitative to a more qualitative perspective (Ponte & Chapman, 2006).

On another account, the literature on mathematics characterizes math teachers' intellectual resources under four titles: (a) teachers' knowledge of mathematics, (b) teachers' knowledge of mathematics teaching, (c) teachers' beliefs and conceptions, and (d) teachers' practice (Ponte & Chapman, 2006). Within the scope of the present study, the initial two categories will be discussed since the latter two are inclined towards teachers' implicit theories and professional practices which tend to interact with a variety of factors.

In this sense, Ponte and Chapman (2006) and Ponte and Chapman (2008) reviews showed that the international body of research under the category of teachers' mathematics knowledge shows that pre- and in-service teachers lack ample conceptual and pedagogical knowledge of fundamental concepts, and their knowledge is heavily influenced by behavioral models. Also, the connection between teachers' procedural and conceptual knowledge was found to be weak, making a strong emphasis on procedures than representing enhanced understandings of concepts. Even in cases where they hold sound conceptual understanding, they appear not to know how to associate it with and embed it into practice. Since teachers' content and pedagogical practices are associated outcomes of their knowledge, these remarks are significant in giving hints about how student learning might be affected from knowledge teachers hold.

Likewise, international studies on teachers' knowledge of mathematics teaching, also known as pedagogical content knowledge, demonstrate that teachers fail to enhance student learning by connecting the mathematical concepts to one another that already are interconnected by nature; they teach fractions and decimals as separate subjects without stressing common features and connections. They appear not to be aware of the difficulties students experience in the learning process and they also lack understanding of how to deal with misconceptions where which frequently are labeled as incorrect and left there. Finally, studies making novice-expert teacher comparisons demonstrate a strong connection between planning and teaching and reveal that expertise in teaching practice enables teachers to prioritize classrooms' emergent needs into consideration rather than sticking to the blue print plans like the novice do in the initial years of practice.

Yet, pre-service and professional development opportunities designed are stated to rather have focused on "developing teachers' knowledge of and skill in understanding students' mathematical work and thinking" (Hill, Ball, & Shilling, 2008, p. 373), concentrating on narrow content areas and sparing a small room for research linking pedagogical knowledge to mathematical outcomes of the students. Moreover, Hill et al. (2008) propose that although teachers' pedagogical content knowledge, knowledge of the content and students' learning/thinking processes are exceptionally significant matters, research remains to lack enough specification in breadth and relation of these matters to student outcomes is not evidenced. Additionally, to the best of our knowledge, there also exist only a scarce number of studies thoroughly investigating the relationship between pre-service teacher education programs and math teachers' knowledge.

Having presented the landscape of research on math teachers' knowledge in the international arena, the present study makes an effort to draw a corresponding picture of the national literature through meta-synthesizing research studies conducted in Turkey, which is identified to be missing in the literature. While realizing this aim, this study tries to bridge the nexus between national and international context to accommodate the former into the outlined framework of the latter.

## 2. METHOD

Since this research is designed as a qualitative meta-synthesis study, it aims to account for all important similarities and differences in the target concept (Sandelowski, Docherty, & Emden, 1997), i.e. math teachers' knowledge, by peeling "multi-layered contexts to reveal generative processes of phenomena not glimpsed in standalone studies" (Walsh & Downe, 2004, p. 205).

To address this concern, a literature search seeking to reach the available research conducted in the Turkish context in reference to pre- and in-service math teachers' knowledge was conducted through a search of Academic Search Complete (EBSCO), Education Source, Education Resources Information Center (ERIC), Humanities International Complete, ULAKBIM, and Google Scholar databases. No year limitation has been applied as the specificity of the subject and its relative currency would render it harder to yield ample number of hits for the Turkish literature. The keywords used included: teacher knowledge, content knowledge, subject matter knowledge, pedagogical content knowledge, effect of teacher knowledge, as well as their Turkish equivalents. All empirical research studies related to math teachers' knowledge -except for unpublished theses- have been included in the review. Reference lists of the identified studies have also been checked to reach further research conducted in the field. These efforts resulted in a final number of 25 empirical research studies.

To identify common themes and patterns present in the Turkish literature on math teachers' knowledge, qualitative thematic analysis has been employed. The research studies have been coded and thematized in terms of their year of publication, research design, sample characteristics, and finally their scope and findings. The themes have then been categorized to correspond to the international framework and the results have been synthesized to inform research and practice. Table 1 summarizes the thematic categorization of the reviewed studies.

## 3. FINDINGS

The meta-synthesis of 25 studies firstly indicated that the Turkish body of research on math teachers' knowledge was quite young spurting only in the last decade, with the oldest study published in 2005. It has also been noted that pre-service teachers took part in vast majority of studies (N = 21), while there are 2 studies conducted with in-service teachers and 2 studies sampled both pre- and in-service teachers. Moreover, research employing qualitative methodology (N = 22) appeared to outweigh the quantitative (N = 2) and mixed method (N = 1) studies. As a result of the dominance of qualitative research designs, frequently utilized data collection tools have been observation, interview, document analysis, and questionnaires with open-ended questions.

When the Turkish literature was examined in depth in terms of the scope and findings of these studies, two research strands were observed to emerge: (1) Studies examining the level of knowledge participants hold in certain subject matter areas, and (2) studies investigating the development of their knowledge through designed programs, workshops, and courses. For the level of knowledge, 17 studies mainly paid attention to math teachers' and teacher candidates' command of certain specific mathematical concepts such as radian, fractions, patterns, 3D objects, and integrals (CK) as well as to their ability to transfer subject matter knowledge into pedagogical situations (PCK). Eight studies, on the other hand, were interested in developing math teachers' knowledge, particularly pedagogical content knowledge, through programs and professional development opportunities.

**Table 1: Thematic analysis of the reviewed studies on math teachers' knowledge**

| Study | Methodology | Participants | Knowledge type | Scope of measurement |
|---|---|---|---|---|
| Akkaya, Akkoç, Bingölbali, & Özmantar (2009) | Qualitative | Pre-service | PCK | Knowledge development |
| Akkoç & Yeşildere (2010) | Qualitative | Pre-service | PCK | Knowledge development |
| Akkoç (2008) | Qualitative | Pre-service | CK | Knowledge level |
| Akkoç (2011) | Qualitative | Pre-service | PCK | Knowledge development |
| Akkoç (2012) | Qualitative | Pre-service | PCK | Knowledge development |
| Akkoç, Uğurlu, Özmantar, & Bingölbali (2009) | Qualitative | Pre-service | CK and PCK | Knowledge development |
| Altaylı et al. (2014) | Qualitative | Pre-service | CK and PCK | Knowledge level |
| Arslan & Özpınar (2010) | Qualitative | Pre-service | PCK | Knowledge level |
| Baştürk & Dönmez (2011) | Mixed | Pre-service | PCK | Knowledge level |
| Baştürk (2009) | Qualitative | Pre-service | PCK | Knowledge level |
| Bozkurt and Koç (2012) | Qualitative | Pre-service | CK | Knowledge level |
| Çakmak, Konyalıoğlu, & Işık (2014) | Qualitative | Pre-service | CK | Knowledge level |
| Gökkurt, Şahin, & Soylu (2012) | Qualitative | In-service | CK and PCK | Knowledge level |
| Şahin, Erdem, Başıbüyük, Gökkurt, & Soylu (2014) | Quantitative | Pre- and in-service | PCK | Knowledge development |
| Tanışlı (2013) | Qualitative | Pre-service | PCK | Knowledge level |
| Toluk-Uçar (2011) | Qualitative | Pre-service | CK | Knowledge level |
| Topçu, Kertil, Akkoç, Yılmaz, & Önder (2006) | Qualitative | Pre- and in-service | CK | Knowledge level |
| Türnüklü & Yeşildere (2007) | Qualitative | Pre-service | CK and PCK | Knowledge level |
| Türnüklü (2005) | Quantitative | Pre-service | CK and PCK | Knowledge level |
| Uğurlu & Akkoç (2011) | Qualitative | Pre-service | PCK | Knowledge development |
| Ulusoy & Çakıroğlu (2013) | Qualitative | In-service | CK | Knowledge level |
| Yeşildere & Akkoç (2010) | Qualitative | Pre-service | PCK | Knowledge level |
| Yeşildere & Akkoç (2011) | Qualitative | Pre-service | CK | Knowledge level |
| Yeşildere (2007) | Qualitative | Pre-service | CK | Knowledge level |
| Yeşildere-İmre & Akkoç (2012) | Qualitative | Pre-service | PCK | Knowledge development |

### 3.1. Level of Knowledge in Mathematics

The studies in this range provided an understanding the competence of pre- and in-service math teachers in terms of their command of the subject matter (Akkoç, 2008; Bozkurt & Koç, 2012; Çakmak, Konyalıoğlu, & Işık, 2014; Toluk-Uçar, 2011; Topçu, Kertil, Akkoç, Yılmaz, & Önder, 2006; Ulusoy & Çakıroğlu, 2013; Yeşildere, 2007; Yeşildere & Akkoç, 2011), as well as the adequacy of their pedagogical content knowledge essential to teach these subjects (Arslan & Özpınar, 2010; Baştürk, 2009; Baştürk & Dönmez, 2011; Tanışlı, 2013; Yeşildere & Akkoç, 2010). Additionally the studies of Altaylı, Konyalıoğlu, Hızarcı, and Kaplan (2014), Gökkurt, Şahin, and Soylu (2012), Türnüklü (2005), and Türnüklü & Yeşildere (2007) combined the level of CK and PCK mastery and tried to explore the correlation in between.

The studies investigating subject matter related knowledge showed that pre-service teachers had difficulty in elucidating mathematical concepts and the underlying theories behind these concepts, especially when they were asked to offer instructional explanations about them (Toluk-Uçar, 2011). To illustrate, Ulusoy and Çakıroğlu (2013) revealed that many among the 6 in-service teachers in their study held certain misconceptions in and could not make meaningful interpretations about histograms where they failed to provide satisfactory explanations about the concept. Correspondingly, in their studies on teacher's concept images of radian, both Akkoç (2008) with 6 pre-service, and Topçu et al. (2006) with 1 pre- and 1 in-service teachers found that the participants were challenged by the task of explaining trigonometric functions as a result of subject matter knowledge inadequacy. Most of the participants related radian to the concept of degree which, in fact, is fundamentally related to the real numbers concept. The authors stressed the potential negative impact of these misconceptions on their pedagogical knowledge and practices underlining the teacher education programs as places to overcome these difficulties as early as possible (Akkoç, 2008). Consistent results have also been obtained for the concept of linear and nonlinear shape patterns where 145 pre-service teachers apparently experienced difficulty in analytically identifying and generalizing the given patterns (Yeşildere & Akkoç, 2011).

The correct use of mathematical terminology in teaching has also been cited as an important indicator of teachers' content knowledge. In this line, it is found that approximately half of 120 teacher candidates were not able to use a correct mathematical language in their teaching. This finding was supported by the content analysis of teacher candidates' responses to 15 open-ended questions, demonstrating that prospective teachers had hard time using correct mathematical terminology, which, by the authors, was linked to their lack of knowledge on basic mathematical concepts (Yeşildere, 2007). Similarly, Bozkurt and Koç (2012) found that more than one third of 158 pre-service teachers failed to make a correct definition of prism, which again has been linked to the lack of knowledge of the concept of prism and of appropriate mathematical language. Both in this study and that of Çakmak, Konyalıoğlu, and Işık (2014), apart from the incorrect definitions they provided, pre-service teachers did not thoroughly consider the specific properties of a prism and suggested broad definitions as "3D objects with a certain amount of volume" which also apply to pyramids and spheres.

Yet, the studies on mathematics teachers' pedagogical content knowledge revealed that despite the expressed confidence in their command of the curriculum, in-depth investigations of pre-service teachers' PCK levels unearthed lack of insight with respect to a variety of instructional tools and insights that are to be consulted in professional practice. Just as in the case of content knowledge, teachers and teacher candidates also were reported to fail to demonstrate the link between subject matter knowledge and practice (Arslan & Özpınar, 2010). In these terms, pre-service teachers were found to experience difficulty in making learning

meaningful for the learners in the concept of patterns (Yeşildere & Akkoç, 2010); and apart from making use of sense-making strategies, student teachers' implementations of subject matter teaching were not seen to go beyond traditional and behaviorist methods (Baştürk, 2009). Even in the cases where pre-service teachers reported constructivist beliefs on the assessment of student learning, they tended to implement an outcome-oriented methodology due to their limited knowledge of constructivist assessment procedures and their dominant experience with and knowledge of traditional tools such as written and oral exams (Baştürk & Dönmez, 2011). The situation was no different for the case of in-service teachers. They were also observed to favor memorization of mathematical rules rather than promoting in-depth and conceptual understanding of bases underlying those mathematical concepts (Baştürk & Dönmez, 2011).

Cited as an important indicator of teachers' PCK, the ways candidate teachers dealt with student misconceptions were found inadequate and they were reported to perceive learner misconceptions as problems that need immediate action to be resolved and eliminated instead of using them as a means for learning (Baştürk, 2009). When asked to develop ways to deal with these misconceptions, they also failed to produce alternative solutions to remedy them (Baştürk, 2009) or to provide sufficient instructional explanations to correct these errors. Questioning skills of math teachers, which appears as another strand of PCK, have also been studied in the literature. In her study, Tanışlı (2013) found pre-service teachers inadequate in making appropriate use of questioning strategies suggesting that they tended to direct learners' responses to the correct answer or instantly began to use direct instruction technique rather than posing questions to understand learner conceptions and evaluate these conceptions.

Studies that investigated both CK and PCK reported congruent findings with the two separate strands mentioned above. In a particular sense, in the first phase of their study, Altaylı et al. (2014) found that the majority of 138 teacher candidates perceived themselves moderately competent in terms of content knowledge and teaching experience in 3D objects, while they have been almost evenly distributed among competent, moderately competent, and not competent when they were asked to rate their pedagogical content knowledge and their levels of readiness to implement the curriculum. More critically, when the researchers wanted the participants to make a distinction among square prism and cube, as well as among oblique and right prisms, certain misconceptions have been identified. When they were further asked about frustocone and frustopyramide, majority of the candidates were observed to be unaware of these particular terminologies. Moreover, given a cone's open form, a considerable number of respondents replied that in order to have a conical form, the shape had to have a triangular form indicating a clear misconception. When their pedagogical content knowledge was analyzed through the strategies they offered to eliminate learners' mistakes on 3D objects, they were observed to hold misconceptions and inadequate learning on the subject and more importantly transposed these conceptions to the learners.

Gökkurt et al. (2012), Türnüklü (2005), and Türnüklü and Yeşildere (2007) further confirmed the strong tie between teachers' CK and PCK, where majority of the participants failed to show mastery on neither one of the two domains. Among the instructional explanations 41 in-service teachers provided for a number of mathematical concepts, only a small number qualified to be adequate in Gökkurt et al.(2012) study; and among those that qualified to provide adequate explanations, only a few could demonstrate sufficient pedagogical approach to teach that particular subject matter. On a quantitative account, Türnüklü (2005) revealed a correlation between pre-service teachers' PCK scores out of the proposed problems and the grades obtained from Math courses in their teacher education programs. However, similar to Gökkurt et al. (2012)'s findings, not all who held higher grades in Math scored high on the PCK test; while

those with low CK also scored low on PCK.. All three studies concluded although CK is a prerequisite for PCK, it still is not enough to ensure appropriate practice.

### 3.2. Development of mathematical knowledge

The national literature also tried to identify the development of domains of pre- and in-service teachers' mathematical knowledge through designated programs constructed by the researchers (Akkaya, Akkoç, Bingölbali & Özmantar, 2009; Akkoç, 2011; Akkoç, 2012; Akkoç, Uğurlu, Özmantar & Bingölbali, 2009; Akkoç & Yeşildere, 2010; Uğurlu & Akkoç, 2011; Yeşildere-İmre & Akkoç, 2012); along with one study investigating prospective teachers' development of PCK throughout the teacher education program (Şahin, Erdem, Başıbüyük, Gökkurt, & Soylu, 2014).

The studies in this strand have shown that the programs, trainings, and workshops specifically designed to improve teachers' content and pedagogical content knowledge made important positive contributions to the participants' mathematical content and pedagogical knowledge repertoires.

To illustrate, the study of Akkaya et al. (2009) aimed at contributing to math teachers' PCK with reference to difficulties students experience in learning. While the pre-service teachers did not consider the potential mistakes pupils may make in their lesson plans prior to the workshop, after the training their awareness and consciousness were reflected in post-lesson plans. With a specific focus on technological pedagogical content knowledge, pre-service teachers' integration of technology into their micro-teaching lessons was also observed to significantly increase after the program offering ways to incorporate software in explaining the concept of radian (Akkoç, 2011).

Assessment of student learning was yet another pedagogical content knowledge component addressed in the study of Akkoç (2012). Through the program designed in this research, student teachers were found to acquire a variety of assessment methods including technology-assisted tools which affected the choices they made in their micro-teaching experiences and lesson plans.

Similarly, in another study (Akkoç, Uğurlu, Özmantar & Bingölbali, 2009), student teachers' conceptions of summative and formative assessment and the way they utilize them in their teaching were assessed. The findings of their research suggest that beforehand, the participants relied heavily on summative assessment techniques but through the workshop, they gained awareness on the formative means to assess pupil learning and to improve their teaching. Yet, as Uğurlu & Akkoç (2011) found in another study, prior to the program they designed, majority of the participants did not regard assessment and evaluation as an integral element of learning and they did not consider that results of their assessments could be used to improve their lessons. In the end, there has been a decrease in the number of candidate teachers who viewed evaluation as a separate endeavor from learning and as an outcome-oriented process.

There have also been studies relating teacher knowledge to specific courses in teacher education programs. To exemplify, Akkoç and Yeşildere (2010) and Yeşildere-İmre and Akkoç (2012) looked at the impact of a field experience course on student teachers' knowledge. These studies suggested that participants demonstrated significant improvements in terms of understanding and making use of pupil difficulties in teaching through their observations of classroom situations. They also gained insight to several instructional strategies for teaching number patterns. Similarly, Şahin et al. (2014) demonstrated teacher candidates' progress through their teacher education programs into the profession of teaching. However evaluated

cross-sectionally, the authors revealed important difference among the groups of 3rd and 4th year pre-service and in-service teachers in terms of their knowledge of students and knowledge of instructional strategies.

## 4. DISCUSSION AND RESULTS

The present study intended to portray the Turkish landscape of pre- and in-service math teachers' knowledge based on the meta-synthesis of 25 studies. Results showed that the national literature started to emerge quite recently, the oldest study being conducted in 2005. This finding is consistent with the remark that teacher knowledge and its development is yet being understood by scholars of teaching and teacher education (Munby et al., 2001).The fact that qualitative studies composed the majority of the data source also shared a common ground with the international observations that the last chapter of research is studied mostly qualitatively (Ponte & Chapman, 2006) due to the shift of paradigms in social research from a quantitative to a more qualitative perspective.

Yet, the majority of participants were seen to be composed of pre-service teachers. Although studying pre-service teacher learning is significant to transform them into competent teachers by amending the apparent problems with teacher education programs, it still leaves a room for identifying the knowledge of practicing teachers. Researchers in the field are therefore suggested to conduct studies on in-service math teachers' knowledge domains as the literature has long proven the tight link between teachers' professional knowledge and student achievement (Hill, Rowan, & Ball, 2005). When identified, the teaching knowledge-related problems in-service math teachers experience in practice can be amended through appropriate in-service trainings designed.

One of the main findings of this study is having revealed the fact that the Turkish experience reflects only two categories of Shulman (1986): Content knowledge and pedagogical content knowledge. On the other hand, a teacher's knowledge of other educational elements as student characteristics, curriculum, learning contexts and ends is also fairly significant for the quality of teaching expertise. Research on these facets of the body of knowledge a teacher should endorse, however, appears to be missing in the local literature. This implies a definite need in the Turkish literature for studies that cover all domains of teachers' knowledge in its particularity and holism. Thus studies that will be conducted on curriculum knowledge, knowledge of learners and their characteristics, knowledge of educational contexts, and knowledge of educational ends, purposes and values are promising to provide a more complete picture of the status of Turkish math teachers' knowledge.

Furthermore, having identified the two most frequently studied research themes in Turkey as (a) levels of math teacher's knowledge with respect to certain mathematical concepts, and (b) development of math teachers' knowledge through designed programs, workshops and courses, congruence with the international framework focus on conceptions and development has been revealed (Baumert et al., 2009; Hill et al., 2008). However, as highlighted earlier, the Turkish body of literature similar to the international context (Hill et al., 2008) lacks research connecting these and other domains of teachers' knowledge to student outcomes. Although it is far acknowledged that teachers' competence relates to student outcomes, empirical research that proves this link are still needed in the local literature.

Yet, except for two studies (Gökkurt et al., 2012; Türnüklü, 2005), no empirical links have been identified between teacher education programs (also measured as mathematical and/or pedagogical coursework completed) and domains of math teachers' knowledge. Whether or not

teacher education programs contribute significantly to the pre-service math teachers' competencies therefore remains to be unknown. Future studies on this strand are particularly important since the findings of the reviewed studies so far outlined critical deficiencies of pre- and in-service teachers in defining, explaining and teaching mathematical concepts and have evidenced "numerous examples of a mismatch between the aims of teacher education programs and prospective teachers' knowledge and beliefs" (Kinach, 2002, p. 51). This very fact undoubtedly leaves a caveat for further research to be conducted to discover how effectively teacher education programs function as a source that contributes to the breadth of mathematics teachers' knowledge domains. Last but not least, except for the study of Şahin et al. (2014), highly informative novice-expert studies also seem to be another missing part of the local puzzle on math teachers' knowledge. To identify the extent to which math teachers learn from practice, i.e. the development of their knowledge domains after graduation, and the differences between the first-year and experienced teachers may provide valuable information on how they need to be supported to become and turn to competent professionals. The researchers in the field therefore are suggested to make novice-expert math teacher comparisons; and alongside crossectional studies, longitudinal research is suggested to be benefitted from to investigate the development of a math teacher's from the beginning pre-service years, through the novice years until becoming an expert teacher.

Finally, as a limitation of this study, it is very well-known that teacher knowledge is not composed merely of solid knowledge they hold but rather is a complex framework interconnected to a variety of factors. The fact that other dynamics operating alongside teachers' knowledge such as teachers' implicit theories, beliefs, knowledge derived from practical experience and reflection in action could not have been handled within teacher knowledge oriented scope of this study. Therefore, we suggest a more elaborated and comprehensive review that combines these dimensions and yields a more complete picture of math teachers' knowledge and professional practice.

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**indicates the research studies reviewed in this article.*

## Uzun Özet

Öğretim kavramının öğretmen boyutunu içeren araştırmalar yaklaşık yüz elli yıllık bir geçmişe sahip olup bu çalışmalar süreç-ürün, öğretmen etkililiği ve öğretmen davranışı gibi başlıklar altında kümelenmiştir (Shulman, 1986). Bu kavramsallaşmanın temel dayanağı öğretmen bilgisi, özellikle de öğretmenin alan bilgisi ile öğrenci başarısı arasında kuvvetli bir bağ bulunduğuna dair verilerdir; bu sebeple de öğretmen bilgisinin tüm boyutları uzmanlar tarafınca araştırmalar yoluyla detaylandırılmıştır.

Ball'a (1991) göre matematik öğretmenlerinin bilgisi (a) öğretmenlerin matematiksel kavram yapıları ve inançları ile (b) öğretmenlerin matematiksel kavram ve süreçleri algılayışları olmak üzere iki boyutta çalışılmıştır. Ponte ve Chapman (2006) ise araştırmaların (a) öğretmenlerin matematik bilgisi, (b) öğretmenlerin matematik öğretimi bilgisi, (c) öğretmenlerin inançları ve kavramsallaştırmaları ve (d) öğretmen uygulamaları bakımından dört çizgide çalışıldığına dikkat çekmiştir.

Bu çalışma alanlarından öğretmen bilgisini irdeleyen araştırmaların bulguları öğretmen yetiştiriciler ve diğer paydaşlar için oldukça önemli ipuçları taşımaktadır. Ponte ve Chapman (2006) tarafından özetlenen çalışmalar, öğretmen adaylarının ve öğretmenlerin temel matematiksel kavramlara yönelik algılarının ve bunların öğretimine dair bilgilerinin yetersiz olduğunu ve daha çok davranışçı ve ilkel modellerden etkilendiğini göstermiştir. Araştırmalarda öğretmenlerin matematiksel sürece yönelik uygulamaları ile kavramsal altyapıları arasındaki bağın yeterince güçlü olmadığı ve kavramsal şemaları kuvvetli olsa bile bunun pratiğe çok da yansımadığı ortaya konmuştur. Benzer şekilde öğretmenlerin pedagojik bilgilerine dair bulgular özünde birbirine oldukça yakın olan matematiksel kavramların, örn. kesirler ve ondalık sistem, benzerlik veya farklılıklarına vurgu yapılmaksızın bağımsız konular gibi işlendiği gözlemlenmiştir. Öte yandan öğretmenlerin öğrencilerin kavram yanılgılarının farkında olmadıklarını ve bunları öğretim için bir fırsat olarak görmek yerine yalnızca yanlış veya doğru cevap kapsamında değerlendirdikleri belirlenmiştir. Deneyimli-deneyimsiz öğretmen karşılaştırması yapan araştırmaların bulguları ise deneyimli öğretmenlerin konular arasında daha çok bağlantı kurduklarını ve deneyimsiz öğretmenler gibi plana sıkı sıkıya bağlı kalmayı tercih etmediklerini göstermiştir. Hill, Ball ve Shilling (2008) ise alandaki çalışmaların daha ziyade öğretmenlerin bilgisinin geliştirilmesine yönelik olduğunu belirtmiş ve bu bilgi ile öğrenci çıktıları arasındaki bağlantıyı irdeleyen araştırmaların azlığına dikkat çekmiştir.

Uluslararası alan yazında ortaya çıkan araştırma trendleri bu şekilde biçimlenirken, matematik öğretmenlerinin bilgisi alanında Türkiye'de ne türden bir yapılanmanın var olduğunu ortaya koyması bakımından bu makale ulusal literatürün bir portresini çizmesi ve gelecek çalışmaları yönlendirmesi açısından anlamlıdır. Bu amaca ulaşmak için Academic Search Complete, Education Source, Education Resources Information Center (ERIC), Humanities International Complete, ULAKBİM ve Google Scholar veri tabanları kullanılmış ve matematik öğretmenlerinin bilgileri konusunda ilgili anahtar kelimeler girilerek 25 veriye dayalı çalışmaya ulaşılmıştır. Tarama sırasında yıl sınırlaması koyulmamış olup yalnızca basılmamış tezlere yer verilmemiştir. Nitel tematik analiz yolu ile yapılan meta-sentez sonucu araştırmalar basım yılına, kullanılan araştırma yöntemlerine, örneklem özelliklerine ve araştırılan bilgi türüne göre sınıflandırılmıştır. Sonrasında da araştırmaların bulguları uluslararası alan yazın üzerinden yorumlanmıştır.

Yapılan ilk analizler öncelikle Türkiye bağlamında matematik öğretmenlerinin bilgisini irdeleyen araştırmaların oldukça yeni dönemde ortaya çıktığını göstermiştir. Basılan en eski çalışmanın 2005 yılında olduğu düşünüldüğünde alanın henüz emekleme döneminde olduğu düşünülebilir. Göze çarpan diğer bir bulgu araştırmaların baskın hizmet-öncesi öğretmen adayları ile yürütülmüş olduğudur (N = 21). Dolayısıyla yapılan çalışmaların daha çok matematik öğretmen adaylarının bilgi alanlarını hedef aldığı söylenebilir. Bu bakımdan hizmet içi öğretmenlerle yapılacak çalışmaların alandaki boşluğu doldurması açısından önemi büyüktür zira öğrenci başarısı ile öğretmenlerin bilgi yeterlikleri ile ilişkisi uluslararası alan yazında sıklıkla vurgulanan bir hususdur (Hill, Rowan, & Ball, 2005). Diğer bir bulgu ise uluslararası trende benzer olarak çoğunlukla nitel araştırma metotlarına (N = 22) başvurulduğu (Ponte & Chapman, 2006), dolayısıyla sıklıkla kullanılan veri toplama araçlarının gözlem, görüşme, doküman analizi olduğudur.

Bunun yanı sıra, ulusal alan yazının Shulman (1986)'ın 7 bilgi kategorisinden alan bilgisi ve pedagojik alan bilgisi olmak üzere yalnızca 2'sine odaklandığı ve diğer boyutların irdelenmediği görülmüştür. Söz konusu olan öğretmen bilgisi olgusunun karmaşık ve bütüncül yapısı düşünüldüğünde

bundan sonra yapılacak çalışmaların bilginin tüm boyutlarını dikkate almalarının daha doğru bir resim sergileyeceği düşünülmektedir. Dolayısıyla ileride konu üzerinde yürütülecek çalışmaların, alan ve pedagojik alan bilgisinin yanı sıra öğretmenlerin eğitim programlarına, öğrenci özelliklerine, eğitim bağlamlarına ile eğitimsel değerlere dair bilgilerini de incelemeleri tavsiye edilebilir.

Ayrıca Hill ve diğerlerinin (2008) de ışık tuttuğu gibi Türkiye'de öğretmen bilgisi ile öğrenci çıktıları arasında bağ kuran çalışmaların azlığı göze çarpmıştır. Benzer şekilde deneyimli ve deneyimsiz öğretmenlerin bilgileri arasındaki farklılıkları açığa çıkaran çalışmalar da yok denecek kadar azdır. Bu nedenle ileride yapılacak araştırmaların hizmet içi öğretmenlerin bilgisine odaklanarak öğrenci başarısı ile arasındaki bağlantıyı ortaya çıkarması, matematik öğretmenlerin hizmet öncesi yıllarından başlayarak mesleklerinin ilk ve deneyimli yıllarına doğru gelişimlerinin boylamsal çalışmalarla irdelenmesi ve sorunların giderilmesi için hizmet içi eğitimler düzenlenmesi tavsiye edilebilir.

Derin tematik analiz sonucu ise bu çalışmanın bulguları, Türkiye'deki alan yazının öğretmenlerin kavram bilgilerine ve öğretmen bilgisinin geliştirilmesine yönelik yürütülen araştırmalar bakımından uluslararası literatüre benzediğini göstermiş (Baumert et al., 2009) ve alandaki ulusal araştırmaların iki grup altında toplandığını ortaya koymuştur. Bu gruptan ilki öğretmenlerin radyan, sayı örüntüleri, integral, limit ve süreklilik gibi belirli alanlardaki bilgi düzeylerini ölçmeyi hedeflemişken diğer başlıktaki çalışmalar öğretmenlerin bilgisinin çeşitli ders/eğitim/çalıştaylarla geliştirilmesini amaçlamıştır.

Yapılan araştırmalar bulguları bakımından incelendiğinde ilk gruptaki çalışmaların (Akkoç, 2008; Altaylı, Konyalıoğlu, Hızarcı, & Kaplan, 2014; Arslan & Özpınar, 2010; Baştürk, 2009; Baştürk & Dönmez, 2011; Bozkurt & Koç, 2012; Çakmak, Konyalıoğlu, & Işık, 2014; Gökkurt, Şahin, & Soylu, 2012; Tanışlı, 2013; Toluk-Uçar, 2011; Topçu, Kertil, Akkoç, Yılmaz, & Önder, 2006; Türnüklü, 2005; Türnüklü & Yeşildere, 2007; Ulusoy & Çakıroğlu, 2013; Yeşildere, 2007; Yeşildere & Akkoç, 2011; Yeşildere & Akkoç, 2010) matematik öğretmenlerinin ve öğretmen adaylarının alan ve pedagojik alan bilgilerinde ciddi eksiklikler olduğuna dikkat çektiği görülmektedir. Öğretmenlerin bilgi düzeylerini ileriye taşımak üzere tasarlanan ders, çalıştay ve programların katkılarının incelendiği ikinci grup araştırmalarda ise (Akkaya, Akkoç, Bingölbali & Özmantar, 2009; Akkoç, 2011; Akkoç, 2012; Akkoç, Uğurlu, Özmantar & Bingölbali, 2009; Akkoç & Yeşildere, 2010; Şahin, Erdem, Başıbüyük, Gökkurt, & Soylu, 2014; Uğurlu & Akkoç, 2011; Yeşildere-İmre & Akkoç, 2012) bu bağlamda geliştirilen ve uygulanan özelleştirilmiş programların öğretmenlerin pedagojik alan bilgilerini geliştirme bakımından oldukça başarılı sonuçlar ürettiği görülmüştür.

Bu veriler değerlendirildiğine, Ponte ve Chapman (2006)'nın da belirttiği gibi öğretmenlerin kavramsal şemalarında ve öğretim uygulamalarında ciddi eksiklikler olduğu fark edilmiştir. Geliştirilen özel programların başarısı açıkken hali hazırdaki öğretmen yetiştirme programlarının yeniden düzenlenmesinin gerekliliği ortadadır. Çalışmaların açığa çıkardığı bilgi ve uygulamada eksikliklerinin belirlenmesinde ve giderilmesinde öğretmen yetiştirme programlarının önemi oldukça açık olup, bu programların kalitesini değerlendiren ve öğretmen bilgisi üzerindeki etkisini inceleyen araştırmalara ağırlık verilmesi gerekmektedir.

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