Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi
Cilt 16, Sayı 1, Haziran 2022, sayfa 135-171. ISSN: 1307-6086
Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education
Vol. 16, Issue 1, June 2022, pp. 135-171. ISSN: 1307-6086

Araştırma Makalesi / Research Article

Trends in Postgraduate Thesis Studies on Pedagogical Content Knowledge in Mathematics Education in Turkey: A Systematic Review

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Received : 08.01.2022 Accepted : 26.04.2022

Doi: 10.17522/balikesirnef.1055083

Abstract – The aim of this study is to systematically review and assess the subliminal theses in Turkey which were subject to pedagogical know-how from the mathematical studies published in the national thesis center between 2016 and 2021. To examine prostheses according to certain criteria, qualitative research methods were based on a systematic examination method. In order to obtain the data of the study, 25 postgraduate theses about pedagogic content knowledge in math education were included in the analysis based on the PRISMA information flow, at the National Thesis Data Center of the Presidency of the Council of Higher Education. The theses chosen in line with the aim of the study were examined in the framework of the study evaluation form. As a result, it has been found that the knowledge of program, content knowledge, knowledge of understanding student, and knowledge of instructional strategies - subcomponents of pedagogical content knowledge as revealed by theorists who reviewed pedagogic content knowledge - is not scrutinized in detail by the graduate thesis studies.

Key words: pedagogical content knowledge, mathematics education, postgraduate thesis, systematic review.

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Introduction

The quality of teaching requires that the teacher have knowledge of the students and their culture, their political and social environment (Ball and McDiarmid, 1990). In order for the teacher to teach the students the field in a useful and effective way, it is believed that the teacher

must have a deep knowledge about the subject first. Shulman (1986) suggests that teachers should be able to transmit their knowledge in a way that makes it easier for students to understand. Since the mid-1980s, studies on teacher training have emphasized the importance of including studies on teachers' knowledge, beliefs and competencies rather than on their behavior (Işıksal Bostan and Osmanoğlu, 2016). Shulman (1986) described the effects of subject knowledge on teaching for teachers as a missing paradigm in education research. He created the pedagogical content knowledge concept (PAB) for the first time by mentioning the importance of how teachers transform their content knowledge to make it easier for students to understand and revolutionized the work in teacher training.

Shulman (1987) defined PAB as a special combination of content knowledge and pedagogy knowledge, and conceptualized the PAB that connects content and pedagogic knowledge in two categories. Grossman (1990) added the PAB as follows: has examined four components: knowledge of understanding student, knowledge of teaching strategies, knowledge of teaching objectives and curriculum knowledge. Marks (1990) PAB he has defined knowledge on the subject he points to interact with each other as students' understanding of the subject knowledge on teaching the media and knowledge of teaching processes.

Numerous studies were carried out after 1990 to conceptualize the PAB (Ball, Thames and Phelps, 2008; Cochran, DeRuiter and King, 1993; Gess-Newsome, 1999; Hill, Ball and Schilling, 2008; Hill, Rowan and Ball, 2005; Magnusson, Krajcik and Borko, 1999; Park and Oliver, 2008). These theorists considered the definition of Shulman (1986) as Grossman (1990) and Marks (1990) and tried to conceptualize the PAB through various components or approaches.

Gess-Newsome (1999) conceptualized the PAB differently and based the information structure that teachers should have on two main structures as an integrating model and transformative model. The integrative model covers the intersection of pedagogical and contextual information gathered by the teacher during teaching, while the transformative model reveals a new information that encompasses the synthesis of these three information.

Blömeke et al. (2015) consider that information a teacher should have: that the background knowledge, pedagogy knowledge, PAB, and described these types of knowledge as the cognitive competences that a teacher has. Baki (2018) has identified five key components for PAB modeling for math education. In this model, while using the expression Teaching Math Knowledge for teaching, Blömeke et al. (2015) defined a Teacher Adequacy Model.

The work on PAB conceptualizing mathematical education was done by Hill, Ball et al. (Ball, Thames, and Phelps, 2008; Hill, Ball and Schilling, 2008; Hill, Rowan and Ball, 2005). Ball et al. (2008) have developed a new comprehensive model based on Shulman's PAB model based on the results of experimental studies in mathematical education. They identified two basic components for the PAB model. In this model, which addresses the subject content knowledge and PAB concepts in a holistic way, we have defined the teaching knowledge of mathematics for teaching. This model, which is explained as a mathematical knowledge model for teaching, is described under the headings content knowledge and PAB to teach mathematics. Rowland et al. (2009) demonstrated a quadruple information model that assessed teachers' mathematical domains and mathematical pedagogic content knowledge information together. According to this understanding, the four dimensions of knowledge a teacher should have are: basic information has been defined as transformation information, contact information and unexpected events information.

The dynamic, complex and holistic structure of the PAB makes it difficult for researchers to reach consensus on the issue (Şimşek and Boz, 2016). However, it is a factor that is primarily emphasized in the importance of teacher knowledge, teaching and learning (Fennema and Franke, 1992; Hill et al., 2008). The PAB directly impacts student learning by introducing demonstrations, representations, examples, simulations, and explanations used to ensure understanding of the concepts taught in the field. At this point, the PAB's influence in math education and learning emerges unambiguously. PAB teaching is important in planning, organizing, and developing a positive attitude towards teaching (Kaya, 2010). It is the teacher competence that concretely demonstrates the knowledge, skills, attitudes and values a teacher must have.

The studies on mathematics education in Turkey, compiled in the PAB mostly involve prospective teachers and qualitative data (Depaepe et al., 2013; Şimşek & Boz, 2016; Sayın et al. , 2021). Examination of the PAB components used in the studies revealed that the most commonly used PAB components are the understanding of students and education strategies (Depaepe et al., 2013; Şimşek and Boz, 2016) and the subject area has been defined as (Sayın et al., 2021). The PAB in the work of Depaepe et al. (2013) included: it has been examined from six different perspectives, namely, the nature of the PAB of teachers, the relationship between the PAB and its content knowledge, the relationship between PAB and teaching practice, the relationship between PAB and student learning, between PAB and personal characteristics, and the development of the PAB of teachers. The studies reviewed revealed that

teachers had gaps in pedagogic content knowledge, a strong relationship between the PAB and content knowledge, the necessity of the PAB for effective teaching, the positive impact of teaching experience on the PAB and the PAB had an effect on student learning.

The studies on PAB reveal that the PAB and its components were revealed differently by various researchers. For example, in some models, the relevant field or program knowledge was not specified as a sub-component of PAB (Grossmnan, 1990; Shulman, 1987), in some models it is emphasized as a subcomponent. Examinations of these components showed that teaching a field discussed topics such as the aims of teaching, understanding students, program, teaching strategies and presentations, evaluation, subject area, context, pedagogy (Park and Oliver, 2008). It was determined that in some studies, the teacher solely bases the knowledge of understanding student and knowledge of instructional strategies in recognizing the students' errors/misconceptions and identifying their causes (Akkaş, 2014; Şahin et al. 2014; Gökkurt et al., 2015; Aksu and Konyalıoğlu, 2014) The studies on the PAB in the literature consist primarily of the understanding of students, knowledge of instructional strategies, subject area knowledge and program knowledge of the subcomponents of the PAB (Altaylı et al., 2014; Gökbulut, 2010: Şahin, 2016). The PAB students' understanding, knowledge of instructional strategies, knowledge of the subject content, and program knowledge were evaluated in this study.

Mathematical discipline is very important in the educational process. However, since mathematics is inherently abstract and concepts are acquired through abstractions, it is of great importance to nurture competent and sufficient teachers for the knowledge of pedagogical fields in the teaching of mathematics. Review of theories on pedagogical content knowledge in the context of the studies carried out, discuss the results, and reveal the situation with a holistic understanding will provide guidance to PAB studies in the field of mathematics education. In this context, it is thought that the purpose of the study would be to bring together the studies conducted and provide an overview of the PAB studies within the scope of mathematical education and provide information about the research conducted in the subject in Turkey.

The objective of this study is to systematically review and assess the postgraduate theses involving the PAB in mathematics education studies published in Turkey's national thesis center between 2016 and 2021. Problem of the research in line with the stated purpose: "What are the trends and results of postgraduate theses that examine the PAB in mathematics education in Turkey?" records).

1. What are the methodologies for the post-graduate theses on mathematics education (PAB) held in Turkey between 2016-2021?
   - how was the distribution of the research by years (2016-2021)?
   - which workgroup was discussed?
   - which research method (quantitative-qualitative-composite -other) was used?
   - what data collection tools have been used?
   - which data analysis methods are used?
2. How were the components of the PAB (program knowledge, content knowledge, knowledge of understanding student, and knowledge of instructional strategies) covered in related post grade thesis and what were the associated learning outcomes?

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Method

Model

This study is based on a systematic review method, which is a qualitative research method, to examine under certain criteria the undergraduate theses involving the PAB in the mathematical education studies published in the national thesis center between 2016 and 2021. Systematic review: there are three basic tools—identifying relevant studies, critically evaluating them, and consistently synthesizing findings (Gough, Oliver, & Thomas, 2012).

Study Group

The criterion sampling was used in determining the study group. The criteria for the work to be included in the analysis are:

- The activity related to "Pedagogical content knowledge" in the mathematics training
- Publication of the study at the National Thesis Data Center of the Presidency of the Council of Higher Education
- Published and available access to the study between 2016-2021.
- The study is written in Turkish and English

In the study, theses examining the PAB in the field of mathematical education were discussed. In the Detailed Search section of the National Thesis Data Center of the Presidency of the Council of Higher Education to obtain data about the study, a scan was conducted between 2016 and 2021 using the key concept of "pedagogical content knowledge" within the subject field of "Education and Training." In the review, 168 postgraduate thesis studies were completed, including 17 graduate thesis studies related to mathematics. In the Detailed Search section, a search was conducted between 2016 and 2021 using the keyword "Education and

Training" in the subject field and "pedagogical content knowledge" in the summary section. The review included 161 postgraduate thesis studies, including 16 postgraduate thesis studies, which differs from the original search results. In the advanced screening section, the search word(s) section was searched using the keywords "pedagogic domain information" and "math" and consequently there were 74 post-graduate thesis studies. Abstracts unrelated to the subject were examined and included in 26 post-language thesis working groups. In 26 postgraduate theses, 11 doctoral and 15 master's dissertations were completed. The selection of the workgroup is based on the PRISMA information flow in figure 1. PRISMA is a "preferred reporting clause for systematic reviews and meta-analyzes" and provides a clear presentation on how systematic review is done based on complete and transparent reporting. (Liberati et al., 2009)

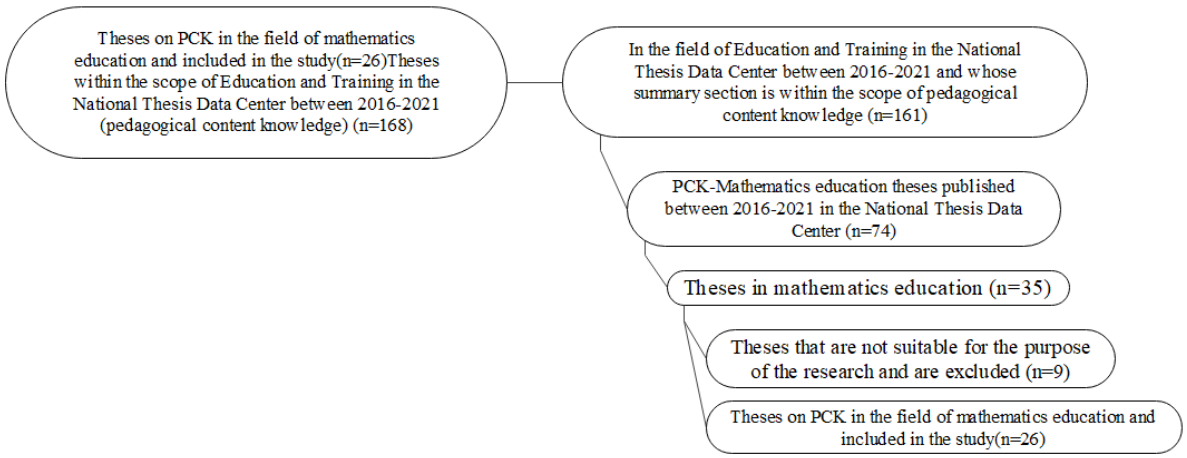

Figure 1. Flow chart for determining the study group

Analysis of Data

The theses selected for the purpose of the study were reviewed within the framework of the evaluation form prepared by the researchers. In this context, the title (reference, authors, year, etc.) of the postgraduate theses, their purpose, methodological aspects (approaches, working group, data collection tools, data analysis method) and results (learning outcomes regarding the sub-dimensions of the PAB model used) were analyzed. Following the research objective, the literature was reviewed, and the most examined sub-components of the PAB models based on graduate theses were identified as "program knowledge", "content knowledge", "knowledge of understanding student" and "knowledge of instructional strategies ". In this context, the postgraduate these included in the study were examined by content analysis in terms of process and results within the framework of four sub-components

determined. Content analysis is to combine similar data into specific concepts and themes and to interpret these in a way that the reader can understand (Marshall & Rossman, 2006; Yıldırım ve Şimşek, 2013). The agreed PAB components were selected as themes, and the data were individually coded by the researchers under four main themes. Miles and Huberman's (1994) [Reliability: The coherence among the researchers was calculated as 87 percent by applying the formulas of the Consensus / (Opinion Union + Difference of Opinion).

The findings of the studies, and the obtained findings on the theses reviewed within the framework of the four PAB components determined, were presented in descriptive form with frequency and percentage values.

All these selected were scanned simultaneously by the researchers within the determined criteria. As the systematic analysis used in the study was a study based on the literature review, the data obtained was examined by three experts in an effort to achieve internal validity by varying researchers. The manner in which the data was obtained, the keywords used, the selection procedure of the postgraduate theses to be included in the analysis, and many details of the theses examined are clearly indicated. To compare the results with data within the PAB, we aimed to establish external security by taking the opinions of two mathematics education experts.

Findings

Findings related to the 1st sub problem

In this study where the trends and results of the postgraduate thesis studies covering the PAB in mathematics education in Turkey are studied, the first study examines the methodologies of postgraduate theses in order to reveal the trends. Data on the distribution of 26 post-graduate theses (11 doctoral dissertations, 15 postgraduate theses) by year (2016-2021) are presented in Chart 1.

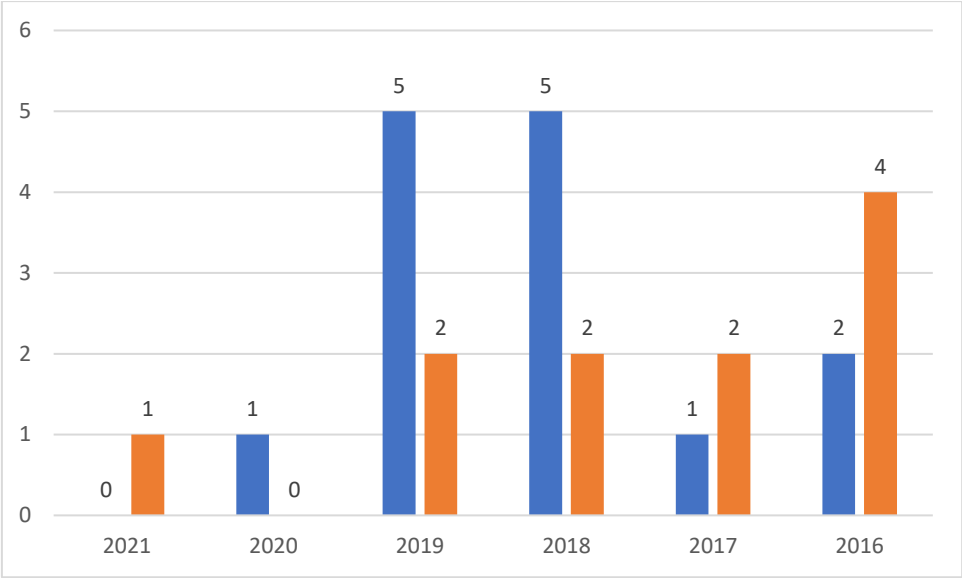

Chart 1. Distribution of graduate theses by years

When the chart is examined, among the selected theses, 1 doctoral thesis in 2021, 1 master's thesis in 2020, 7 theses in 2019 (2 doctorate, 5 master's), 7 theses in 2018 (2 doctorate, 5 master's), 3 theses in 2017 (2 doctorate, 1 master's), and 6 theses (4 doctorate, 2 master's) were published in 2016. Distribution of the analyzed theses regarding their working groups is presented in chart 2.

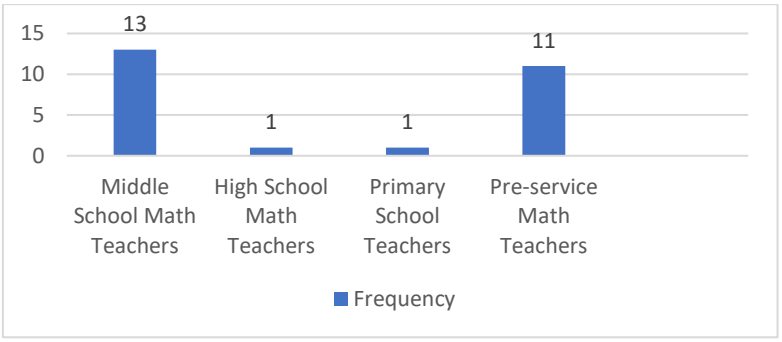

Chart 2. Study group frequencies of graduate theses

The study revealed that 13 theses were performed with the middle school mathematics teachers, one thesis with high school mathematics teachers and one thesis with classroom teachers and 11 dissertations with the prospective math teachers. It was observed that pedagogic content knowledge of the most secondary school math teachers were studied. Chart 3 shows the distribution of the research methods by the postgraduate theses reviewed.

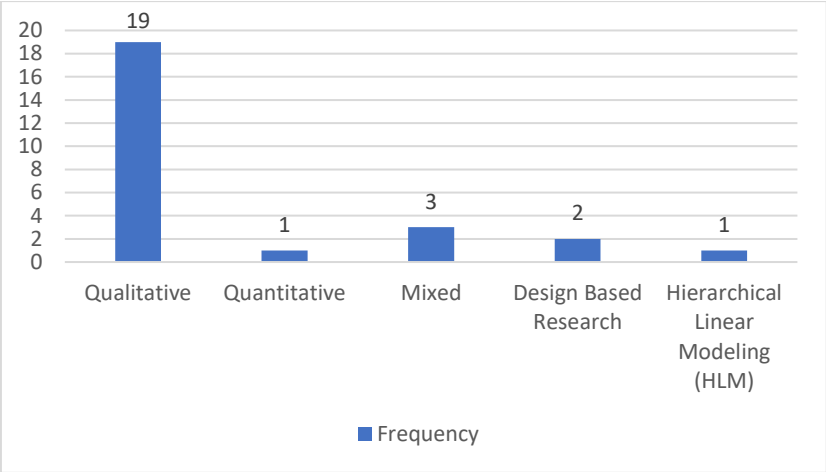

Chart 3. Distribution of research methods in graduate theses

Chart 3 reveals that 73 percent of the theses were based on qualitative research method, 3.8 percent on quantitative research method and hierarchical linear model, 11.52 percent on mixed research method, and 7.8 percent on design-based research method. Studies on PAB in math education revealed that the most qualitative research methods were used. Illustration 4 shows the breakdown of the data collection tools used in the postgraduate theses examined.

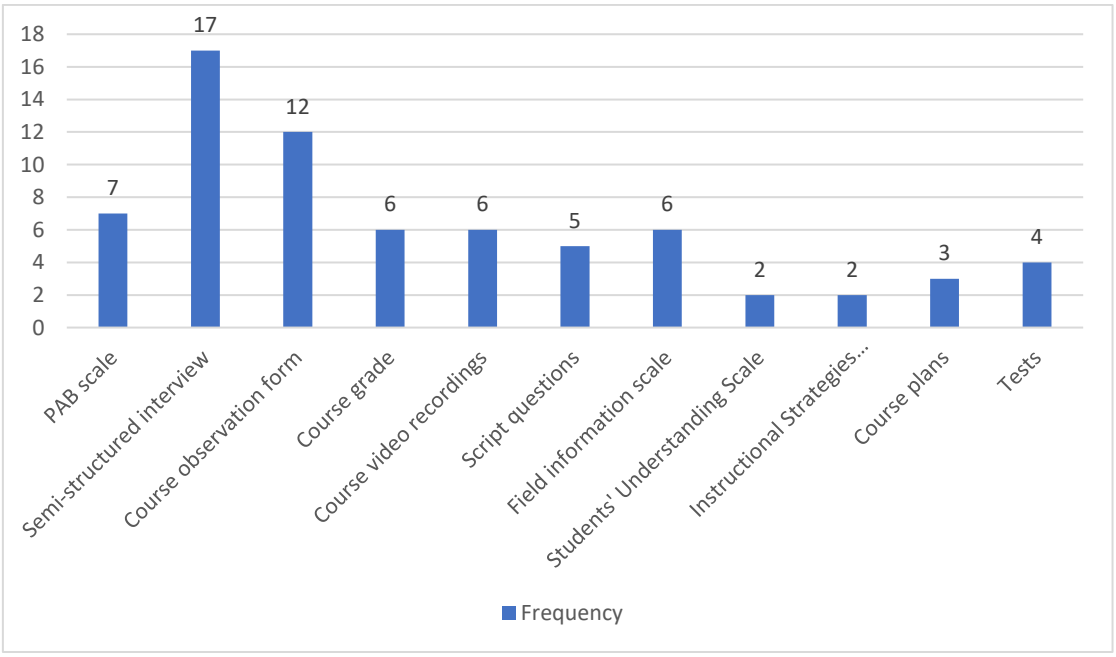

Chart 4. Distribution of the data collection tools used in graduate theses

Chart 4 reveals that 65 percent of the theses use semi-structured interviews, 46 percent use lesson notes, course video recordings, and content knowledge scale. In addition, the theses used course video recordings, PAB scales, course notes, scenario questions, domain knowledge scale, tests (Pedagogical Math Knowledge Test, PAB Self-Sufficiency Test, Faculty Cluster

Test, Success Test). A breakdown of the data analysis methods used in the postgraduate theses examined is presented in Chart 5.

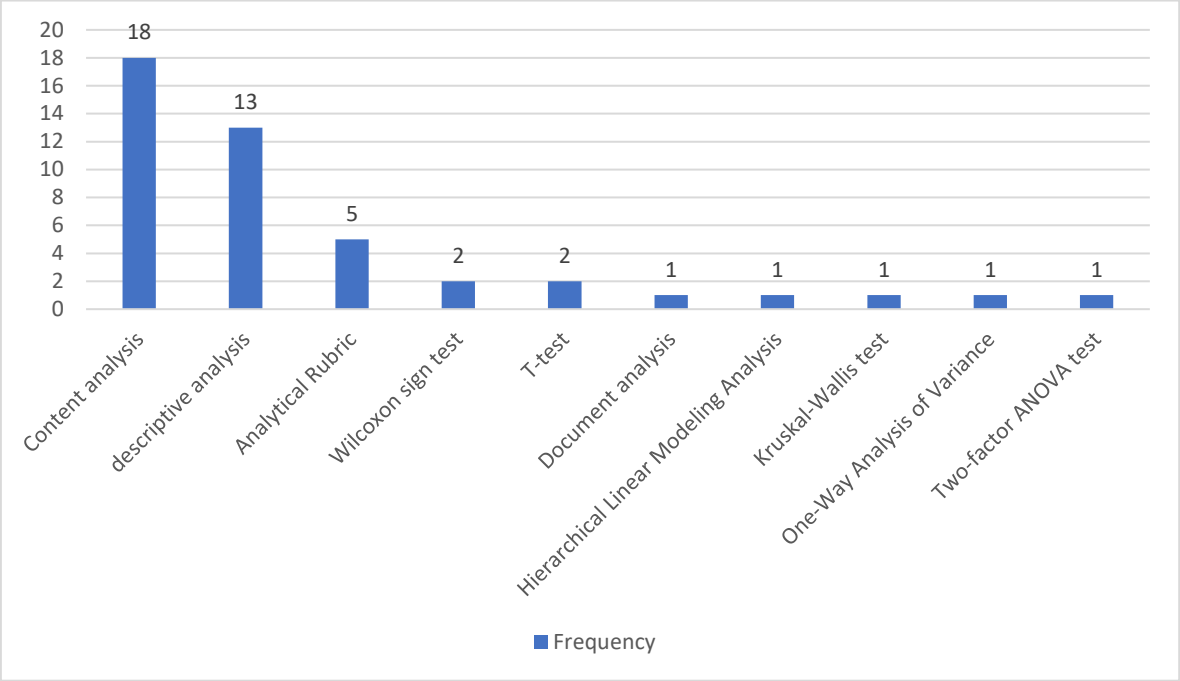

Chart 5. Distribution of data analysis methods used in graduate theses

The Chart revealed that 69.2 percent of post-graduate theses utilized content analysis while 50 percent used descriptive analysis methods. Since the studies are mostly based on the qualitative research pattern, the most preferred methods are content analysis and descriptive analysis. Analytical rubrics are used for the analysis of various scenario questions in some scales. T-test and Wilcoxon marker test in 8% of the analysis of quantitative data, Kruskal-Wallis test in 4%, one-way variance analysis and two-factor ANOVA test; Four percent used document and hierarchical linear modeling analysis.

Findings for the 2nd sub-problem

In the postgraduate theses related to the PAB carried out in the field of mathematics education in Turkey between 2016-2021: How the components of the PAB (program knowledge, content knowledge, knowledge of understanding student, and knowledge of instructional strategies) were addressed and the related learning outcomes were individually examined under the identified components. The findings obtained in this context are explained based on the definitions of the theorists.

Program knowledge

In the evaluation of program knowledge, which is one of the components of the PAB in the postgraduate theses examined in the research, it was found that 19% (5 theses) of the theses included the dimension of program knowledge in their studies. When we examined which PAB model was the basis for the theses involved in the Program Knowledge dimension study, we found that 20% of the theses were based on the PAB model defined by Shulman (1987), 20% on Baki (2012), 20% on Blomeke and their friends (2015) and 40% on the PAB model defined by Ball and friends (2008). Examination of the said PAB models reveals different descriptions that theorists have come up with regarding program knowledge. According to Shulman (1987), program knowledge content knowledge and related education program is described as information to use teaching materials (textbooks, technological tools, concrete teaching materials), knowledge of horizontal programs (information on intra- and inter-disciplinary relationships), knowledge of vertical programs (information on subject ranking and materials covering this sequence). Ball et al. (2008) described program knowledge to be given by a teacher in what order, as knowledge of how topics relate to each other and with other disciplines, while Baki (2012) described the place of the subject in the curriculum and its relevance to other achievements or topics as knowledge-making knowledge. Blömeke et al. (2015) defined program knowledge as a curriculum related to content knowledge, acquisition, use of teaching materials, design of learning environment, teaching methods, and techniques knowledge. Table 1 presents the PAB models used in the dissertation studies for the program knowledge component and the scope of the program knowledge examined in this context.

Table 1. PAB models and scope of program knowledge

PAB model based on	**Thesis**	**Scope of program knowledge reviewed**
Shulman (1987) Ball et al. (2008) Baki (2018) Blömeke et al. (2015)	Şimşek (2016) (Functional subject) Keleş (2019) (learning area to process data) Girit (2016) (algebra learning area) Güler (2019) Kutlu (2018)	Knowledge of benefits in a curriculum for a given content
Shulman (1987) Ball et al. (2008)	Şimşek (2016) Keleş (2019)	Information on the distribution of subjects by class level
Shulman (1987) Ball et al. (2008) Baki (2018) Blömeke et al. (2015)	Şimşek (2016) Keleş (2019) Girit (2016) Güler (2019) Kutlu (2018)	Information about pre-requisite relationships and which order they should be taught
Shulman (1987)	Şimşek (2016)	Knowledge of the skills program aims for
Baki (2018) Blömeke et al. (2015)	Güler (2019) Kutlu (2018)	How to prepare the content of a lesson for basic knowledge (operational/conceptual) and skills (reasoning, association, communication...)

Table 1 shows that all of the studies that examined program knowledge included "knowledge of achievements in education program for content" and "information on pre-condition relations and which order education should be realized," 2 studies "distribution of subjects by class level, 1 knowledge of skills targeted by the program of study, 1 understanding of basic knowledge (operational/conceptual) in 2 studies and knowledge on how to prepare content of a course in relation to skills (reasoning, association, communication...) within the scope of program knowledge. On the basis of the PAB model developed by Ball et al. (2008), it was found that program knowledge, the sub-component of the model, was not discussed in the studies (Amaç, 2018; Çıkrıkçı, 2015; Çopur-Gençtürk, 2012; Doğruel, 2019; Hacıömeroğlu, 2013: Özdoğan, 2018; Yazıcı, 2017; Yılmaz, 2016).

Ball et al. (2008)'s program knowledge, which is the PAB component of the "Mathematical Knowledge for Education" model of "Mathematical Knowledge"; the knowledge about the educational program on content knowledge was considered as informational, intra-disciplinary, interdisciplinary relationship knowledge and subject ranking. however, in the studies under consideration, it was analyzed that the outcomes of the content-related education program generally addressed variables such as class-based distribution of subjects, pre-condition relations and order of teaching need to be carried out (Esen, 2013; Lannin, et al., 2013; Stacey and Chick 2004).

Ball et al. (2008) have found that studies based on the PAB model look at some of the questions added to scales at the dimension of program knowledge. It has been noted that, within the context of program knowledge, studies do not examine educational programs and skills or information variables for using teaching materials (computer-aided materials, concrete materials, etc.). In studies based on the PAB model developed by Shulman (1986), it is found that the program's sub-component is: the knowledge of program is also seen in the Kula (2011) study, which looks at the dimensions of knowledge, intra-disciplinary and interdisciplinary relationship and subject ranking information to use teaching materials (textbooks, technological tools, concrete teaching materials).

The results obtained for studies on program knowledge in postgraduate theses are presented in Figure 2.

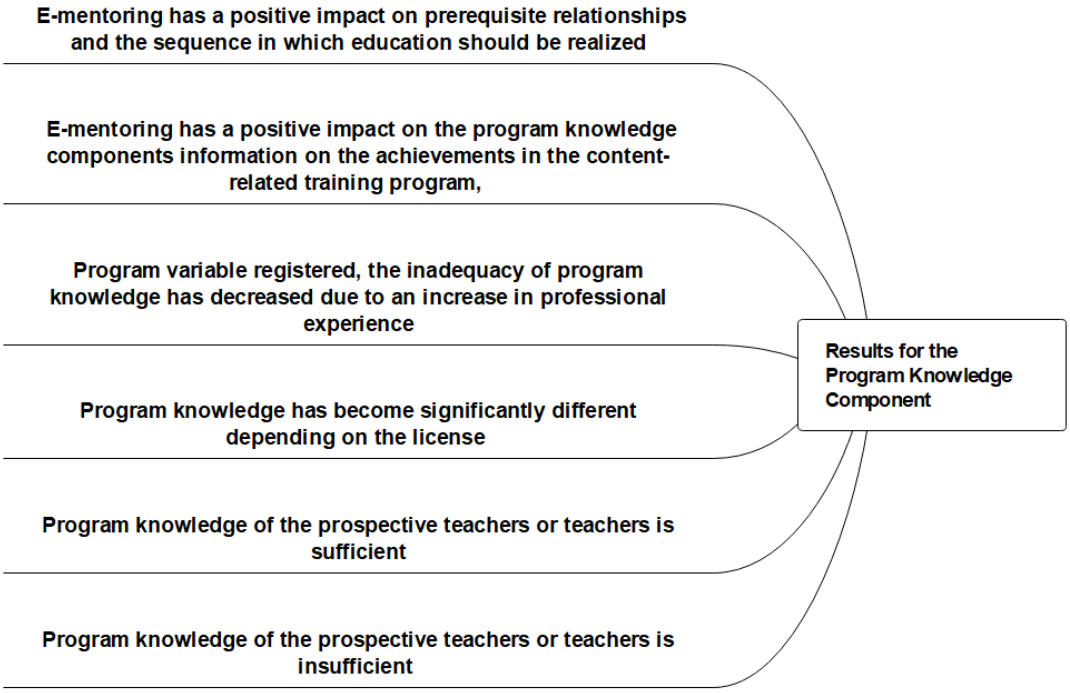

Figure 2. Results for program knowledge component

In reviewing the results regarding program knowledge, we found that program knowledge of the prospective teachers or teachers is insufficient or insufficient, program knowledge has become significantly different depending on the license program variable registered, the inadequacy of program knowledge has decreased due to an increase in professional experience, and e-mentoring has a positive impact on the program knowledge components (information on the achievements in the content-related training program, prerequisite relationships and the sequence in which education should be realized).

According to reviews on program knowledge in the studies, we see that program knowledge is examined in terms of information related to the algebra, function, and data processing learning areas. It was determined that program knowledge was not considered in terms of the knowledge of gains in the educational program for a given content, knowledge of the distribution by class levels of the subjects, prerequisite relationships and what order teachings should be taught, knowledge of the skills the training program is intended for, knowledge of basic knowledge (operational/conceptual) and knowledge on how to prepare content of a course for the skills (reasoning, association, communication...), knowledge of the use of teaching material in the underlying PAB models, which is analyzed.

Content knowledge

In the evaluation of content knowledge, which is one of the components of the PAB in the postgraduate theses examined in the research, it was found that 60 percent (15 theses) of the theses included the content knowledge size in their studies. In the study of the PAB model on which the studies including the content knowledge dimension are based, it has been determined that 53.4 percent of the theses are based on the content knowledge component defined by Shulman (1987), 6.6 percent by Lesseig (2016) and 40 percent by Ball et al. (2008). Examination of the said PAB models reveals that the definitions suggested by theorists differ for the content knowledge. According to Shulman (1987), the field knowledge is the type of information that covers the concepts, processes, proofs and problem-solving skills that teachers will teach. According to Lesseig (2016), "the subject area for content teaching is two parts. General content knowledge for content teaching; information held by the person using math in relation to the content; specific domain knowledge for content teaching; it is described as unique knowledge solely that teachers have in teaching content. Ball et al. (2008) categorizes content knowledge into general domain, custom field, and horizontal space. General content knowledge is mathematical knowledge that can be used in areas other than education, with knowledge of mathematical concepts, identifying correct and incorrect answers. Specific field knowledge is the mathematical knowledge that mathematical teachers have, unlike experts in other fields; horizontal content knowledge is described as the knowledge of mathematical concepts in relation to the other concepts in the educational program.

Table 2 presents the PAB models used in the dissertation studies that examine the content knowledge component and the scope of the content knowledge examined in this direction.

Table 2. PAB models and content knowledge

PAB model based on		**Scope of content knowledge**
Shulman (1987)	Uçar (2019) (non-routine problems); Yurtyapan (2018) (triangles and rectangles); Duran (2018) (derivatives and applications): Aliustaoglu (2018) (linear equation and slope); Özdemir Baki (2017) (area measurement sub-learning area); Sahin (2016) (algebra learning area)	Information on what to teach (content knowledge)
Ball et al. (2008)	Keleş (2019); Doğruel (2019) (rate and ratio); Girit (2016); Gürel (2016) (central trend and distribution measurements); Bulut (2021) (ratıonal numbers) Yazıcı (2017) (basic concepts in clusters); Yılmaz (2016) (addition and removal operations in fractions)	
	Uçar (2019): Yurtyapan (2018)	Information on the methods used for problem solving

Shulman (1987) Ball et al. (2008)	Uçar (2019); Tosuncu (2019) (numbers, geometry, data processing and measurement learning area); Yurtyapan (2018); Duran (2018), Aliustaoğlu (2018), Özdemir Baki (2017): Sahin (2016) (Keleş, 2019; Girit (2016); Gürel (2016); Doğruel (2019): Yazıcı (2017) Yılmaz (2016);Bulut (2021)	Information for concepts relevant to the subject to be taught (e.g. Definitions, treatments)
Shulman (1987) Ball et al. (2008)	Duran (2018) Tosuncu (2019); Duran (2018), Özdemir Baki (2017) Keleş (2019); Girit (2016); Gürel (2016); Yılmaz (2016); Bulut (2021)	Uses of the subject to be taught Links between the concepts and concepts contained in the subject
Shulman (1987) Ball et al. (2008)	Tosuncu (2019); Duran (2018), Özdemir Baki (2017): Sahin (2016); Aliustaoğlu (2018) Doğruel (2019): Yazıcı (2017)	Skills to problem and solve the issue
Shulman (1987)	Duran (2017) (multiplication and division by fractions)	Information for model usage (field model, length model, cluster model)
Lesseig (2016)	Cihan (2019) (methods of proof)	Knowledge of the method of proof and know how to apply it Main proof diagrams they have

Upon examination of the data from Table 2, PAB model, most frequently deployed by Shulman (1987) and Ball et al. (2008) is preferred for work addressing content knowledge. Non-routine problems, triangles and quadrants, derivatives and applications; linear equation and slope; area measurement sub-learning area, algebra learning area, rate and proportion central tendency and dissemination metrics have been determined that in the clusters, fundamental concepts, such as collecting and subtracting with fractions, content knowledge is examined. Information on the subject to be taught in 12 studies upon examination of the table data related to the area of knowledge covered in the theses reviewed; 2 problems resolution method information of the study; 13 studies' information on the subject to be taught; 1 information on the use area of the study, 7 information on the studies' concepts and connections; Seven studies had examined problem-building and problem-solving skills, while one study had examined information about model use. In addition, one study examined the information on proofing methods that Lesseig (2016) preferred the PAB model and the information on implementation, within the scope of the content knowledge on the main proof diagrams they have.

The content knowledge, which is the sub-component of the PAB model, is expressed as the information required or used in the teaching of lessons in the math program based on class levels, as well as the concepts, processes, proofs of the field, their underlying mathematical meanings, mathematical representations, and information on how mathematics develops and changes as a discipline (Ball et al., 2008; Lesseig, 2016; Shulman, 1986). In studies based on

the PAB model developed by Shulman (1986), content knowledge, which is the sub-component of the model, can be found: it was determined that the mathematical program is studied in the dimensions of establishing the relationship between the information required or used in lesson teaching according to class levels, as well as the underlying mathematical meanings and processes, and the concepts and concepts related to the field (Aliustaoğlu, 2018; Duran, 2018; Özdemir-Baki, 2018; Şahin, 2016; Uçar, 2019; Tosuncu, 2019;Yurtyapan, 2018). The content knowledge along with these dimensions; It has been examined by Uçar (2019) and Yurtyapan (2018) according to the methodology used in the subject: the studies Duran (2018), Aliustaoğlu (2018), Özdemir Baki (2017) Şahin (2016) showed the ability to provide a problem with respect to the subject. Duran (2017) reviewed the content knowledge for model use by factoring multipliers and dividing operations. Ball et al. (2008) looked at the subject area knowledge holistically in the "Mathematical Knowledge for Teaching" model. Subject content knowledge: general content knowledge is defined in three categories: specific content knowledge and horizontal content knowledge. In the postgraduate studies reviewed, only the information related to the Keleş (2019) study was examined in an integrated manner. Within the scope of general field and specific content knowledge, we have reviewed the works of Doğruel (2019), Girit (2016) and Yazıcı (2017); Gürel (2016) study demonstrated that she was only exploring general content knowledge, and Yılmaz (2016) examined only specific content knowledge. Figure 3 provides the results of the content knowledge research for the postgraduate theses examined.

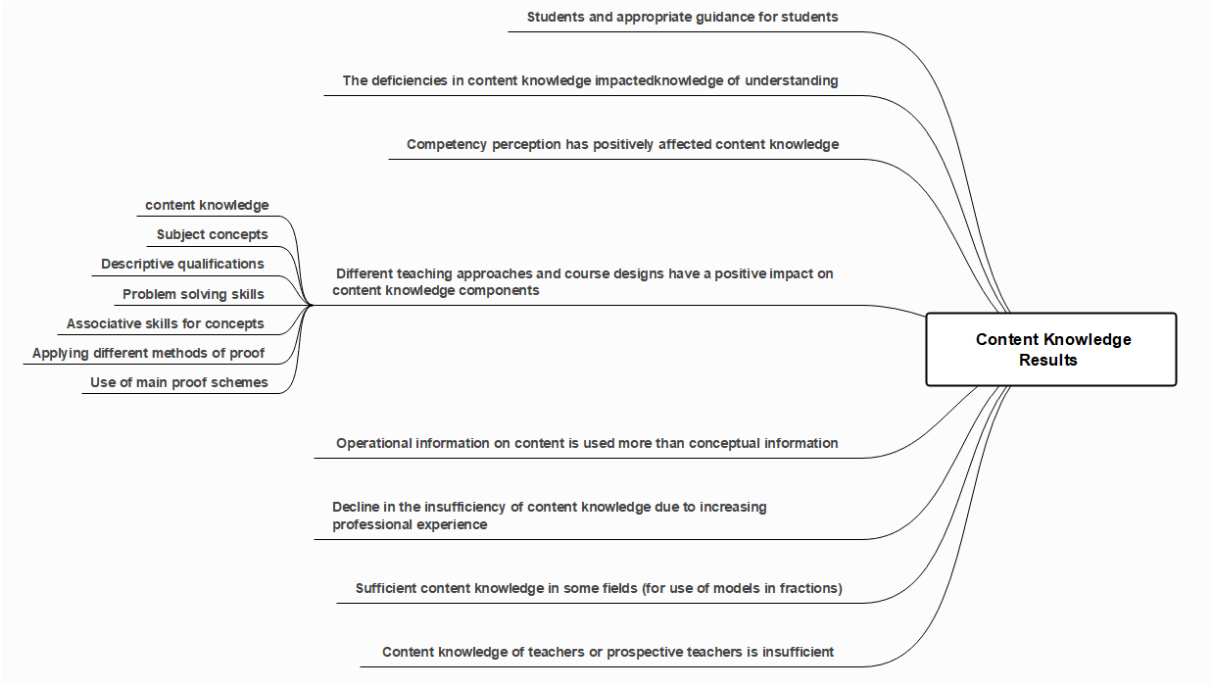

Figure 3. Results for the content knowledge

Upon examination of the results, we found that the content knowledge of teachers or prospective teachers is insufficient for the majority of the studies that address content knowledge. Moreover, there is a decline in the insufficiency of content knowledge due to increasing professional experience (Uçar, 2019; Yurtyapan 2018: Duran, 2018. Doğruel, 2019), that operational information on content is used more than conceptual information (Duran, 2018), and different teaching approaches and course designs have a positive impact on domain information components (content knowledge, subject concepts, descriptive qualifications, problem solving skills, associative skills for concepts, applying different methods of proof, use of main proof schemes) (Aliustaoğlu, 2018; Özdemir and Baki, 2017: Cihan, 2019), has sufficient content knowledge in some fields (for use of models in fractions) (Duran, 2017), and competency perception has positively affected content knowledge (Tosuncu, 2019). The deficiencies in content knowledge impacted knowledge of understanding students and appropriate guidance for students (Girit, 2016; Gürel, 2016).

Knowledge of understanding student

PAB models described by 4.2% as Grossman (1990), Magnusson et al. (1999), Lesseig (2016), Baki (2018), Rowland et al. (2009), Blömeke et al. (2015), where 24 studies examined the understanding of students who are PAB components in the post-graduate theses study, of this 41.5 % is Shulman (1987); 8.3 % in Covariates (2008); 25% were based on the PAB model defined by Ball et al. (2008). The evaluation of the said PAB models show that the explanations about understanding the student differ. Shulman (1987): Understanding students a teacher's awareness of the preliminary knowledge, misconceptions, what are the points they experience difficulty, their motivation, attitudes and level of interest in a course from students of different ages and experiences, Ball et al. (2008) defined a particular mathematical concept or process-oriented information as knowledge of more what students think or do. Grossman (1990) believes that knowledge of understanding student is the teacher's knowledge of pupils' understanding, concepts and misconceptions in a given subject area; the ability to connect initial knowledge and new information according to Magnusson et al. (1999), and how to identify students' misconceptions, errors, and student challenges. According to Kovarik (2008), understanding information is grouped into two sub-dimensions. Preliminary information of the students; it includes mathematical background in the subject students will learn according to their development levels, as well as misconceptions, the ability to guess the questions in their minds, and the information to identify where they have difficulties and their reasons. Lesseig

(2016) has been described as clear knowledge for the student's schemes (characteristics of extrinsic, experimental and deductive schemes, students' tendency to rely on authority or experimental examples, descriptions and expressions appropriate to students, representations within students' conceptual access, discussion patterns appropriate to the students' level, and the relation between the mathematical and everyday use of terms). Rowland et al. (2009) reported that there is information within the medium of knowledge of incidents with unexpected learners in a lesson about events with unexpected understanding of the student, that it is information about unanticipated learning opportunities, opportunities as they arise during learning, deviations from schedule or plan as needed, which is almost impossible to plan in class. Blömeke et al. (2015) knowledge of understanding student; learning disabilities, difficulties of learning and knowledge of students' prior knowledge. When the definitions in the underlying PAB models are examined, students' understanding of the student can be defined as preliminary information, misconceptions, what are the difficulties, their motivations, attitudes and awareness of their level of interest, understanding the student's conceptual or operational knowledge, and relational thinking. Table 3 lists the PAB models used in the dissertation studies that examine the knowledge of understanding student component and the scope of the content knowledge examined in this direction.

Table 3. PAB models and knowledge of understanding student

PAB model based on	Investigations	Knowledge of understanding student
Shulman (1987)	Uçar (2019); Aliustaoğlu (2018)	Knowing the mindset-strategies of students
Ball etc. (2008)	Keleş (2019); Girit (2016)	
Baki (2018)	Güler (2019)	
Blömeke, etc. (2015)	Kutlu (2018)	
Kovarik (2008)	Duran (2017)	
Shulman (1987)	Uçar (2019); Uz (2019), Aliustaoğlu (2018), Amaç (2018) (algebraic use of letters in algebra); Şimşek (2016); Özdemir Baki (2017): Sahin (2016); Tosuncu (2019)	Identifying learning challenges
Grossman (1990)	Can (2019) (fractional transactions)	
Magnusson Tax Office 1999	Sert Çelik (2018) (equality and equation)	
Kovarik (2008)	Duran (2017)	
Baki (2018)	Güler (2019)	
Blömeke, etc. (2015)	Kutlu (2018)	
Rowland Tax Office (2009)	Bilik (2016) (triangle)	
Ball etc. (2008)	Keleş (2019); Gürel (2016); Doğruel (2019): Yazıcı (2017); Özdoğan (2018) (concept of function)	
Shulman (1987)	Uçar (2019); Uz (2019), Duran (2018), Aliustaoğlu (2018), Amaç (2018) Şimşek (2016); Özdemir Baki (2017): Sahin (2016); Tosuncu (2019)	

Grossman (1990) Kovarik (2008) Magnusson Tax Office 1999 Rowland Tax Office (2009) Ball etc. (2008) Baki (2018) Blömeke, etc. (2015)	Can (2019) Orman (2020) (chamomile numbers); Duran (2017) Sert Çelik (2018) Bilik (2016) Girit (2016); Gürel (2016); Doğruel (2019): Yazıcı (2017); Özdoğan (2018) Güler (2019) Kutlu (2018)	Identifying misconceptions, errors and causes Knowledge of questions to be asked of the student to understand his/her mistake
Shulman (1987) Ball et al. (2008) Kovarik (2008) Magnusson Tax Office 1999 Baki (2018) Blömeke, etc. (2015)	Yurtyapan (2018); Duran (2018), Özdemir Baki (2017): Sahin (2016) Keleş (2019); Gürel (2016); Doğruel (2019) Orman (2020); Duran (2017) (multiplication and division by fractions) Sert çelik (2018) Güler (2019) Kutlu (2018)	Identifying preliminary information of students
Shulman (1987)	Aliustaoğlu (2018), Sahin (2016)	Attracting student attention, Motivating students
Ball v.d (2008)	Girit (2016)	Identifying students' mathematical needs
Baki (2018) Blömeke, etc. (2015)	Güler (2019) Kutlu (2018)	Analyzing students' mathematical solutions and discussions
Baki (2018) Blömeke, etc. (2015)	Güler (2019) Kutlu (2018)	Determining the relevance of the activities to the student level
Lesseig (2016)	Cihan (2019)	Information for identifying evidentiary schemes Information on identifying student difficulties for proving and explaining the reasons

Looking at the table data regarding the factors that are examined within the scope of understanding the students who prefer the PAB, we can see that 7 studies are interested in students' thinking, 20 studies' learning difficulties, 21 studies identify students' misconceptions and errors, 11 studies identify the reasons for conceptual misconceptions and mistakes, 12 studies identify students' preliminary information, 4 the questions to be directed to the student to understand the student's mistake, 2 to get the students attention of1 studies, determine the students' needs 2 study analyzed the students' mathematical solutions and discussions, 2 determined the suitability of activities to student level, 1 determined the proofing schemes of the study, 1 assessed the knowledge of understanding student components regarding the information to identify the student's difficulties in proving the study and explaining the reasons. It was determined that the most common research was conducted on identifying learning difficulties and misconceptions, errors and causes.

Within the studies based on the PAB model developed by Shulman (1986), understanding students as sub-components of the model could include: Students were examined

to determine learning difficulties, errors, misconceptions and reasons for content (Uçar, 2019; Oz, 2019; Tosuncu, 2019; Yurtyapan 2018: Duran, 2018. Aliustaoğlu, 2018: Amaç 2018. Şimşek, 2016; Özdemir Baki, 2017: Sahin, 2016). Understanding the learner with these dimensions; student preliminary information has been reviewed in the studies conducted by Yurtyapan (2018), Duran (2018), Özdemir Baki (2017), Şahin (2016). The study was conducted by Aliustaoğlu (2018) with the aim of getting students' attention and motivating them.

Figure 4 presents the results of the studies on knowledge of understanding student about the student in the evaluation postgraduate theses.

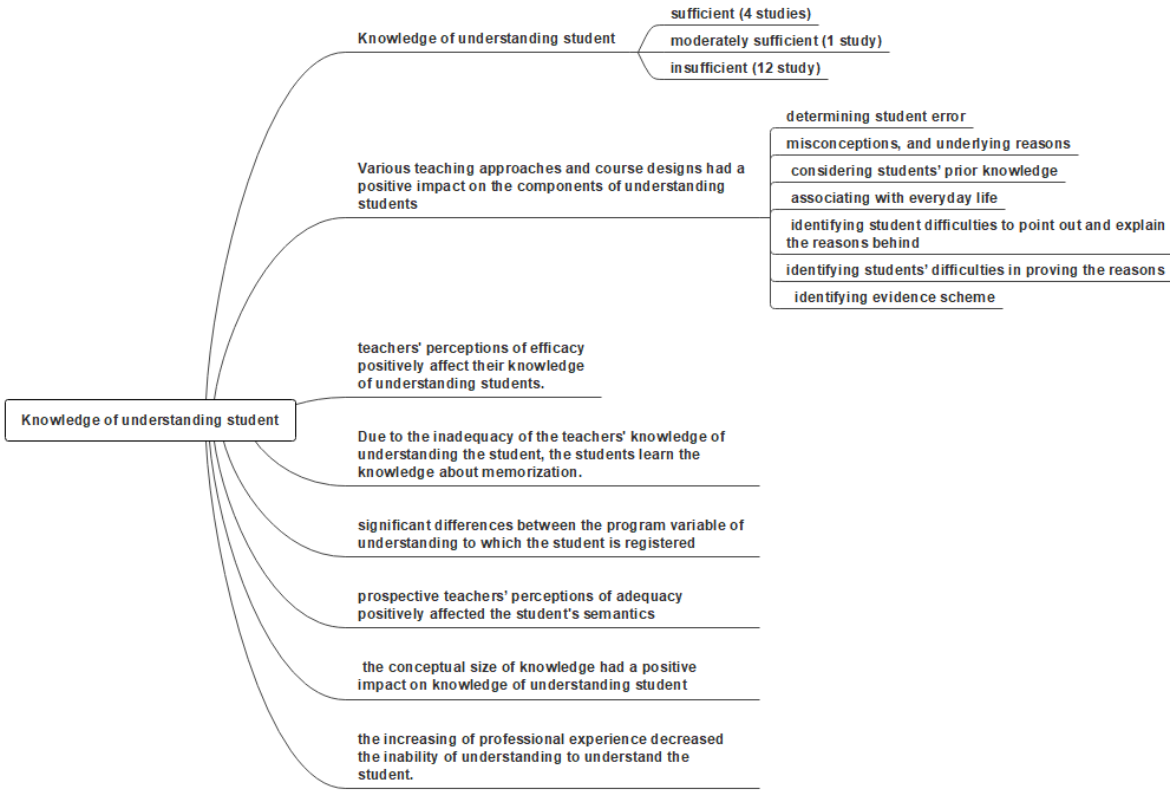

Figure 4. Results from knowledge of understanding student

When the results of the assessment of student comprehension in the studies that selected the PAB were examined, it was observed that prospective teachers or teachers had insufficient understanding of the student in 12 studies, moderate level in one study and adequate level in four studies. Knowledge of understanding student on memorizing students due to insufficient teacher understanding knowledge (Yurtyapan, 2018), various teaching approaches and course designs had a positive impact on the components of understanding students (determining student error, misconceptions, and underlying reasons, considering students' prior knowledge, associating with everyday life, identifying student difficulties to point out and explain the

reasons behind, identifying students' difficulties in proving the reasons, and identifying evidence schemes) (Aliustaoğlu, 2018; Özdemir and Baki, 2017: Cihan, 2019; Güler, 2019); significant differences between the program variable of understanding to which the student is registered (Şimşek, 2016) have been reached. (Tosuncu, 2019), prospective teachers' perceptions of adequacy positively affected the student's semantics (Tosuncu, 2019), the conceptual size of knowledge had a positive impact on understanding the student (Can, 2019), and the increasing of professional experience decreased the inability of understanding to understand the student.

Knowledge of instructional strategies

4.8% of the theses examined and examined the knowledge of instructional strategies of the PAB components in postgraduate theses, as defined by Lesseig (2016), Baki (2018), Rowland et al. (2009), Blömeke et al. (2015); of this 42.8% is Shulman (1987); Kovarik of 9.5% (2008); 28.5% were based on the PAB model defined by Ball et al. (2008). Following are the explanations for knowledge of teaching strategies when the related PAB models are examined. Knowledge of teaching strategies according to Shulman (1987); is described as the teacher's teaching method and know-how to communicate space to the students, eliminate students' misconceptions and increase students' success. Knowledge of strategies, methods, techniques, decision-making and implementation skills that can be used to teach an subject based on Ball et al. (2008), knowledge of teaching strategies by Kovarik (2008); knowledge of mathematical representations describes in three sections: representations (Charts, tables, and formulas), examples (real-world problems), and analogies (teaching the students about abstract concepts of math education with the concepts or facts known to students). Baki (2018) knowledge of teaching strategies explaining the strategy, method, and technique used by teachers during teaching. Lesseig (2016), on the other hand, the relationship between demonstration schemes and education (answering questions, responding to student opinions, using examples, and teaching methods that raise or reduce authoritarian or experimental demonstration schemes), questioning strategies (to justify beyond transactions and encourage thinking in the general case), use of significant examples or contrasting examples (broadening thought, bridging or scaffolding, focusing on key ideas in evidence), and knowledge of proof links (How to connect visual, symbolic or oral evidence to the agreed characteristic or contextual definitions? how to generate a generic argument from the diagram?). In general, knowledge of instructional strategies can be defined as teaching methods and technical knowledge that aim to convey the knowledge of these fields to students, eliminate

misconceptions, and increase students' success. Table 4 presents the PAB models used in the dissertation studies that examine the Instructional strategies knowledge and the scope in this direction.

Table 4. PAB models and Scope of the Coverage of the Learning Strategies Reviewed

PAB model based on	Thesis	Instructional strategies knowlegde components
Shulman (1987) Ball v. d. (2008) Baki (2018) Blömeke v. d. (2015) Rowland v. d. (2009)	Uçar (2019); Tosuncu (2019); Yurtyapan (2018); Duran (2018) Aliustaoğlu (2018);Goal (2018) Şimşek (2016); Özdemir and Baki (2017): Sahin (2016); Tosuncu (2019) Keleş (2019); Girit (2016); Gürel, 2016 Güler (2019) Kutlu (2018) Bilik (2016)	Educational, technical, and strategy information to be used in correcting mistakes made by the student and misconceptions.
Shulman (1987) Ball et al. (2008) Baki (2018) Blömeke et al. (2015)	Yurtyapan (2018);Duran (2018); Aliustaoğlu (2018), Şimşek (2016) Özdemir - Baki (2017): Sahin (2016) Keleş (2019); Girit (2016); Gürel (2016); Doğruel (2019): Yazıcı (2017); Yılmaz (2016); Bulut (2021) Güler (2019) Kutlu (2018)	Teaching method, strategy, and know-how to be used by the teacher during the teaching process
Shulman (1987)	Aliustaoğlu (2018), Şimşek (2016); Özdemir and Baki (2017): Sahin (2016)	Designing suitable learning environments to effectively teach concepts
Kovarik (2008) Baki (2018) Blömeke v. d. (2015) Ball v. d. (2008)	Orman (2020) Güler (2019) Kutlu (2018) Keleş (2019); Girit (2016); Gürel, 2016	Knowledge of mathematical representations, examples, and analogies
Kovarik (2008)	Duran (2019)	Use of modeling for information on mathematical representations (area model, length model, cluster model)
Ball v. d. (2008)	Yazıcı (2017); Yılmaz (2016) Yazıcı (2017) Yılmaz (2016)	Subject-specific lesson planning information Ability to use technological materials and programs Teaching multi-representation use
Lesseig (2016)	Cihan (2019)	Identifying teaching strategies to overcome student challenges
Baki (2018) Blömeke v. d. (2015)	Güler (2019) Kutlu (2018)	Knowledge of relationship between mathematics and the real world

Examination of the Table 4' data on the scope of Instructional strategies knowledge in studies based on PAB models reveals that 16 studies will use the teaching methods, techniques and strategies to eliminate errors and misconceptions made by the students; 14 teaching methods, strategies and technical information to be used in the teaching process; 4 information on designing suitable learning environments to effectively teach concepts of the study; six studies' knowledge of mathematical representations, examples and analogies; 1 model of the study for mathematical representations knowledge of the study (field model, length model,

cluster model); 2 use of subject-specific course materials and use of teaching programs 1, it was determined that 1 study examines the information about determining knowledge of instructional strategies to overcome student challenges, and 2 study examines the information about teaching strategies to create relationships between mathematics and the real world. Within the studies based on the PAB model developed by Shulman (1986), education strategies subcomponent of the model is included in the following: Students were identified with the objective of eliminating misconceptions and mistakes related to content, preparing suitable learning environments for teaching concepts, the teaching method, strategy and technical information used by the teachers, and how to apply them in the teaching process (Uçar, 2019; Yurtyapan 2018: Amaç 2018. Duran, 2018. Aliustaoğlu, 2018: Şimşek, 2016; Özdemir Baki, 2017: Sahin, 2016). The educational knowledge by Ball et al. (2008) which is the PAB component of the "Mathematical Knowledge for Education" model; a subject has been examined as the type of knowledge covering strategies, methods and techniques to be used in teaching and applying them (Doğruel, 2019; Keleş, 2019;Yazıcı, 2017; Girit, 2016; Gürel, 2016). The results obtained for studies on instructional strategies knowledge in graduate theses are presented in Figure 5.

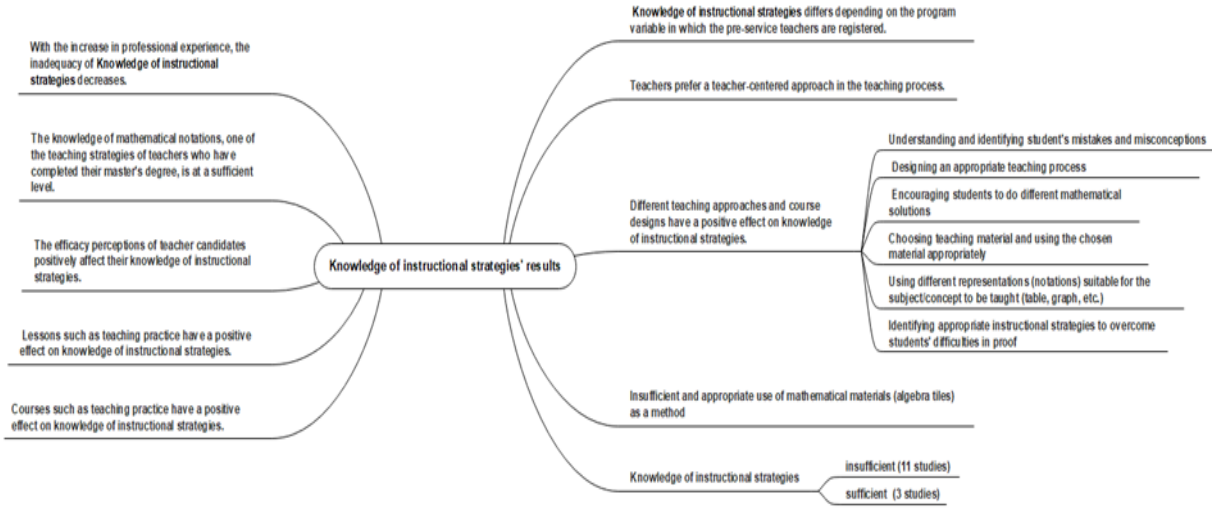

Figure 5. Results with respect to the knowledge of instructional strategies

In examining the data on the outcomes of the knowledge of instructional strategies components in which the knowledge of instructional strategies of the participants who prefer the PAB are examined, it is seen that the knowledge of instructional strategies of prospective teachers or teachers are insufficient in 11 studies and that they are sufficient in three studies, that they follow a teacher-centered approach during the education process, that different teaching approaches and course designs have a positive impact on the teaching information components of the education strategies (e.g., table and charts), that they identify teaching

strategies to overcome the difficulties of students that aim to perceive errors of concept, design and prove a suitable teaching process, use the appropriate representations(), encouraging students to develop different mathematical solutions), results have been obtained regarding the significant difference between the program variable in which the Instructional strategies knowledge is recorded in the scale development study, where prospective teachers can vary positively with the class level, and the effects of this variation on the teaching profession have, perceptions of competence of teachers have a positive effect on the education of the teaching profession, the mathematical representations of teachers who have obtained their master's degree are of sufficient knowledge, the knowledge of field within the scope of mathematical representations is used, and the insufficiency in knowledge of instructional strategies is reduced with increasing professional experience.

Conclusion, Discussions and Recommendations

This study investigated methodological aspects of postgraduate theses (distribution by year, workgroup, research methods, data collection tools and data analysis methods), how to handle the components of the PAB (program knowledge, content knowledge, understandings to students and teaching strategies) and what the related outcomes were.

An examination of the results of the PAB achieved by the mathematical teachers and teacher candidates revealed that the PAB had been largely inadequate for teachers and teacher candidates. With the increase of professional experience, the inadequacy of the PAB was reduced, different teaching approaches and course designs had a positive impact on the development of the PAB. It was concluded that the training courses offered for the teaching profession positively improved the PAB, and that teachers' perceptions of competence had an impact on the level of PAB. It also found that teachers use operational information about the content more than conceptual information. Teachers tend to provide teacher-centered teaching due to PAB deficiencies.

The program knowledge component in postgraduate theses, based on PAB models; the achievements in the context-oriented training program were expressed as the distribution of subjects by class level, pre-condition relations, the order in which the teaching was to be realized, the selection and use of teaching materials in accordance with the objective of the subject and establishment of in disciplinary and interdisciplinary conceptual relations. It was determined that 20 percent of the examined graduate these included the program knowledge component in their research. In the dimension of program knowledge, it was found that the outcomes of the context-oriented training program, the distribution of the subjects by class

level, prerequisite relationships and the order in which they should be taught were examined. However, within the scope of program knowledge, it has been noted that the educational program and skills, information variables for using teaching materials (computer-aided materials, concrete materials, etc.), and the dimensions of interdisciplinary relationship information have not been reviewed.

It was determined that 60 percent of the theses examined within the scope of the content knowledge, which is the sub-component of the PAB model, included the content knowledge size in their research. In this dimension, we examined information on subjects to be taught, methods used for problem solving, information on concepts, information on the field of use and connections between concepts, knowledge of problem solving and problem-solving skills, knowledge of model usage and methods of proof, knowledge of the main proof charts they have.

Understanding undergraduate thesis based on PAB models; students' ability to sense preliminary information is expressed as being able to recognize problems, errors, misconceptions and reasons for learning. Lesseig (2016) discusses its understanding of the student for demonstration in its model. It was determined that 96 percent of the theses examined included the student in his studies on the cognitive knowledge component.

It was noted that the dissertation addressed the understanding component of students with the extent to which they identify learning difficulties, errors, misconceptions, and reasons, but not with respect to the interest, attitudes, and motivations of students in the course (Uçar, 2019; Uz, 2019; Tosuncu, 2019. Yurtyapan 2018: Duran, 2018. Amaç 2018. Şimşek, 2016; Özdemir Baki, 2017: Sahin, 2016). Studies on understanding the student have revealed that teachers' competence in identifying students' preliminary information about a certain subject, students' perceptions, motivations and attitudes are not reviewed, and students' misconceptions and difficulties are limited to knowledge.

The background information on teaching strategies, which is the sub-component of the PAB model, is expressed as the teacher’s general knowledge to transfer to students, dispensing students’ misconceptions and teaching methods, strategical and technical knowledge used by teachers. It was noted that 84% of the examined graduate these included the teaching strategies knowledge component in their research. It was concluded that some studies examined the knowledge of knowledge of instructional strategies solely in terms of eliminating the misconceptions of students on the subject but did not examine the concepts effectively as part of the design of suitable learning environments, and the use of appropriate methods and

strategies. The studies that examine the knowledge of knowledge of instructional strategies in terms of the teaching methods, strategies, and technical information used by teachers did not involve the use of technology. Yazıcı (2017) study alone showed that the knowledge of teaching strategies was examined in terms of their ability to use technological materials or programs.

In the examination of results regarding program knowledge, it was concluded that program knowledge of the prospective teachers or teachers is insufficient or adequate, program knowledge has become significantly different depending on the license program variable registered, the inadequacy of program knowledge has decreased due to the increase in professional experience, e-mentoring has a positive effect on the program knowledge components (information on the achievements in the content-related training program, prerequisite relations and the sequence in which education should be realized).

Looking at the scope of program knowledge reviewed in the studies, we see that program knowledge is examined in terms of information related to the algebra, function, and data processing learning areas. It was determined that program knowledge was not considered in terms of the knowledge of gains in the educational program for a given content, knowledge of the distribution by class levels of the subjects, prerequisite relationships and what order teachings should be taught, knowledge of the skills the training program is intended for, knowledge of basic knowledge (operational/conceptual) and information on how to prepare content of a course for the skills (reasoning, association, communication...), knowledge of the use of teaching material in the underlying PAB models, which is analyzed.

When the results obtained from these studies, we concluded that in the vast majority of the studies in content knowledge, prospective teachers or teachers have insufficient content knowledge, there is a decrease in the insufficiency of content knowledge due to increasing professional experience, the processing knowledge of content is more used than conceptual information, different teaching approaches and course designs have a positive impact on the components of content knowledge, there are sufficient content knowledge in some areas (areas for model use in fractions), competency perception affects space information positively, and the inadequate information perception of students and suitable guidance can be given to students. Upon examining the results regarding knowledge of understanding student, we found that the understanding of students by teachers or prospective teachers is largely insufficient, that inadequate teacher understanding information is learned about students due to inadequate teacher understanding skills, that different teaching approaches and course designs have a positive impact on the components of understanding the student, that there are significant

differences about the program variable of which the understanding of the student is recorded, that the perceptions of teacher competencies and conceptual knowledge have a positive effect on the knowledge of understanding student, and that due to improved professional experience, there is a lack of understanding of students.

Upon examining the data on the results of the components of the knowledge of instructional strategies, we found that the instructor or teacher candidates' instructional strategies had a largely insufficient understanding, that different teaching approaches and course designs had a positive impact on the components of the education strategies, that the education strategies had a significant effect on the program variable of record, that the education strategies of prospective teachers varied correctly with the class level, and that this variation had an effect on the application classes for the teaching profession, that the competency perceptions of teachers had a positive effect on the teaching strategies and that the insufficiency in teaching strategies had decreased.

The PAB is an important element for teaching profession qualifications. However, there are differences in theories. The reason for this is considered to be related to the language, association and representation characteristics of the discipline. While content information is a prerequisite for linking special content with other content subjects and concepts, understanding the student and learning strategies may differ depending on the content chosen. Therefore, the PAB must be examined and evaluated as a whole. Whereas, in other studies conducted in literature and in the postgraduate theses examined, it is observed that the PAB components sometimes focus only on the knowledge of the field or student mistakes. Similarly, to the results shown, in most of the systematic analysis or meta-synthesis studies in the literature there seems to be a PAB concept following Shulman (Depaepe et al., 2013). Similar to the results obtained after examining the studies conducted in the literature, teachers' PAB is not sufficiently adequate (Dönmez, 2009; Sezer, 2012; Eroğlu, and Tanışlı, 201; Çıkrıkçı, 2015; Köklü, 2008; Şimşek and Boz (2016) it has been established that prospective teachers or teachers have difficulty in identifying and eliminating misconceptions (Şahin, Erdem, Başıbüyük, Gökkurt, & Soylu, 2014; Güler, 2014: Şimşek ve Boz, 2016). It was determined that the range of approaches proposed by the teachers regarding the teaching of the subject was far from conceptual perception and that plain narration and rote learning were preferred. Furthermore, PAB has been observed to develop gradually during university education (Bulut, 2021). In-service training has also been found to be significantly contributing to PAB's development (Altaylı, Konyalıoğlu, Cihan, Hızarcı, and Kaplan, 2014). The most striking result in the field

is that the content knowledge of teachers and teacher candidates is not sufficient for math teaching. Because the concept of mathematics is operational, the explanations of teachings remain at the operational level. It has also been established that a linear relation between PAB and professional experience was created due to lack of content knowledge making it difficult for students to understand and analyze their mistakes (Cankoy, 2010; Köklü, 2008).

Mathematical understanding is known to be problematic, and many abstract concepts include forms of representation. It is important that the PAB of teachers and teacher candidates develop and improve in math teaching. There is a need for teachers who are skilled in recognizing and resolving the errors or mistakes of their students and who can use a variety of teaching strategies. Furthermore, it is necessary to create a relation between the concepts and achievements in the training program and to pay attention to these elements in the design of the teaching process. Studies show that PAB gradually develops within the licensing process and within the teaching profession. Accordingly, teachers who develop themselves while being aware of the PAB must keep up with new education strategies and methods as well as innovative technologies.

Methodological tendencies, study areas, and results of postgraduate theses on the PAB in mathematics education were established with a current perspective. In this respect, it is recommended that comprehensive studies that identify and develop the PAB are conducted. Course content can be developed to improve the PAB as part of the updated new higher education program. Self-regulatory skills of teachers and teacher candidates may be improved. Mathematical educators can work together to develop a common language and educational policy around the PAB. This way, the results obtained can be evaluated and integrated into the teaching process.

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Türkiye'de Matematik Eğitiminde Pedagojik Alan Bilgisi Konulu Yüksek Lisans Tez Çalışmalarında Eğilimler: Sistematik Bir İnceleme

Özet:

Bu çalışmanın amacı Türkiye'de 2016-2021 yılları arasında ulusal tez merkezinde yayınlanmış matematik eğitimi araştırmalarında pedagojik alan bilgisini konu alan lisansüstü tezlerin sistematik olarak incelenerek değerlendirilmesidir. Bu doğrultuda lisansüstü tezleri belirli kriterlere uygun şekilde incelemek amacıyla nitel araştırma yöntemlerinden sistematik inceleme yöntemi temel alınmıştır. Çalışmanın verilerini elde etmek için Yüksek Öğretim Kurumu Başkanlığı ulusal tez veri merkezinde yer alan matematik eğitiminde pedagojik alan bilgisi konulu 26 lisansüstü tez PRISMA bilgi akışı referans alınarak analize dahil edilmiştir. Çalışmanın amacı doğrultusunda seçilen tezler oluşturulan çalışma değerlendirme formu çerçevesinde incelenmiştir. Bu kapsamda lisansüstü tezlerin künyesi (referans, yazarlar, yıl vb.), amacı, metodolojik unsurları (örneklem sayısı ve grubu, modeli, veri toplama araçları, veri analiz yöntemi) ve sonuçlar (kullanılan pedagojik alan bilgisi modeli alt boyutlarına ilişkin öğrenme çıktıları) analiz edilmiştir. Pedagojik alan bilgisini inceleyen teorisyenlerin ortaya koyduğu pedagojik alan bilgisi alt bileşenleri olan program bilgisi, alan bilgisi, öğrencileri anlama bilgisi ve öğretim stratejiler bilgisinin lisansüstü tez çalışmalarında nasıl ele alındığı ve sonuçları ayrıntılı olarak değerlendirilmiştir.

Anahtar kelimeler: pedagojik alan bilgisi, matematik eğitimi, lisans üstü tezler, sistematik inceleme