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Content Analysis of Research on Processes of Constructing Knowledge in Mathematics Education in Turkey

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Abstract

APOS, RBC, procept and abstraction theory with the students' knowledge creation processes on researches, are examined in order to scan in National Thesis Center, ULAKBİM, Google Scholar and papers in the symposium. A total of 27 postgraduate thesis, 15 articles and 8 papers were included in the study. By using descriptive content analysis method; the research was conducted by taking into consideration the year-type-publication language, sample-number and sampling type, the preferred topic and information creation theory in the research, the model-pattern and validity-reliability used, data collection tools and data analysis methods. It was determined that the most studies were conducted in 2018, and in the field of algebra learning with numbers. Most of the studies were conducted at middle school level. Studies were conducted with a small number of students in terms of sample numbers. In most of the researches, qualitative models were preferred and mostly open-ended questions, achievement tests, video and audio recordings as well as data diversity were used for data collection. There were some deficiencies in the researches about the validation and reliability of the studies with sampling methods. In order to overcome these deficiencies, research methods courses given to the researches can be made more effective.

Türkiye'de Matematik Eğitiminde Bilgiyi Oluşturma Süreçleri İle İlgili Araştırmaların İçerik Analizi

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Öz

Türkiye'de APOS, RBC, procept ve soyutlama teorileriyle öğrencilerin bilgi oluşturma süreçleri üzerine yapılan araştırmaları incelenmek amacıyla YÖK Ulusal Tez Merkez, ULAKBİM, Google Akademik ve sempozyumlardaki bildiriler kapsamında tarama yapılmıştır. Yapılan taramada toplam 27 lisansüstü tez, 15 makale ve 8 bildiri araştırmaya dâhil edilmiştir. Araştırmalar, betimsel içerik analizi yöntemi kullanılarak; araştırmanın yapıldığı yıl-türü-yayın dili, örneklem düzeyi-sayısı ve örnekleme çeşidi, araştırmada tercih edilen konu ve bilgi oluşturma teorisi, kullanılan model-desen ve geçerlik-güvenirlik sağlanması, veri toplama araçları ve veri analiz yöntemlerine göre sınıflandırılmıştır. En fazla çalışmanın 2018 yılında ve sayılar ile cebir öğrenme alanında çalışıldığı belirlenmiştir. Çalışmalar en fazla ortaokul düzeyinde yapılmıştır. Örneklem sayıları yönüyle genel olarak az sayıda öğrencilerle çalışmalar yürütülmüştür. Araştırmaların çoğunda nitel model tercih edilerek verilerin toplanmasında açık uçlu sorular, başarı testleri, video ve ses kayıtları ile veri çeşitlemesi kullanılmıştır. Örnekleme yöntemleri ile çalışmaların geçerlik ve güvenirlik süreçlerinin yansıtılması konusunda araştırmalarda bazı eksiklikler görülmüştür. Bu eksikliklerin giderilmesi amacıyla araştırmalara verilen araştırma yöntemleri dersleri daha etkili bir duruma getirilebilir.

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Introduction

In recent years, it is seen that the qualitative researches on which the factors affecting learning are examined, as well as how the students construct the knowledge, which stages they pass during the constructing knowledge, and at which levels of thinking they take place are among the important research subjects. It is known that the process of learning the concepts, the stages of structuring, the meaning of understanding, and the development of cognitive structures in the mind are important for learning and teaching of mathematics (Açan, 2015; Akkaya, 2010; Bahar, 2017; Bulut, 2018; Deniz,2014; Güler & Arslan, 2018; Öksüz, 2018). In this sense, it is necessary to employ the theories that will make it easier for students to determine their learning paths and levels according to their level. APOS and RBC theories appear in the literature about the process of constructing knowledge of students.

APOS theory, which shows the stages of cognitive development in the mind during the learning of concepts, is based on Piaget's theory of reflective abstraction (Dubinsky, 1991). APOS theory first appeared in the studies of RUMEC (Research Society of Mathematics Education Community) founded in 1995 by Dubinsky (Cottrill, Dubinsky, Nichols, Schwingendorf, Thomas and Vidakovic, 1996). Dubinsky (2000) has focused on five basic mental mechanisms for the development of advanced mathematical thinking, including internalization, encapsulation, reversal, coordination, generalization-thematization. According to APOS theory, it is necessary to cope with a mathematical situation and to create cognitive structures called action, process, object and schema by using these mental mechanisms (Dubinsky, Weller, McDonald & Brown, 2005).

The idea of abstraction from Aristotle to the present is presented with various definitions. Russell (1926) considered abstract thought as the highest level of human intelligence and as the most powerful tool in Sierpinska (1994, p. 61) defined the action of the separation of certain features from a concept as abstraction. Nowadays, it is seen that the abstraction is interpreted with two points of view as cognitive and sociocultural. Decontexualization the context with respect abstraction cognitive approaches using characteristics of the concept and Piagets (1985) indicating that occurs upon its relationship to other concepts is to speak of empirical and semi-empirical abstraction it noted that occur at similar process. According to Piaget, the subject in experimental abstraction observes a large number of objects and isolates their common characteristics while the process in semi-experimental abstraction proceeds in the same way as experimental abstraction, and in later stages, actions are applied on objects. Another idea that Piaget put forward about abstraction is reflective abstraction. It is thought that abstraction is a mechanism developed for the mental structures in the development of thought as well as the logical-mathematical structures in the mind of the individual (Arnon, Cottrill, Dubinsky, Oktaç, Fuentes, Trigueros & Weller, 2014). As a matter of fact, the idea of reflective abstraction is also the basis for further research on abstractions (Tall, 1991). Also, Dienes (1961: p. 281), used abstraction from a cognitive point of view, defines abstraction as a process of making a common feature from different situations; Skemp (1986) sees the similarities in a previously formed classification as a continuous change in recognition of new experiences. When abstraction is interpreted from a sociocultural perspective, it is thought that learning cannot be separated from the environment, social interaction and use of tools. Noss and Hoyles (1996), some of the researchers with a sociocultural perspective, produced the idea of situational abstraction, which supports students to understand how they create mathematical ideas by extracting results from the materials they use and the dispersed components in the environment.

Procept refers to a high level of reasoning that expresses both a process and a concept that is formed by the merging of process and concept words (Gray & Tall, 1991). While the theory of APOS theory examines the formation and the relationship between process and object thoughts, procept explains this situation with the symbols used in the representation of concepts (Bayazit, 2016). In this context, it can be said that the idea of procept is a learning theory which is considered in the understanding of the processes of constructing the knowledge of students.

The RBC abstraction model introduced by Hershkowitz, Schwarz and Dreyfus in 2001 and which became an RBC + C abstraction model by Dreyfus in 2007 is also based on Davydov's (1990) Knowledge Creation Philosophy and Leontev's (1981) Theory of Activity. RBC defined abstraction as in vertically re-organization activity of pre-acquired mathematical knowledge to form a new mathematical structure (Dreyfus, 2007; Hershkowitz, Schwarz, & Dreyfus 2001). RBC + C based on the theory that abstraction can be observed by cognitive actions, it is stated

that four different cognitive actions enable the study of recognition, building with, consruction and consolidation processes of constructing the knowledge (Dreyfus, 2007).

First of all, the theory of reducing abstraction developed by Hazzan (1999) was used by abstraction levels to explain the perception of abstract algebra concepts of undergraduate students. These abstraction levels are:

- quality of the relationship between the thought object and the thinking person
- reflection of process-object duality
- the degree of complexity of the thought mathematical concept

In short, the idea of reducing abstraction is based on the tendency of students to work with abstraction at a level lower than the abstraction level in which the concepts are given (Şenay & Özdemir, 2014).

In the literature, it is seen that researches about the process of constructing knowledge and different mathematical concepts are studied within the framework of APOS and RBC + C theories and it is seen that efforts are made to contribute to the development of theories. In this study, it has been tried to contribute to the literature by content analysis of the researches. In this context, when the content analysis in the literature is examined, it is seen that the content analysis studies conducted in mathematics education are quite few. Descriptive content analysis of Albayrak's (2017) mathematical model and modeling studies, Aztekin and Taşpınar Şener's (2015) meta-synthesis study of mathematical modeling studies in the field of mathematics education, Gül and Sözbilir's (2015) thematic content analysis for scale development studies in science and mathematics education, Kutluca, Hacıömeroğlu and Gündüz's (2016) computer assisted mathematics teaching, Ulutaş and Ubuz's (2008) researches in mathematics education between 2000 and 2006 and content analysis of technology-assisted mathematics education research of Tatar, Kağızmanlı and Akkaya (2013), Çiltaş, Güler and Sözbilir (2012) mathematics education on research content analysis was found. However, no content analysis, meta-analysis, or meta-synthesis studies have been found for the process of constructing knowledge. However, increasing the number of content analysis, meta-analysis and meta-synthesis studies on various subjects is important for researchers to open new research areas. As a result; no relevant research has been found in the literature. What kind of results discussion has been obtained in this context made the content analysis of the prepared research with the process of creating knowledge in math in Turkey in existing research in the process of creating knowledge with the students intended this research by working on what topics, researchers and educators to new research aims also be given new ideas. The sub-problems of the research for these purposes are as follows:

In the process of generating information in mathematics;

- ✓ What is the distribution by type of research?
- ✓ What is the distribution by publication language?
- ✓ What is the distribution by years?
- ✓ What is the distribution of the subjects studied according to the learning areas?
- ✓ What is the preferred process of constructing knowledge theory?
- ✓ How is the model and pattern distribution used?
- ✓ How is the sample-size distribution and sampling type?
- ✓ Are validity and reliability criteria included? What criteria are reflected?
- ✓ What is the distribution according to the data collection tools used?
- ✓ What is the distribution according to the data analysis methods used?

Method

Research Model

In this study, prepared by research in mathematics process of constructing knowledge in Turkey were examined. In this context, document analysis method was used. Document analysis involves the analysis of printed materials for the intended purpose in the study (Yıldırım & Şimşek, 2016). According to Yıldırım and Şimşek

(2016), in the document analysis method, firstly a framework for descriptive analysis is created, then the data is arranged according to the thematic framework, and finally the findings are presented and interpreted.

Sample

Freankel and Wallen (2006) stated that although all sampling methods can be preferred in content analysis, it is purposeful for sampling. For the purpose of this study, criterion sampling was used from purposive sampling methods. Criteria: i) the sample is Turkey ii) APOS, RBC, procept and abstractions theories are studied. In order to determine the studies included in the study, the Higher Education Council National Research Center / ULAKBIM / Google Scholar conducted an advanced screening. For the purposes of the research, "APOS", "RBC", "RBC + C", "processes of construction knowledge", "abstraction" and "mathematics", "procept", "object-process" keywords were used for the purposes of this study. Theses produced in theses and articles were included in the research. It was observed that the studies included in this study as a result of screening were between 2005-2019 and between. In the screening, 3 of the theses were closed to access but they were examined according to the information in the summary sections. A total of 27 postgraduate theses, 15 articles and 8 papers were included in the study (See Appendix 2).

Data Collection Tool

"*Research Classification Form"* (See Appendix 1), which was developed by the researchers and finalized in accordance with the opinions of an expert, was used as a data collection tool. Research classification form consists of thirteen chapters; general information about the research, year-type-publication language of the research, sample-size and sampling type, preferred topic in the research, construction knowledge theory, model-pattern and validity-reliability, data collection tools and data analysis methods.

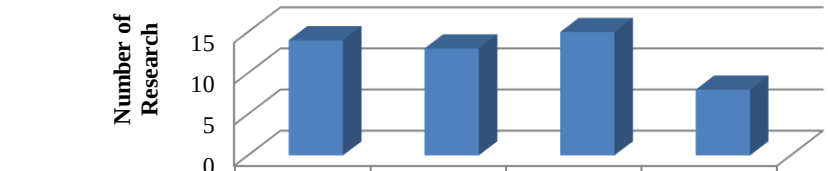
Data Analysis

Content analysis technique was used to evaluate the data obtained from the studies included in the study.When we look at the literature, we see that there are generally three types of content analysis with all advantages. Meta-synthesis, which is defined as a thorough synthesis and interpretation of research on a common subject in accordance with a specific theme (Au, 2007; Finfgeld, 2003; Walsh & Downe, 2005), is a quantitative study of research with the same subject or related purpose. meta-analysis of the findings by using appropriate statistical methods (Büyüköztürk, Kılıç, Çakmak, Akgün, Karadeniz & Demirel, 2016; Cooper, Hedges, & Valentine, 2009; Dinçer, 2014; Durlak, 1995; Wolf, 1986) and preferred for the purpose of this study. "Descriptive Content Analysis" is a systematic and renewable method for determining the tendencies and consequences of quantitative and qualitative research on a common subject (Çalık, Ünal, Coştu & Karataş, 2008; Göktaş, 2012; Jayarajah, Saat & Rauf, 2014; Lin, Lin & Tsai, 2014; Selçuk, Palancı, Kandemir & Dündar, 2014; Sözbilir, Kutu & Yaşar, 2012; Suri & Clarke, 2009; Umdu Topsakal, Çalık & Çavuş, 2012). In this context, it is thought that every research to be conducted with these kinds of analyzes can guide new researches, and this research, which examines the students' knowledge building processes in depth, will give a perspective on mathematics education. In this context, descriptive content analysis was preferred because it was appropriate for the purpose of this study. Researchers classified together twelve studies which were randomly selected among the studies. The remaining studies were classified independently by each researcher. The researches classified later were discussed in order to increase the reliability and disagreements on the classifications were eliminated. The data were presented in descriptive form as graph, frequency and percentage.

Results

In this section, the findings obtained from the descriptive content analysis in accordance with the various criteria mentioned below, including 27 theses, 15 articles and 8 papers are presented.

Findings of Distribution According to Research Types

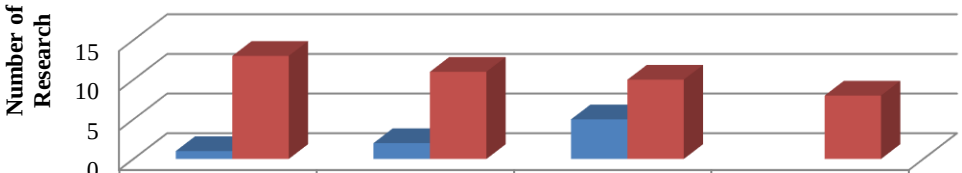


	Master's Thesis	Doctoral Thesis	Article	Paper
Number of Research	14	13	15	8

Figure 1. Distribution of Research by Type

When the distribution of the researches according to the types are examined, it is seen that there are 27 (54%) graduate thesis, 14 (28%) of them are master's thesis, 13 (26%) are doctoral thesis, 15 (30%) are articles and 8 (16%) are papers (Figure 1). It is determined that thesis are more than the articles in their distribution according to the types of research.

Findings of Distribution According to Publication Language



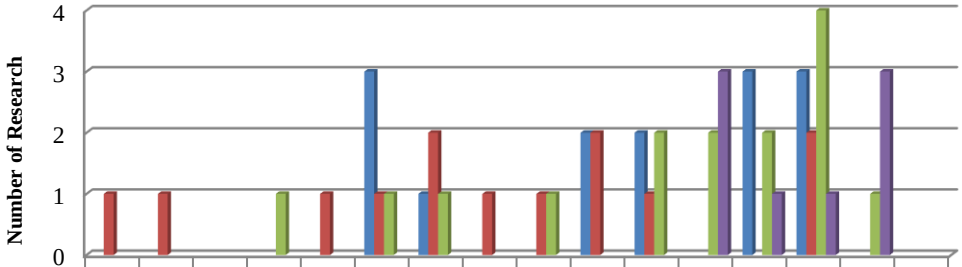
	Master's Thesis	Doctoral Thesis	Article	Paper
English	1	2	5	
Turkish	13	11	10	8

Figure 2. Publication Language of Studies

Eight of the studies (16%) reported that the language of publication was English and 42 (84%) of them were Turkish. 5 (10%) of the articles were English.

Findings of Distribution by Years

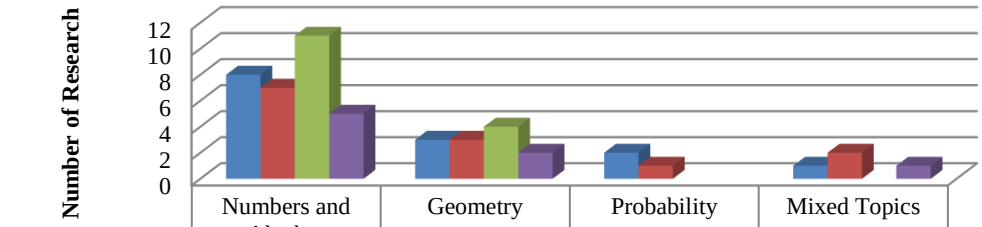
When the related researches are in the years 2005-2019 and the research types in all years are examined, it is seen that the research numbers are close to each other (Figure 3). In addition, it has been determined that the research has increased since 2014.



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Master's Thesis						3	1			2	2		3	3	
Doctoral Thesis	1	1			1	1	2	1	1	2	1			2	
Article				1		1	1		1		2	2	2	4	1
Paper												3	1	1	3

Figure 3. Distribution of Researches by Years

Findings Related to the Distribution of Subjects by Learning Areas



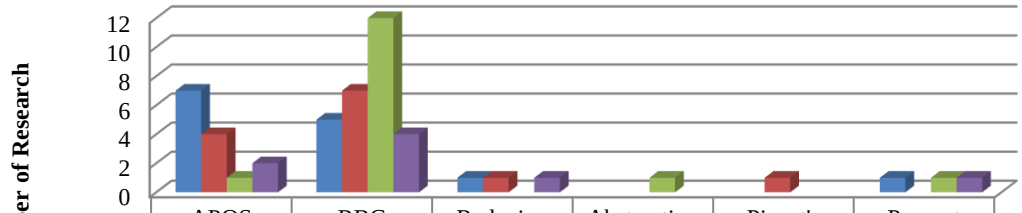
	Numbers and Algebra	Geometry	Probability	Mixed Topics
Master's Thesis	8	3	2	1
Doctoral Thesis	7	3	1	2
Article	11	4		
Paper	5	2		1

Figure 4. Subject Areas of Research

As seen in Figure 4, content analysis includes mathematics subjects from primary, secondary, high school and undergraduate. It is seen that these researches at different levels of education are subject to different learning areas in mathematics curriculum. Research subjects have been identified as “numbers and algebra” (62%) , “geometry” (24%), “probability” (6%) and “mixed topics” (8%). It was determined that the most “numbers and algebra” (62%) and least “probability” (6%) were studied in the learning area. Researches on the process of construction knowledge on more than one subject has been included in the mixed topics.

When we examine the researches at the level of the subjects studied, in *elementary school;* fraction, inequality, symmetry and geometry. *At secondary* level; coordinate system, linear relationship information, slope, identity, patterns, proportion-ratio, integers, exponential numbers, irrational numbers, polygons, triangular inequality, Pythagorean theory, transformation geometry, symmetry, rectangular prism and volume, surface area of vertical cylinder, geometry. It is seen that the most studied subjects are equations and probability. *At high school* level; the concept of irrational numbers and general algebra issues were studied in one study and the others were studied. In the studies conducted at the *undergraduate* level, probability, combination, limit, derivative, parabola, number theory, spherical geometry, analytical geometry, as well as functions in three studies have been studied. Generally speaking, it can be said that the most studied subjects are equations and functions.

Findings of Preferred Construction Knowledge Theory

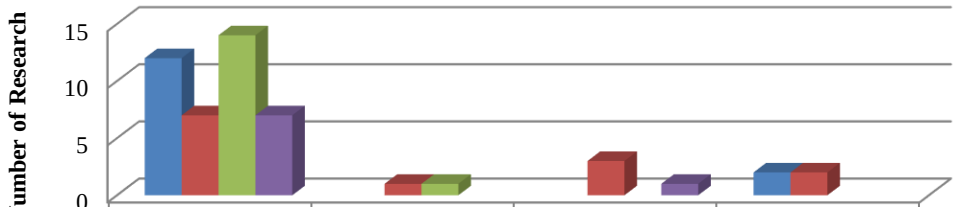


	APOS	RBC	Reducing Abstraction	Abstraction ve Generalization	Piaget's Abstraction Theory	Procept
Master's Thesis	7	5	1			1
Doctoral Thesis	4	7	1		1	
Article	1	12		1		1
Paper	2	4	1			1

Figure 5. Processes of Knowledge Creation Processes

The RBC and RBC + C studies were evaluated as RBC. Most of the researches was conducted with APOS (28%) and RBC (56%) theories. Out of these two theories, it is observed that reducing abstraction (6%), abstraction-generalization (2%), Piaget's abstraction theory (2%) and procept theory (6%) are included in the studies. Although APOS and RBC theories form the main framework of the research in general, the procept theory in research, Piaget's abstraction processes, realistic mathematics education, predictive learning road map and mathematical habits approaches of the mind, from the ideas of Tall / Vinner and Gray / Tall, Bloom taxonomy, mathematical power, Van Hiele geometric thinking levels, visualization, dynamic geometry software support is also seen.

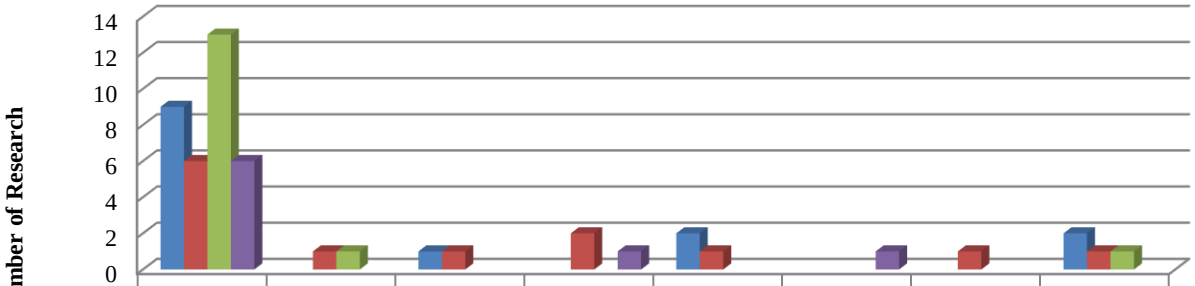
Findings of Model and Pattern Distribution Results



	Qualitative	Quantitative	Qualitative and Quantitative	Mixed
Master's Thesis	12			2
Doctoral Thesis	7	1	3	2
Article	14	1		
Paper	7		1	

Figure 6. Preferred Models in Research

In 3 studies, the preferred model type is not mentioned. 2 of these researches are qualitative research, 1 is a qualitative research considering the general process of the research and it is reflected in the data categories. In this case, 80% of the research qualitative, 8% of the qualitative and quantitative, 8% of mixed and 4% of the quantitative model has been preferred.

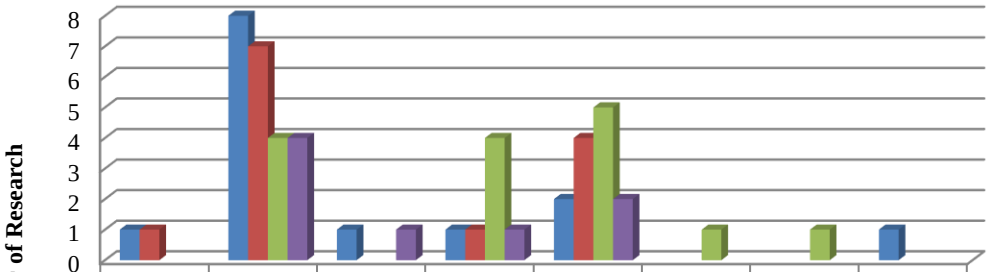


	Case Study	Semi-experimental	Case Study and Survey	Case Study and Semi-experimental	Teaching Experiment	Phenomenology	Nested Embedded Pattern	Other
Master's Thesis	9		1		2			2
Doctoral Thesis	6	1	1	2	1		1	1
Article	13	1						1
Paper	6			1		1		

Figure 7. Preferred Pattern Types in Research

68% of the studies were case studies , 4% were semi-experimental, 4% were case studies and survey, 6% were case studies and quasi-experimental, 6% were teaching experiments, 2% were phenomenology and 2% nested embedded patterns are preferred (Figure 7). In 4 studies (8%), the preferred pattern type was not specified.

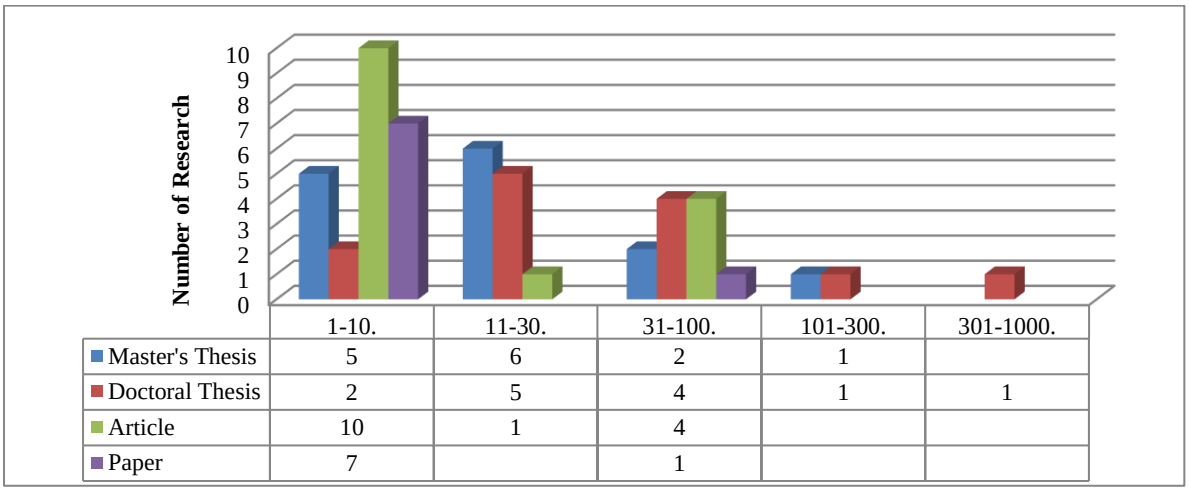
Findings of Distribution of Sample Level, Sample Size and Sampling Type



	Primary School Students	Secondary School Students	Secondary and High School Students	High School Students	Undergraduate Students	High School Maths Teacher (PhD Students)	High, Undergraduate and Graduate Students	Undergraduate and Graduate (Master) Student
Master's Thesis	1	8	1	1	2			1
Doctoral Thesis	1	7		1	4			
Article		4		4	5	1	1	
Paper		4	1	1	2			

Figure 8. Sample Level of Research

When the sample levels of the researches were examined, it was found that most of the researches were at the level of secondary school (46%), undergraduate (26%), high school (14%), primary school (4%) and graduate degree (PhD students) (2%). In 4 researches, it was determined that the process of forming information together with the participants in different teaching levels were conducted.

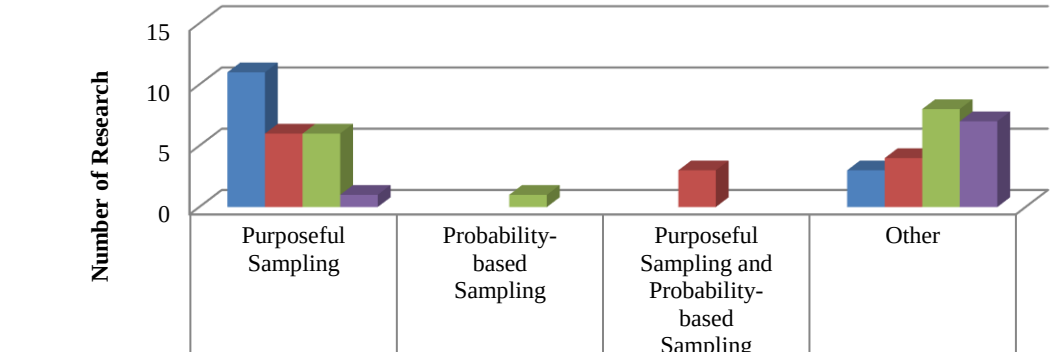


	1-10.	11-30.	31-100.	101-300.	301-1000.
Master's Thesis	5	6	2	1	
Doctoral Thesis	2	5	4	1	1
Article	10	1	4		
Paper	7		1		

Figure 9. Distribution of Sample Size by Research Type

It was determined that the studies were conducted with a small number of students. In addition, it was seen that the number of samples was limited by the number of tests among the larger study groups in determining the number

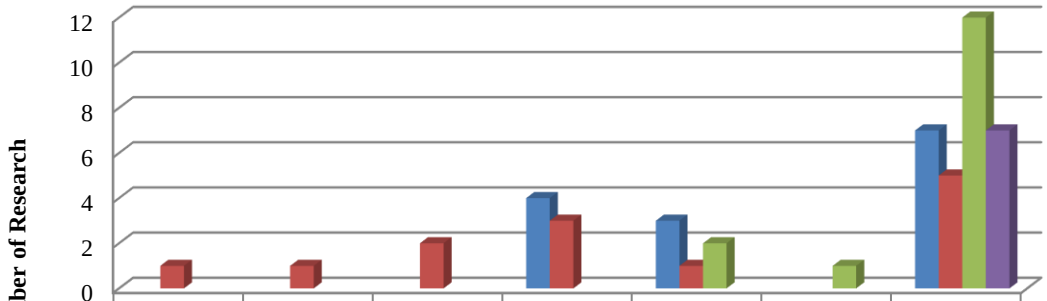
of samples. 48% of the studies were conducted in the range of 1-10, 24% in the 11-30 range, 22% in the 31-100 range, 4% in 101-300 and 2% in the 301-1000 range. At the same time, most of the theses are in the 11-30 range and most of the articles are in the sample sizes in the range of 1-10.



	Purposeful Sampling	Probability-based Sampling	Purposeful Sampling and Probability-based Sampling	Other
Master's Thesis	11			3
Doctoral Thesis	6		3	4
Article	6	1		8
Paper	1			7

Figure 10. Preferred Sampling in Research

It was observed that the preferred sampling type was specified in 28 (56%) of the investigated studies, while the other 22 (44%) did not indicate what the sampling type was. Purposeful and probabilistic sampling was used in 3 (6%) studies and probabilistic sampling was preferred in 1 (2%) study (Figure 10).



	Cluster Sampling	Deviant Case Sampling and Stratified Sampling	Extreme and Deviant Case Sampling	Criterion Sampling	Maximum Variation Sampling	Convenience Case Sampling	Other
Master's Thesis				4	3		7
Doctoral Thesis	1	1	2	3	1		5
Article					2	1	12
Paper							7

Figure 11. Sampling Methods

Of the 28 studies in which the sampling type was specified, 7 were selected as criterion sampling, 6 as maximum variation sampling, 2 as extreme and deviant case sampling, one cluster sampling, one convenience case

sampling, one case and stratified sampling methods were preferred. In 10 of these 28 studies, it was found that they did not specify to sampling methods.

Findings of Validity and Reliability Indication in Research

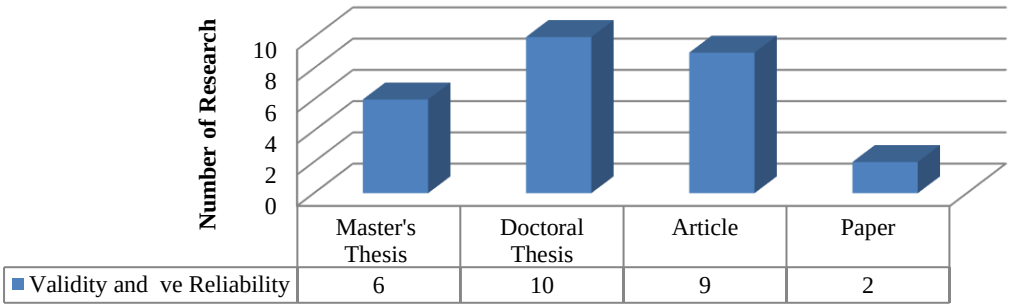


Figure 12. Determination of Validity and Reliability in Research

While 27 (54%) studies examined the process for validity and reliability, the other 23 (46%) studies did not mention this process. In 16 (32%) of the thesis, 9 (18%) of the articles and 2 (4%) of the papers were mentioned about the process to provide validity and reliability for the study. The validity and reliability of the studies are given in Figure 13.

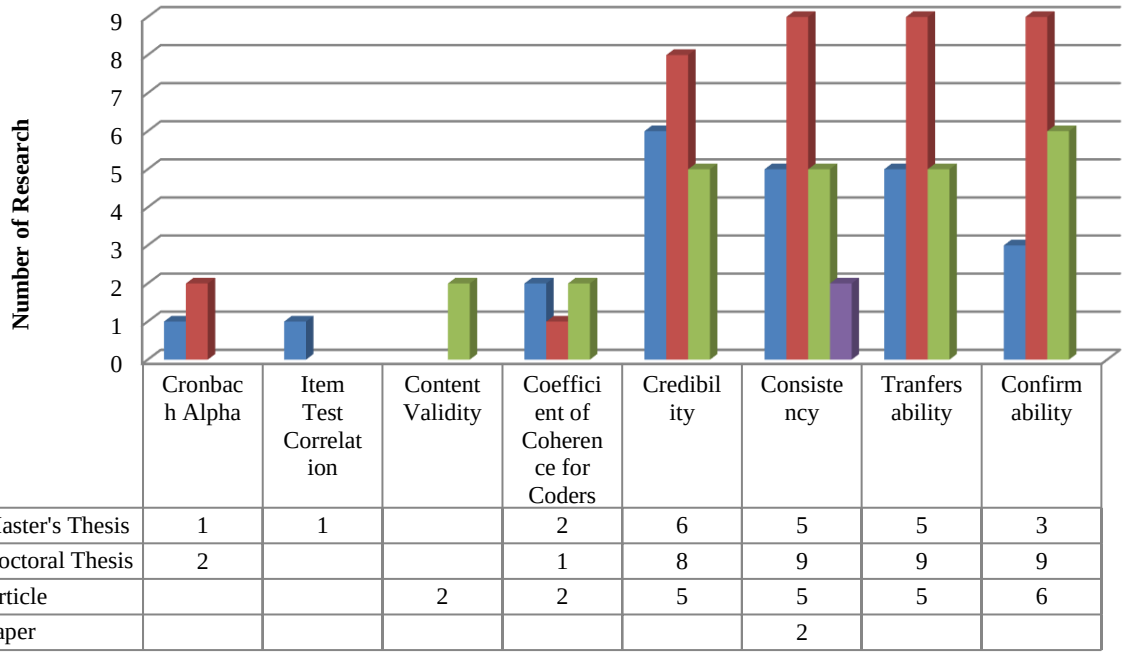
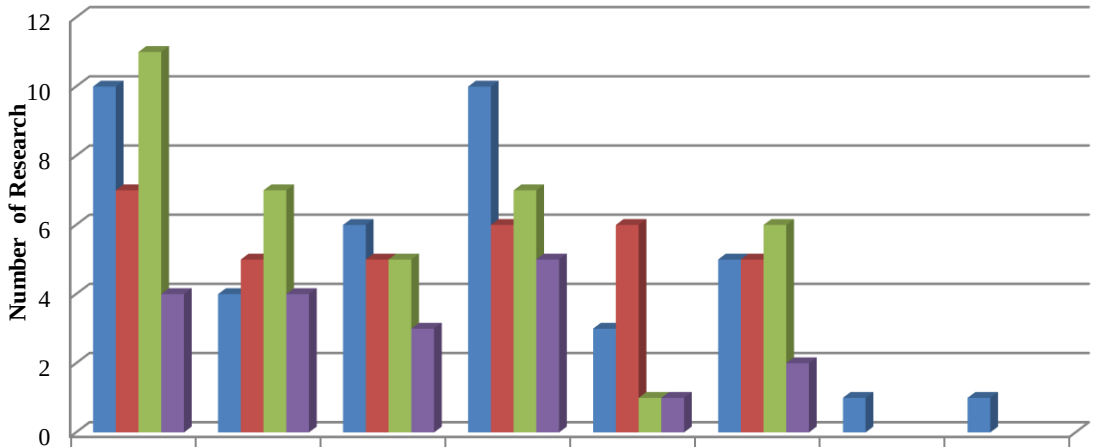


Figure 13. Validity and Reliability Types in Research

Since most of the studies examined in the study are qualitative researches, it was found that credibility (19), consistency (21), transferability (19) and confirmability (18) reflecting the validity and reliability of qualitative research were reflected. In addition, it was found that the most commonly used strategies for increasing the validity

and reliability of qualitative research were triangulation, expert opinion, participant confirmation and long-term observations. In addition, it was observed that the correlation coefficient between 5 coders was calculated. In 3 studies, it was found that the cronbach alpha coefficient and item test correlation were calculated in 1 to reflect the reliability of the scales. Content validity was also made in 2 studies.

Findings of Data Collection Tools Used

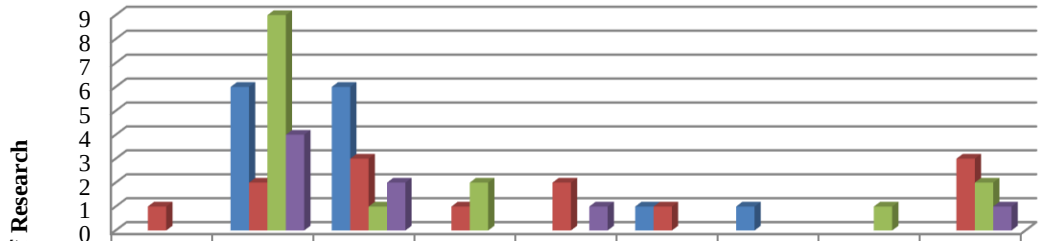


	Interview	Observation	Document	Open-ended Problems	Multiple Choice Testing (Achievement Test)	Activity-Worksheet	Survey	Scale
Master's Thesis	10	4	6	10	3	5	1	1
Doctoral Thesis	7	5	5	6	6	5		
Article	11	7	5	7	1	6		
Paper	4	4	3	5	1	2		

Figure 14. Preferred Data Collection Tools in Research

In most of the studies, it was determined that data triangulation (interview-observation-document analysis) and open-ended problems were used. At the same time, it is determined that multiple choice tests and activity-work sheets are among the preferred data collection tools. In addition, since most of the studies were conducted using more than one data collection tool, the data were generated as shown in Figure 14 above.

Findings Related to Data Analysis Methods



	Predictive Analysis	Descriptive Analysis	Content Analysis	Predictive Analysis and Content Analysis	Predictive Analysis and Descriptive Analysis	Predictive Analysis and Content Analysis	Content Analysis ve Thematic Analysis	Thematic Analysis	Other
Master's Thesis		6	6			1	1		
Doctoral Thesis	1	2	3	1	2	1			3
Article		9	1	2				1	2
Paper		4	2		1				1

Figure 15. Data Analysis Methods Used in Research

In most of the studies, descriptive (42%) and content (24%) analysis is preferred as data analysis method (Figure 15). In addition, 6% of the researches included descriptive and content analysis, 6% of the predictive and descriptive analysis together, 4% of the predictive and content analysis were used together. Predictive analyzes, thematic analysis and content-thematic analysis were used together in one study (2%). In addition, the data analysis method used in 6 (12%) studies was not specified.

Discussion and Conclusion

It is known that the abstraction processes should be valued for the students to think mathematically (Schoenfeld, 1992). In this context, it is important to examine students' thinking processes in depth. Examining students' knowledge contruction processes, In the literature, it can be seen that various approaches to theories can contribute to more detailed findings in cognitive analysis. In the research examined in the scope of this study, APOS and RBC theories, as well as procept theory, Piaget's abstraction processes, realistic mathematics education, projected learning roadmap and mathematical habits of mind, from the thoughts of Tall/Vinner and Gray/Tall, Bloom's taxonomy, mathematical power, Van Hiele geometric thinking levels, visualization, dynamic geometry software is also supported. At the same time, we can say that various encodings in the sub-problems of the research will be important in terms of directing new researches. The results of the findings obtained in line with the sub-problems of the research are presented below.

It is seen that the master thesis, doctoral dissertation and article distribution of the researches are close to each other. In addition, the number of papers is less. The fact that there are few studies in the type of papers may be that the studies made as papers were later expanded and accepted as journals. In addition, most of the studies were found to be in Turkish. This situation is likely to occur mostly in Turkey's graduate studies of the effect of teaching Turkish. It is determined that the related researches are between 2005-2019. According to findings in mathematics APOS, RBC, procept and descriptive content analysis included in the scope of the investigation it was determined that theories of abstraction of the fifteen-year history. It is seen that the highest number of studies was done in 2018 and the researches increased after 2014. This may be due to the revision of the mathematics curriculum in 2013. It may be thought that the emphasis of “students should be helped to create meaning and abstraction from their concrete experiences” (MEB,2013) might have attracted the attention of researchers. Also, such an increase

is a pleasing finding. In this sense, students' process of contruction knowledge is also important for the subjects they will learn next.

It is seen that these researches at different levels of education are subject to different areas of learning in the subjects of mathematics curriculum. In this sense, subjects were taken into consideration in which learning areas were to be included in the learning area, and the learning areas at the secondary and high school level were taken into account. The studies have been examined as numbers and algebra, geometry, probability and mixed topics. Albayrak's (2017) study of the content analysis of the researches about mathematical model and modeling published in our country is parallel with this situation. The subject of "*Equations and Functions*" has been the most studied subjects. These issues may have been preferred because of the inherent epistemological difficulties of the relevant concepts during teaching. In addition, it can be preferred to take measures for misleading and incomplete learning if it can be observed how the students abstract the concepts because it is important that pre-learning is conceptually meaningful and permanent in teaching advanced subjects.

Most of the research was conducted with APOS and RBC theories. Apart from these two theories, it is observed that abstraction reduction, abstraction-generalization and Piaget's abstraction theory and procept theory are included. RBC theory is observed to be more research than the others. This can be said to be more research based on sociocultural approaches, and because researchers take into account the impact of the environment in learning.

In the research, the preferred models are as follows; qualitative, quantitative and mixed. The number of qualitative research is quite high. These results do not correspond to some studies (Saban et al., 2010; Çiltaş, Güler & Sözbilir, 2012). But results are in line with the results of content analysis studies on different topics. (Albayrak, 2017; Aztekin & Taşpınar Şener, 2015). Similarly, Hart, Smith, Swars and Smith (2009) stated that qualitative methods have been used in researches in recent years. In this context, it can be said that qualitative methods can be used to analyze the learning processes in mathematics education research. At the same time, there are no studies using a mixed model except one study. This situation is similar to the studies of Gökçek et al. (2013) and Çiltaş, Güler and Sözbilir (2012). However, in mathematics education researches, it is thought that using mixed method will enrich the researches methodically. The types of patterns preferred in research are as follows: Case study, quasi-experimental, case study, case study and quasi-experimental, teaching experiment, phenomenology and nested embedded patterns. It is seen that mostly case study is preferred. This result may justify the practice of the theories in the research as appropriate to the case study. Besides, it can be said that only one research method and pattern should not be maintained.

When we look at the sample level, the highest level of middle school education, undergraduate, high school, primary school and graduate were found. It can be said that the high number of studies done with middle school students in construction knowledge processes is valuable in terms of structuring the learning processes in the upper levels. Even more similar researches at primary school level may also guide the middle school level.

When the sample size of the researches is examined, it is seen that the maximum of 11-30 ranges in the thesis and 1-10 in the articles are preferred. It has been found that the studies are generally conducted with a small number of students. 28 of the studies examined indicated the sampling type and the other 22 researches did not specify the sampling type. purposeful sampling was used in 24 of the studies, purposeful sampling and probabilistic-based sampling were used in 3 studies, probabilistic sampling was used in 1 research. In the descriptive content analysis, which is the majority of the qualitative researches, criterion, maximum variation, easily accessible status and density sampling, excessive and contradictory sampling were used for the purpose of sampling. In most of the studies, purposeful sampling was preferred but it was not specified which purposive sampling method was used. In 27 studies, while the process for validity and reliability was mentioned, the other 23 were not mentioned in this study. From these 27 studies; 16 of them are graduate thesis, 9 of them are articles and 2 of them are papers. It was determined that these studies knew the strategies used to increase the validity and reliability of qualitative research and that they made the most data diversification, expert opinion, participant confirmation and long-term observations. It can be said that the fact that almost half of the researches in which the majority of the researches consisted of qualitative research did not mention validity and reliability processes was an important deficiency in terms of research. In order to overcome this situation, researchers can be supported with the necessary trainings.

In the research, it was determined that the data collection (observation, interview, document) supported by open-ended questions, success tests, activity-work sheets, video and audio recordings were mostly used in data collection. In most of the studies, descriptive and content analysis is preferred as data analysis method. It can be said that this result is consistent with the majority of qualitative method and case study studies. It is known that researchers are expected to increase the variety of data collection tools in order to reach more valid results and to increase the reliability of the research findings. In this sense, it can be said that researches prefer to use data triangulation and other tools in data collection tools.

Suggestions

In addition to contributing to the literature examining the processes of knowledge creation, it also has the task of guiding teachers and prospective teachers. It is understood that the studies conducted in this context require more studies at different levels of education in order to fulfill this task. In addition, research examining the processes of creating knowledge on different mathematics topics should be conducted. In future researches, using mixed method may be beneficial in terms of advantage from qualitative and quantitative research models. In order for the methodological parts of the studies to be strong, the research methods lessons given to the researchers should be made more effective. The results of this study were obtained through 50 years of research conducted between 2005-2019 in Turkey. In future studies, it may be considered to carry out content analysis of the research conducted in the relevant field abroad.

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Researchers' Contribution Rate

Contribution Categories		Author's Name and Contribution Rate	
Category 1	Study Design	F.T. 60%	B.C.G. 40%
	Data Collecting	F.T. 70%	B.C.G. 30%
	Data Analysis and Interpretation	F.T. 55%	B.C.G. 45%
Category 2	Manuscript	F.T. 50%	B.C.G. 50%
Category 3	Final Approval and Responsibility	F.T. 50%	B.C.G. 50%

Conflict of Interest

This study does not have any conflict of interest.

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Appendix 1: Research Classification Form

Name of the Study:
Authors: **Year:**

1) Type of Research
- Doctoral Thesis
- Master Thesis
- Article
- Paper

2) Publication Language of Research
- Turkish
- English

3) Method of Research
- Qualitative
- Quantitative
- Qualitative and Quantitative
- Mixed

4) Learning Areas of the Research
- Number and Algebra
- Geometry
- Possibility
- General

5) Type of Construction Knowledge Process
- APOS
- RBC
- Reducing Abstraction
- Piaget's Abstraction Theory
- Abstraction and Generalization
- Procept

6) Pattern Types in Research
- Case Study
- Semi-experimental
- Case Study and Survey
- Case Study and Semi-experimental
- Teaching Experiment
- Phenomenology
- Nested Embedded Patterns
- Other (Not Specified)

7) Sample Level of Research
- Primary School Students
- Secondary School Students
- Secondary and High School Students
- High School Students
- Undergraduate Students
- High School Mathematics Teachers (PhD students)
- High School, Undergraduate and Graduate Students
- Undergraduate and Graduate (Master) Students

8) Sample Size of Research
- 1-10 person
- 11-30 person
- 31-100 person
- 101-300 person
- 301-1000 person

9) Sample Selection in Research
- Purposeful Sampling
- Probability Based Sampling
- Purposeful and Probability Sampling
- Other (Not Specified)

10) Sampling Methods
- Cluster Sampling
- Deviant Case and Stratified Sampling
- Extereme and Deviant Case Sampling
- Criterion Sampling
- Maximum Variation Sampling
- Convenience Case Sampling
- Other (Not Specified)

11) Validity and Reliability
- Credibility
- Transferability
- Consistency
- Confirmability
- Coefficient of Coherence for Coders
- Cronbach Alpha
- Item Test Correlation
- Content Validity

12) Data Collection Tools
- Interview
- Observation
- Document
- Open Ended Problems
- Multiple Choice Test (Achievement Test)
- Activity-Worksheet
- Survey
- Scale

13) Data Analysis
- Predictive Analysis
- Descriptive Analysis
- Content Analysis
- Descriptive and Content Analysis
- Predictive and Descriptive Analysis
- Predictive and Content Analysis
- Content and Thematic Analysis
- Thematic Analysis
- Other (Not Specified)

Appendix 2: Research Included in Descriptive Content Analysis

No	Authors and Year	Name of Research	Type
1	Ozmantar, F. M. (2005)	An investigation of the formation of mathematical abstractions through scaffolding	PhD
2	Yeşildere, S. (2006)	Farklı matematiksel güce sahip ilköğretim 6,7 ve 8. sınıf öğrencilerinin matematiksel düşünme ve bilgiyi oluşturma süreçlerinin incelenmesi	PhD
3	Çetin, İ. (2009)	Students' understanding of limit concept: An APOS perspective	PhD
4	Köse Tunalı, Ö. (2010)	Açı kavramının gerçekçi matematik öğretimi ve yapılandırmacı kurama göre öğretiminin karşılaştırılması	Master
5	Akkaya, R. (2010)	Olasılık ve istatistik öğrenme alanındaki kavramların gerçekçi matematik eğitimi ve yapılandırmacılık kuramına göre bilgi oluşturma sürecinin incelenmesi	PhD
6	Katrancı, Y. (2010)	Olasılığın temel kuralları bilgisinin yapılandırmacı kurama göre oluşturulması sürecinin incelenmesi	Master
7	Birinci, K. S. (2010)	Matematik öğretmen adaylarının ispatlama performanslarının süreç-nesne ilişkisi açısından incelenmesi	Master
8	Can, M. (2011)	Matematiksel soyutlama ve soyutlamanın indirgenmesi	Master
9	Yılmaz, R. (2011)	Matematiksel soyutlama ve genelleme süreçlerinde görselleştirme ve rolü	PhD
10	Sezgin Memnun, D. (2011)	İlköğretim altıncı sınıf öğrencilerinin analitik geometrinin koordinat sistemi ve doğru denklemi kavramlarını yapılandırmacı öğrenme ve gerçekçi matematik eğitimine göre oluşturması süreçlerinin araştırılması	PhD
11	Özcan, B. (2012)	İlköğretim öğrencilerinin geometrik düşünme düzeylerinin geliştirilmesinde bilgiyi oluşturma süreçlerinin incelenmesi	PhD
12	Çekmez, E. (2013)	Dinamik matematik yazılımı kullanımının öğrencilerin türev kavramının geometrik boyutuna ilişkin anlamalarına etkisi	PhD
13	Ercire, Y. (2014)	İrrasyonel sayı kavramına ilişkin yaşanılan güçlüklerin incelenmesi	Master
14	Deniz, Ö. (2014)	8. Sınıf öğrencilerinin gerçekçi matematik eğitimi yaklaşımı altında eğim kavramını oluşturma süreçlerinin APOS teorik çerçevesinde incelenmesi	Master
15	Şenay, Ş.C. (2014)	Matematik öğretmen adaylarının sayılar teorisine yönelik soyutlamayı indirgeme eğilimlerinin düşünme stilleri ve matematik öz yeterlikleri ile ilişkisinin incelenmesi	PhD
16	Çelebioğlu, B. (2014)	Kesir kavramına ilişkin bilgi oluşturma sürecinin incelenmesi	PhD
17	Açıl, E. (2015)	Ortaokul 3. sınıf öğrencilerin denklem kavramına yönelik soyutlama süreçlerinin incelenmesi: APOS teorisi	PhD
18	Ulaş, T. (2015)	Sekizinci sınıf öğrencilerinin özdeşlik kavramını oluşturma süreçlerinin incelenmesi	Master
19	Açan, H. (2015)	8. sınıf öğrencilerinin dönüşüm geometrisinde bilgiyi oluşturma süreçlerinin incelenmesi	Master
20	Bahar, A. (2017)	İlköğretim matematik öğretmen adaylarının olasılık kavramına yönelik bilgi oluşturma süreçlerinin incelenmesi	Master
21	Şefik, Ö. (2017)	Öğrencilerin iki değişkenli fonksiyon kavramını anlamalarının APOS teorisi ile analizi	Master
22	Şimşekler, Z. H. (2017)	Özel yetenekli çocuklarda matematiksel soyutlama	Master
23 KISITLI	Camci, F. (2018)	Altıncı sınıf öğrencilerinin tahmini yol haritası çerçevesinde tasarlanan bir öğretim deneyindeki matematiksel soyutlama süreçleri	PhD
24	Öksüz, R. (2018)	5. sınıf öğrencilerinin kesir kavramını oluşturma süreçlerinin APOS teorik çerçevesinde incelenmesi	Master
25	Bulut, S. (2018)	Ortaokul 6. sınıf öğrencilerinin üçgende alan bilgisini oluşturma sürecinin RBC+C modeline göre incelenmesi	Master
26	Koçyiğit Gürbüz, M. (2018)	Yedinci sınıf öğrencilerinin etkinlik temelli öğrenme yaklaşımı altında oran-orantı kavramlarını oluşturma süreçlerinin incelenmesi: APOS Teorisi	Master
27	Altaylı Özgül, D. (2018)	Ortaokul öğrencilerinin çokgenler konusundaki soyutlama süreçlerinin incelenmesi: RBC+C modeli	PhD
28	Altun, M., ve Yılmaz, A. (2008)	Lise öğrencilerinin tam değer fonksiyonu bilgisini oluşturma süreci	Article
29	Altun, M., ve Yılmaz, A. (2010)	Lise öğrencilerinin parçalı fonksiyon bilgisini oluşturma ve pekiştirme süreci	Article
30	Uygur Kabael, T. (2011)	Generalizing single variable functions to two-variable functions, function machine and APOS	Article
31	Altun, M., ve Durmaz, B. (2013)	Doğrusal ilişki bilgisini oluşturma süreci üzerine bir durum çalışması	Article
32	Kaplan A., ve Açıl, E. (2015)	Ortaokul 4. sınıf öğrencilerinin eşitsizlik konusundaki bilgi oluşturma süreçlerinin incelenmesi	Article
33	Biber, K.Ç., ve Argün, Z. (2015)	Matematik öğretmen adaylarının tek ve iki değişkenli fonksiyonlarda limit konusunda sahip oldukları kavram bilgileri arasındaki ilişkilerin incelenmesi	Article

34	Altaylı Özgül, D., ve Kaplan, A. (2016)	7. sınıf öğrencilerinin silindirin yüzey alanı konusundaki soyutlama süreçlerinin ve paylaşılan bilgilerinin incelenmesi	Article
35	Gür, H., ve Kobak Demir, M. (2016)	Öğretmen adaylarının parabol bilgisini oluşturma süreçleri ve bu süreçte öğretmenin rolü: Durum çalışması	Article
36	Güler, H.K., ve Arslan, Ç. (2017)	Consolidation of similarity knowledge via pythagorean theorem: A Turkish case study	Article
37	Sezgin Memnun, D., Aydın, B., Özbilen, Ö., ve Erdoğan, G. (2017)	The Abstraction Process of Limit Knowledge	Article
38	Güler, H.K., ve Arslan, Ç. (2018)	Matematik öğretmeni adaylarının düzlemde dönme dönüşümü formüllerini oluşturma sürecinin incelenmesi	Article
39	Gürbüz, M. Ç., Ağsu, M., ve Özdemir, M. E. (2018)	An analysis of how preservice math teachers construct the concept of limit in their minds	Article
40	Güler, H. K., ve Gürbüz, M. Ç. (2018)	Construction Process of the Length of $\sqrt[3]{2}$ by Paper Folding	Article
41	Akarsu Yakar, E., ve Yılmaz, S. (2018)	Üçgen eşitsizliği'ne yönelik 6.sınıf öğrencilerinin matematiksel düşünme gelişim aşamaları	Article
42	Kobak Demir, M., ve Gür, H. (2019)	Lise öğrencilerinin parabol bilgisini oluşturma süreçlerinde öğretmen etkisi	Article
43	Çomarlı, S.K., Gökkurt, B., ve Usta, N. (2016)	8. sınıf öğrencilerinin RBC+C modeline göre bilgi oluşturma süreçlerinin incelenmesi: Doğrusal denklemler örneği	Paper
44	Boz, B., ve Akgün, Ç. (2016)	Fonksiyon dönüşümleri üzerine bir inceleme: APOS teorisi	Paper
45	Gürbüz, M.Ç., ve Altun, M. (2016)	Değişken kavramını soyutlamaya yönelik ders tasarımı	Paper
46	Arslan, Z., Sönmez, N., ve Arslan, S. (2017)	Öğretmen adaylarının küresel düzlemde üçgen oluşturma sürecinin RBC soyutlama teorisi ışığında incelenmesi	Paper
47	Onkun Özgür, E., ve Yenilmez, K. (2018)	İlköğretim altıncı sınıf öğrencilerinin negatif tam sayılar kavramının oluşturma ve pekiştirme süreçlerinin RBC+C modeline göre incelenmesi	Paper
48	Kılıçoğlu, E., ve Kaplan, A. (2019)	Ortaokul 7.sınıf öğrencilerinin matematiksel soyutlama süreçlerinin incelenmesi	Paper
49	Akarsu Yakar, E., ve Yılmaz, S. (2019)	Üstün yetenekli bir 5.sınıf öğrencisinin Pisagor Teoremi'ne dair matematiksel düşünme gelişim aşamları	Paper
50	Yücel, A., ve Narlı, S. (2019)	Matematik dersinde ortaokul ve lise öğrencilerinin soyutlama seviyesini indirgemelerinin incelenmesi	Paper

Appendix 3

Bartın University Journal of Faculty of Education
The Ethical Issues Declaration Form For Authors

Article Title	Content Analysis of Research on Processes of Constructing Knowledge in Mathematics Education in Turkey
Discipline	Education
Type of Article	Research Article
Year of Data Collection	2019

As the author of the article, I declare in this form that scientific and ethical rules are followed in this article and that the article does not require the permission of ethical committee for the reason that this study is based on document analysis.

May 7, 2020

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