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The Thematic and Methodological Tendency of the Articles Conducted with Teachers and Pre-Service Teachers about GeoGebra in Turkey: A Content Analysis[1]

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Abstract: Within the scope of the competencies that teacher candidates and teachers should have, the importance of using technology and being able to integrate technology into their lessons are increasing day by day. In this study, the articles, published in the field of mathematics education about GeoGebra and conducted with teachers and pre-service teachers in Turkey, are aimed to analyze both thematically and methodologically. By selecting a total of 54 articles, published between 2010-2020, were analyzed by content analysis method with purposeful sampling method. The articles were analyzed under seven headings: mathematical topic, genre, year of publication, method, sample profile, data collection tool, and data analysis method. When the findings were examined, it was clear that the articles, examined, were published mostly in 2016. In addition, it was observed that there are more studies designed within a specific mathematical subject, for example, geometry (triangles and Pythagoras), then mostly in the fields of mathematics courses at the university such as Calculus 1. On the other hand, while the case study method was preferred among the qualitative research approaches, the most used data collection tool was the interview. It was determined that the pre-service teachers composed of the majority group of the sample.

Keywords: *Dynamic software, GeoGebra, Teacher, Pre-service teachers, Content analysis.*

1. INTRODUCTION

The objective of mathematics education is to train individuals who know the meaning of mathematics, who have the necessary mathematical knowledge to adapt to the developing world, and who are experts in using advanced technology (Ersoy, 2003). In this regard, the role of the teacher, one of the basic elements of the learning-teaching process, is of great importance (Üredi, 2006). The quality and effectiveness of education are directly proportional to the

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qualifications of the teacher. In addition to these qualities, it is emphasized that teachers integrate their lessons with technology in order to train individuals of the information society. Contemporary qualifications are commonly referred to as general culture, subject matter knowledge and pedagogical knowledge in the related literature (Çetin, 2001). Besides, technological knowledge is considered among the ideal teacher qualifications (Baki & Çelik, 2005; Gündüz & Odabaşı, 2004; Koehler & Mishra, 2005; NCTM, 2000). One of the main issues in terms of raising mathematics teachers is to educate them to use technology effectively during teaching process (Kokol-Voljc, 2007). Beyond the ability to use technological tools, the use of technology in the field of mathematics depends upon its integration with mathematics pedagogy (Erdoğan, 2010; Öksüz et. al., 2009).

The National Council of Mathematics Teachers has promoted technology integration in mathematics classrooms since the early 1980s (Stoilescu, 2011). The last century opened new gates for numerous innovations in terms of development and accessibility to technology integration in mathematics education (Koyuncu, Akyüz & Çakıroğlu, 2015), and mathematics software changed and evolved (Hall & Chamblee, 2013). The increase in the availability of technologies that can be used in mathematics classrooms has provided new opportunities for its use in mathematics education (Fahlgren & Brunström, 2014). The Movement of Enhancing Opportunities and Improving Technology (FATİH Project) was put into practice by the Ministry of National Education (MoNE) in 2010. This comprehensive project has provided full complements to teachers, students and classes (MoNE, 2013). The use of information and communication technologies for each lesson, especially math due to its structure, has gained a special importance.

Two significant software tools can be used during the learning process of the mathematics lesson. These are; computer algebra systems (CAS) and dynamic geometry software (DGS). CAS includes those that can provide precise results by performing operations with numbers, symbols, algebraic expressions and algebraic objects. Maple and Derive are the samples of CAS software. DGS, on the other hand, can visually present geometric structures and the relationships between these structures. In addition, these software offer an opportunity to move the structure, drag and measure the shapes. Software programs such as Cabri and Sketchpad are the examples of DGS. In the early 2000s, GeoGebra software was designed to present both CAS and DGS features together (Hohenwarter & Jones, 2007). Since this software combines two different structures and offers it together, its designer expressed it in a separate category as dynamic mathematics software (Doğan, 2013; Hohenwarter & Jones, 2007; Hohenwarter & Lavicza, 2007).

2. LITERATURE REVIEW

There has been a remarkable increase in the number of studies conducted on GeoGebra in Turkey in recent years. Thus, there is a need for content analysis studies that will provide a bird's-eye view towards the studies on GeoGebra so far. The relevant literature includes some studies conducted on GeoGebra and meta synthesis. The studies examined the effect of dynamic geometry software on students' geometry and mathematics achievement (Günhan & Açan, 2016; Kaya & Öçal, 2018; Kaya, 2017), technology-supported mathematics education

in terms of demographic information, keywords and methodology (Aldemir & Tatar 2014; Tatar, Kağızmanlı & Akkaya, 2013), methodological dimensions and general trends (Göktaş et. al., 2012). In addition, studies were published on both thematic and methodological analyzes of the postgraduate theses on GeoGebra in mathematics education in Turkey (Kök, Dalgıç & Şahin, 2012; Şimşek & Yaşar, 2019), along with the theses conducted with computer aided mathematics teaching (CAMT) in national literature (Bayram, 2019; Kutluca, Hacıömeroğlu & Gündüz, 2016; Tabuk et. al., 2018; Tabuk, 2019).

The significance of using and integrating technology into the lessons increases day by day. This has aroused an interest in GeoGebra, which is the dynamic mathematics software that has become popular recently. This trend has also led to an increase in publications. However, as mentioned above, no content analysis study was published on analyzing both the thematic and methodological effects of the articles conducted with teachers and pre-service teachers regarding GeoGebra in the field of mathematics education in Turkey in recent years. Therefore, in this study, the articles, published in the field of mathematics education about GeoGebra and conducted with teachers and pre-service teachers in Turkey, are aimed to analyze both thematically and methodologically. The methods, designs, sample profiles, data collection tools and data analysis methods were methodologically analyzed. Thus, this study aims to present the current trend of the articles about GeoGebra with a systematic approach. The similarities and differences of the studies were revealed and the current situation was depicted for the researchers. Besides, this study is expected to both provide a more effective literature and guide the researchers who will study on GeoGebra. Moreover, the study will contribute to the original design of the studies related to GeoGebra.

Within the scope of this study, answers to the following questions were sought;
1. What are the general thematic characteristics of the articles about GeoGebra in the field of mathematics education in Turkey?
a. What objectives are aimed to be achieved?
b. Which math subjects are preferred?
c. What is their distribution by year?
2. What are the general methodological characteristics of the articles about GeoGebra in the field of mathematics education in Turkey?
a. What are the research designs?
b. What are the sample profiles like?
c. Which data collection tools are used?
d. What are the data analysis methods?

3. METHODOLOGY

3.1. Study Design

The main purpose of the content analysis is to reveal the trends, deficiencies, gaps and backlogs in this field. Therefore, articles were analyzed through a descriptive approach. The design of this study was content analysis in general and descriptive content analysis in particular. This

study used content analysis as a research method rather than a data analysis technique. Content analysis is a research technique which is used to draw systematic and unbiased conclusions from certain characters defined in the text (Stone et. al., 1966).

This study was carried out in three stages. In the first stage, the decision was taken according to which criteria the articles would be selected. Thus, the keywords were determined for literature review. The second stage was carried out in databases. In the third stage, the elicited studies were analyzed according to the research problems. These stages were explained in detail in the following sections.

3.2. Data Collection and Inclusion Criteria

A total of 54 articles were found in the Google Academic search engine, DergiPark and TR Index (year 2010-2020) databases. All of these articles are Turkish, 5 of them were worked teachers and 49 of them worked with pre-service teachers. The following criteria were taken into account while selecting the articles for this study:

• The articles must be conducted with teachers and pre-service teachers,

• The GeoGebra software must be used

• The manuscripts must be published as articles in the journal.

After the identification of these criteria, a preliminary literature review was conducted to determine the keywords. Accordingly, the following keywords were determined for the main search.

• GeoGebra

• GeoGebra and teacher

• GeoGebra and pre-service teacher

• Dynamic geometry/math software

• TPACK (Technological and Pedagogical Content Knowledge)

• Computer algebra systems

• Computer-aided mathematics teaching/training

• Dynamic math/geometry environment

In addition, two criteria were identified as such: The sample must be selected from Turkey and the studies must be conducted by Turkish researchers. Those that were unavailable for access were not included in the study.

3.3. Data Analysis

Content analysis is one of the methods used in cases where written and visual data density is high among the qualitative data analysis types (Silverman, 2001). This method aims to find

appropriate concepts and relationships to explain the obtained data (Yıldırım & Şimşek, 2011). For this purpose, with a deductive approach, the data was examined and certain possible categories were created and transferred to the computer environment. For this, each study was coded as A1,A2,A3, …, A54. The articles were presented in tables in accordance with the sub-problems. Only frequencies were depicted in the tables statistically. After a general explanation specified under each table, the remarkable results were expressed in detail. In this way, it was tried to reveal the connections between the data. In addition, the researchers encoded the data for a second time over a three-month period, contributing to the reliability of the study.

4. FINDINGS

4.1. The Thematic General Characteristics of the Articles Related to GeoGebra in Mathematics Education in Turkey

4.1.1. Themes Covered in the Articles

The aims and the problem statements of the studies were examined in order to determine the themes of the articles regarding GeoGebra. The focus of each study was identified. This focus was the main research topic that the articles aimed to reveal as a whole. Considering these identified focal points, the articles were organized in four different themes. These were: (1) GeoGebra's effect on different variables, (2) Examination of different topics through GeoGebra, (3) Activity/worksheet/learning environment design with GeoGebra, and (4) Views on GeoGebra (Table 1).

Table 1. *Themes Covered in the Articles*

Themes		**f**	**Article Codes**
Effect of GeoGebra on different variables	Achievement	5	A10*, A15, A37, A40*, A53
	Learning	1	A4
	Anxiety	1	A13
	Self - Efficacy	1	A48
	Motivation	1	A20
	Types of Thinking	1	A11*
Examination of different topics with GeoGebra	Mathematical modeling	7	A31, A32, A33, A34, A35, A 44, A45
	Problem solving / posing	3	A12*,A43*,A50
	Mathematical Communication	1	A7
	Visual Literacy	1	A36
	TPCK **	6	A3, A16, A18, A19, A21, A54
	RSGS ***	1	A14
	Instructional Technologies	2	A42, A49*
	Experimental and theoretical modeling	2	A46,A47
Learning environment design with GeoGebra		18	A1, A2, A5, A6*, A22, A23, A24, A25, A26, A27, A28, A29, A30, A38, A39*, A40*, A41*, A51*
Views on GeoGebra		11	A6*,A8, A9,A10*.A11*,A17,A39*,A43*,A49*, A51*,A52

* These articles are based on more than one theme.

** Technological Pedagogical Content Knowledge

*** Reasoning Skill on Geometric Shapes

Table 1 depicts that the articles mostly examined different topics through GeoGebra. These were followed by the learning environment design with GeoGebra. The effect of GeoGebra on different variables was the least preferred one compared to other themes. Only 10 articles were constructed on this theme. The articles within this category mostly investigated the effect on achievement. Furthermore, the effects of GeoGebra-aided instruction on deductive, inductive and inferential reasoning skills (A11) were analyzed. The most studied areas with respect to the GeoGebra perspective were determined as mathematical modelling, technological pedagogical content knowledge and problem solving/posing. On the other, the least studied areas were instructional technologies, experimental-theoretical modelling, and reasoning skills on geometric shapes, mathematical communication and visual literacy.

4.1.2. The Preferred Mathematics Subjects in Articles

Upon analyzing the articles regarding GeoGebra in terms of math subjects, the studies were divided into four categories, the first of which was the studies carried out on the axis of a specific mathematical subject. The second was those that were not designed around a specific mathematical subject, the third included the studies that were designed around a theorem, and the fourth involved those that were carried out within the framework of problem posing in mathematical modeling. 32 studies were available in the first category, 10 in the second category, 2 in the third category and 10 in the fourth category. There are also university mathematics learning areas and subjects that are carried out on the axis of a certain mathematics subject. Table 2 and Table 3 displays the selected mathematics topics.

Table 2. The *Selected Middle School and High School Math Topics in Articles*

	f	**Subjects**	**f**	**Article Codes**
Numbers and Algebra	17	Exponential and root numbers	2	A1,A17
		Definite integral	2	A1, A9
		Derivative	3	A1, A5, A9
		Functions and graphics	4	A2, A5, A24, A30
		Algebraic expressions and identities	4	A5, A9, A17, A19
		Sets	1	A19
		Integers	1	A1
Geometry	45	Transformation geometry	3	A17, A23, A36
		Plane geometry	4	A1, A27, A37, A55
		Geometric solid	3	A1, A17, A37
		Analytical geometry	4	A7, A9, A10, A11
		Circle and circular region	5	A1, A5, A7, A12, A55
		Quadrangles and polygons	6	A5, A6, A9, A17, A19, A48
		Lines and angles	2	A6, A17
		Triangles and Pythagorean relation	11	A1, A2, A4, A5, A7, A9, A12, A19,A36, A37, A48
		Geometric locus	4	A21, A24, A25, A26
		Trigonometry and slope	3	A1, A5, A9
Counting and Probability	1	Combination	1	A5

Table 3. The *Selected University Math Topics in Articles*

	f	Subjects	f	Article Codes
Calculus 1	11	Limit and continuity	4	A29, A40,A52,A54
		Function and extremum point	2	A39, A49
		Derivative	3	A29, A49, A54
		Integral	2	A29,A54
Calculus 2	7	Trigonometric and exponential functions	4	A7, A9, A49, A54
		Convergence of Series	1	A20
		Riemann Sum	2	A7,A9
Analytical Geometry	4	Plane Geometry	4	A22,A26,A43,A49
Linear Algebra	1	Systems of Linear Equations	1	A15

As seen in Table 2, the articles were noted to mostly prefer subjects from the field of learning geometry. The most studied subject in the field of learning geometry was determined as triangles and the Pythagorean relation. On the contrary, the least studied was lines and angles. 17 articles were prepared for the numbers and algebra learning area. The most preferred subjects were function-graphics and algebraic expression-identity.

As seen in the university math topics in Table 3 Calculus 1, Calculus 2, Analytical Geometry and Linear Algebra were examined through GeoGebra within the scope of the courses pre-service teachers received. These studies were included in these articles (A7, A9, A15, A20, A22, A26, A29, A39, A40, A43, A49, A52, A54).

Table 4 shows articles that have not been made by selecting any mathematical topic or are not limited to a single topic.

Table 4. The *Studies That Are Not İntended to Teach Any Mathematical Topic*

	f	Article Codes
Studies Not Designed around a Specific Mathematical Subject	10	A3, A8, A14, A16, A18, A28, A38, A41, A42, A45
Studies Designed around a Particular Theorem	2	A13,A53
Studies Carried out within the Framework of Problem Posing in Mathematical Modeling	10	A31, A32, A33, A34, A35, A36, A44, A46, A47,A50

As seen in Table 4, 10 studies (A3, A8, A14, A16, A18, A28, A38, A41, A42, A45) did not intend to teach a specific mathematics subject. 2 studies (A13,A53) were designed around a theorem. These studies were designed with theorems such as Calculus Level theorem, Varignon Theorem, Van Aubel and Rolle. In addition, 10 studies (A31, A32, A33, A34, A35, A36, A44, A46, A47, A50) were carried out within the framework of problem posing in mathematical modeling. The article coded as A50 analyzed free structured problem posing situations.

4.1.3. Publishing Years of Articles

The distribution of articles by year are presented in Figure 1.

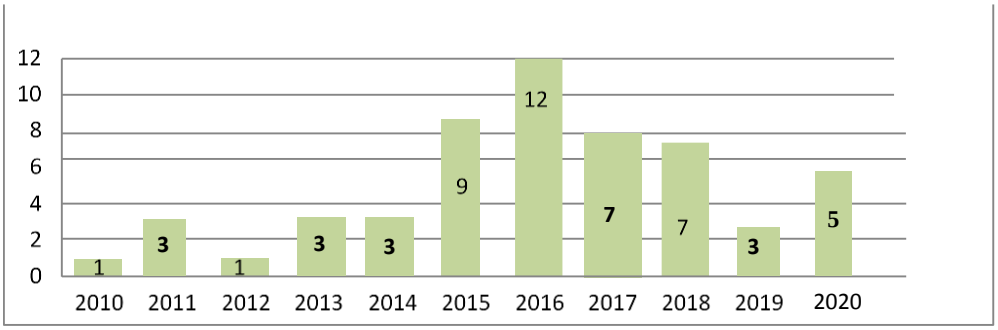

Figure 1. *Distribution of GeoGebra-Related Articles by Year*

Despite a fluctuation in Figure 1, there has been an increase in the number of studies since 2015. This increase mostly emerged in 2016. However, a decrease was observed in 2019.

4.2. The Methodological General Characteristics of the Articles Related to GeoGebra in Mathematics Education in Turkey

This section covers information regarding the design, sample profiles, data collection tools and data analysis techniques of GeoGebra related articles.

4.2.1. The Design of the Articles

The articles about GeoGebra were analyzed according to research methods, and they were divided into three categories as qualitative, quantitative and mixed method. Table 5 shows the distribution of the articles.

Table 5. *Research Methods and Designs of the Articles*

Research Methods	f	Research Patterns	f	Article Codes
Quantitative	9	Experimental	9	A3,A14*,A15*, A18, A20, A29, A36, A37, A40
Qualitative	40	Case study	34	A1, A2, A4,* A5, A6*, A7*,A8, A9, A11, A12, A17, A19, A21, A22, A26, A27, A28, A30, A31, A32, A33,A35,A39,A41,A42,A43*,A44,A46,A47,A48,A49,A50,A52,A54
		Creating a theory	1	A34
		Action research	3	A23, A24, A25
		Unspecified	2	A45, A51
Mixed	4	Grounded theory	2	A10, A53
		Experimental + action research	2	A13,A38

The article coded A16 was not analyzed as it was designed as a special pattern.
The articles coded A14* and A15* are the examples of quasi-experimental studies within experimental studies. A4*, A6*, A7*, A43* coded articles were designed as single case studies, and A50* as holistic multiple case studies.

Having analyzed the articles according to research methods, they were identified to mostly use case study design, one of the qualitative research methods. Accordingly, the articles coded A4, A6, A7, A43 used the single case design, while A50 holistic multiple case design. In addition, 9 articles utilized the experimental method, one of the quantitative research methods. However, mixed research method was preferred less than other research methods. The number of articles were found to be equal (2) in grounded theory and experimental/action research designs. The design of the study coded A16 was a part of the TUBITAK project, aiming to develop a program with a view to providing secondary school mathematics candidates with TPCK (Technological Pedagogical Content Knowledge). The program developed within the scope of the project was shaped by the TPCK theoretical framework. Therefore, it was not included in the analysis methodically since it was determined as a special method of its own.

4.2.2. Sample Profiles in Articles

When the articles related to GeoGebra were analyzed within the context of the sample profile, two different categories emerged as in Table 6.

Table 6. *Sample Profiles in Articles*

Sample Profiles	**f**	**Type**	**f**	**Article Codes**
Teacher	5	Elementary mathematics	3	A17,A27,A38
		Secondary mathematics	2	A30,A48
Pre-service teacher	49	Elementary mathematics	30	A3,A6,A7,A8,A9,A10,A11,A12,A14,A15,A16,A18,A19,A20,A21,A22,A23,A24,A25,A26,A28*,A29, A36,A40,A42,A43,A45,A46,A47,A50
		Secondary mathematics	15	A1,A2,A4,A5,A13,A31,A32,A33,A34,A35,A41,A44,A49,A52A53
		Unspecified	4	A37,A39,A51,A54

The 28* coded article included two different sample profiles both primary school pre-service mathematics teachers and instructors.

Considering the articles in terms of sample profile, pre-service teachers were mostly preferred. In the sample group formed by the pre-service teachers, more studies were conducted with the pre-service elementary mathematics teachers. Four studies were conducted with pre-service mathematics teachers, yet no information was presented about its type. 5 articles were carried out with the teachers.

4.2.3. Data Collection Tools Used in Articles

Table 7 suggests six different categories in terms of data collection tools.

Table 7. *Data Collection Tools in Articles*

Data Collection Tools	f	Type	f	Article Codes
Test	13	Achievement Test	6	A10*,A15,A20*,A29*,A37*,A41*
		Other tests	7	A4*, A14*, A29*, A39, A40, A43*, A54*
Scales	5			A13, A20*, A3*, A18, A36
Interview	24	Structured	2	A2, A37*
		Semi-Structured	11	A4*, A12, A17, A21*, A22*, A26*, A28*, A30*, A42, A43*, A48*
		Focus-Group	6	A10*, A28*, A43*, A45, A46*, A47*
		Task-Based	1	A11*
		Unspecified	4	A24*, A27, A38*, A41*
Questionnaire	13			A1*, A3*, A4*, A5, A7, A8, A9, A13*, A16, A38*, A51, A52, A53
Observation	9			A11*, A19*, A22*, A27*, A32*, A33*, A34*, A35*, A48*, A49*
Document	22			A1*,A6,A21*,A22*,A23,A24*,A25,A26*,A30*,A31* A32*,A33*,A34*,A35*,A41*,A44, A46*, A47*, A48*, A49*,A50, A54

* These articles were built on more than one data collection tool.

The articles using more than one data collection tool were coded separately. As is seen in Table 7, most of the articles deployed more than one data collection tool together. The analysis results showed that the interview was mostly used as a tool in the articles. The articles employed four types of interview techniques such as structured (2), semi-structured (11), focus-group (6) and task-based (1). Four articles did not specify the type of interview technique. Other tests in the Tests category were found to include GeoGebra Constructions Comparison Test, Reasoning Skills on Geometric Shapes Test, Readiness Test, Topological Concepts Achievement Test, Basic Geometry Constructions Test and Derivative Applications Knowledge Test. Following the interview tool, the most used data collection tools were noted as document (22), questionnaire (13), test (13), observation (9) and scale (5) respectively. The analysis results indicated that the articles used various data collection tools such as written answer sheets, worksheets, output, field-screen notes, reflective thinking reports, audio-video documents, etc. These data collection techniques were categorized as documents, and that they were the most

used data collection tools apart from the interview. 13 survey data were found and these surveys were mostly the opinion form, information form and open-ended questions.

4.2.4. Data Analysis Techniques in Articles

Table 8 depicts the emerging categories related to the analysis of the articles in terms of data analysis techniques.

Table 8. *Data Analysis Techniques Used in Articles*

Data Analysis Methods		**f**	**Article Codes**
Quantitative descriptive		22	A3*, A4*, A8*, A13, A14, A18*, A19, A20*, A26, A29*, A33, A36*, A37*, A38, A39, A40*, A42*, A48*, A49*, A50, A52*, A53*
Quantitative predictive	t-test	9	A3*,A13*, A14*, A18*, A20*, A29*, A36*, A37*, A40*,
	Kolmogrov Smirnov	3	A20*, A29*, A40*
	Mann Whitney U	2	A15, A20*
	Shapiro Wilk	5	A3*, A14*, A20*, A37*, A53*
	Wilcoxon	2	A13*, A20*
	Multiple Regression	1	A8*
Qualitative	Content Analysis	32	A1, A2, A4*, A5*, A6, A7, A8*, A9*, A10*, A13*, A17, A18*, A21*, A22, A26*, A27, A28*, A30, A31, A32, A35, A41, A42*, A43, A44, A45, A46, A47, A48*, A49*, A52*, A53*
	Descriptive Analysis	14	A4*, A5*, A9*, A10*, A11, A12, A19*, A38, A39, A49*, A51, A52*, A53*, A54
	Continuous Comparative Analysis	5	A19*, A23, A24, A33*, A34
	Other	3	A25, A50, A54*

* These articles are based upon multiple data analysis methods.

As observed in Table 8, the articles mostly used more than one data analysis techniques together. 22 of the articles analyzed the data through use of one or all of the quantitative descriptive data analysis techniques such as frequency, percentage, mean, standard deviation, etc. t-test (9) was the most preferred analysis among the quantitative predictive data analysis techniques. This was followed by Shapiro Wilk (5) and Kolmogrov Smirnov (3) tests, respectively. Of all the qualitative data analysis techniques, content analysis (32) was used the most, which was followed by descriptive analysis. Besides, continuous comparative analysis method was used in theory building articles coded A19, A23, A24, A33, A34.

Different analysis methods were used in those in the other category of qualitative data analysis method. The data belonging to the A25 coded article were analyzed according to the REACT (Relating, Experiencing, Applying, Cooperating, Transferring) strategy, which is a contextual teaching approach. The article coded A50 used the Square Analysis Method developed by Karadağ (2009) during his doctoral study for the analysis of screen recordings containing the posing problems identified by pre-service teachers. In the article coded A54, the elicited data were analyzed through the theoretical framework of TPCK leveling by Bowers and Stephens (2011).

5. RESULTS AND DISCUSSION

When the aim and problem statements of the articles related to GeoGebra were analyzed, the majority of the articles were conducted to examine different subjects with GeoGebra. The category with the highest number was mathematical modeling. In fact, as stated by Ang (2010), this may be due to the fact that technological software provides a rich environment for examining the behavior and trends of mathematical models during the solution process. In particular, different software not only supports different stages of the modeling and problem solving process but it also allows students to better understand mathematical situations and experience different ways of thinking by enabling multiple representations (numerical, algebraic, graphic) (MoNE, 2013).

The study results also suggested that different subjects were preferred in the fields of geometry, numbers, algebra and mathematics learning at the university. In addition, some studies were carried out on the problem posing process in mathematical modeling and around certain theorems without the purpose of teaching mathematics. However, the findings demonstrated that the geometry learning field was preferred more than other fields. The contribution of the GeoGebra software to the linking process between algebra and geometry in this process may be the reason for more studies in the field of geometry. In addition, the relevant literature includes studies examining the derivative applications in general and maximum-minimum problems, mean value, Fermat and Rolle Theorems in particular by using the GeoGebra software effectively. This supports the general view that GeoGebra has become usable from primary education to higher education as an open source dynamic mathematics software that brings geometry, algebra and calculus to a single interface (Hohenwarter & Lavicza, 2007).

The majority of the articles aimed to determine the views on learning environment design and GeoGebra, and thus qualitative research methods were mostly used. The method of a study varies across the subject and aim of that study (Karasar, 2006). Similar results emerged in another study conducted on analyzing technology-aided mathematics education research in Turkey. Tatar, Kağızmanlı and Akkaya (2013) analyzed 54 articles and found that 9 of them used quantitative research, 40 qualitative and 4 used mixed research method. It may be wise to mention that qualitative research method is preferred more than quantitative and mixed research methods in GeoGebra supported mathematics education studies. When the articles about GeoGebra were examined methodologically, the researchers did not write the data analysis method (A25, A50, A54) in detail. However, the accuracy, credibility and

reproducibility of the results are closely related to the detailed methodological presentation of the study (Karasar, 2006).

Taking the sample profile into account, the majority of the articles were conducted with the pre-service teachers. This may arise from the fact that pre-service teachers play a key role in integrating technology into the learning environment. Pre-service teachers can relearn and deepen their previous knowledge by making sense of it through GeoGebra (Tatar, 2013). The improvement of physical conditions in learning environments alone is not sufficient for technology-aided teaching. In order for an effective technology-aided teaching, the teacher's technological pedagogical content knowledge, in which technology, pedagogy and content knowledge are combined, must be at a sufficient level (Koehler & Mishra, 2008).

6. RECOMMENDATIONS

Studies examining the effectiveness of GeoGebra in different learning areas such as measurement, data processing, Calculus I / II, analytical geometry may be increased. Above all, it should not be forgotten that the teacher is one of the significant factors in the effective use of technology in the classroom (NCTM 2000). Therefore, the issue of what can be done for teachers to use technology effectively has become increasingly important in recent years (ISTE, 2008). Because teachers' positive attitudes and impressions about a technology may not be enough to easily integrate that technology into their lessons (Wu, Hsu & Hwang, 2008). GeoGebra has a great potential to instill technology-oriented pedagogical methods in raising mathematics teachers (Hall & Chamblee, 2013). Thus, this study recommends to increase the number of studies conducted with primary and secondary school teachers. Otherwise, studies using quantitative and mixed methods should be designed.

7. ABOUT THE AUTHORS

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8. References

*Aldemir R. & Tatar, E. (2014). An analysis of articles on technology assisted mathematics *education. Bartın University Journal of Faculty of Education, 3*(1), 298-319.

Ang, K. C. (2010). Teaching and learning mathematical modeling with technology. W. Yang, M. Majewski, T. always and W. P. Hew (Eds.), *Proceedings of the fifteenth Asian Conference on technology in mathematics* (ss. 1-11). US.

Baki, A. & Çelik, D. (2005). Opinions of mathematics teachers about the adaptation of graphical calculators to mathematics courses. *The Turkish Online Journal of Educational Technology (TOJET), 4*(4), 146-162.

*Bayram, G-M. (2019). *Analyses of the theses studied on mathematics education published between the years of 2008-2018 in the context of computer aided mathematics teaching.* Master's thesis, Bayburt University, Institute of Education, Mathematics Education, Bayburt.

*Cantürk-Günhan, B. & Açan, H. (2016). The effect of using dynamic geometry software on success of geometry: A meta-analysis study. *Turkish Journal of computer and mathematical education, 7*(1), 1-23.

Çetin, Ş. (2001). A study of the ideal teacher. *Journal of National Education*, 149.

Doğan, M. (2013). A dynamic mathematics software: GeoGebra. M. Doğan & E. Karakırık (Eds.) *The use of technology in mathematics education*, (p. 125-195). Ankara: Nobel-Atlas.

Erdogan, A. (2010). Variables that affect math teacher candidates' intentions to integrate computer-assisted mathematics education (CAME). *Education, 131*(2), 295-305.

Ersoy, Y. (2003). Mathematics education supported by technology-I: Developments, policies and strategies. *Elementary Online, 2*(1), 18-27.

Fahlgren, M. & Brunström, M. (2014). A model for task design with focus on exploration, explanation, and generalization in a dynamic geometry environment. *Technology, Knowledge and Learning, 19*(3), 287-315.

Galbraith, P., Stillman, G., Brown, J. & Edwards I. (2007). Facilitating middle secondary modelling competencies. C. Haines, P. Galbraith, W. Blum, S. Khan (Eds), *Mathematical Modelling: ICTMA 12: Education, Engineering an Economics*, (ss. 130-140). Chichester, Horwood Publishing.

*Göktaş, Y., Küçük, S., Aydemir, M., Telli, E., Arpacık, Ö., Yıldırım, G. & Reisoğlu İ. (2012). Educational technology research trends in Turkey: A content analysis of the 2000-2009 decade. *Educational Sciences: Theory & Practice, 12*(1), 177-199.

Gündüz, Ş. & Odabaşı, F. (2004). The importance of instructıonal technologıes and materıal development course at pre-servıce teacher educatıon in informatıon age. *Turkish Journal of online educational technologies, 3*(1), 43-48.

*Gündüz, S. & Kutluca, T. (2019). A meta-analysis study on the effect of the use of smart board in the teaching of mathematics and science to students' academic achievements. *Journal of Computer and Education Research, 7*(13), 183-204.

*Gürsoy, K. (2017). *The effect of the computer-aided mathematic teaching on the academic achievement and attitude toward math courses: A meta-analysis and meta-synthesis study*. PhD

Thesis, Karadeniz Technical University, Institute of Educational Sciences, Department of Mathematics Education, Trabzon.

Hall, J. & Chamblee, G. (2013). Teaching algebra and geometry with GeoGebra: Preparing pre-service teachers for middle grades/secondary mathematics classrooms. *Computers in the Schools*, *30*(1- 2), 12-29.

Hohenwarter, M., & Jones, K. (2007). Ways of linking geometry and algebra: The case of GeoGebra. *Proceedings of British Society for Research into Learning Mathematics*, *27*(3), 126-131.

Hohenwarter, M., & Lavicza, Z.(2007). Mathematics teacher development with ICT: Towards an international GeoGebra institute. *Proceedings of British Society for Research into Learning Mathematics, 27*(3), 49-54.

International Society for Technology in Education (ISTE). (2008). *National educational technology standards for teachers*, (2nd. Ed.). Eugene.

Karasar, N. (2006). *Scientific research method*. Ankara: Nobel Publication Distribution.

*Kaya, A. (2017). *The effect of GeoGebra as a dynamıc mathematıcs software on student's academıc achıevements: Meta-analysıs study*. Master's Thesis, Ağrı İbrahim Çeçen University, Graduate School of Natural and Applied Sciences, Elementary Education Department, Elementary School Mathematics Education, Ağrı.

*Kaya, A. & Öçal, M-A. (2018). A meta-analysis for the effect of GeoGebra on students' academic achievements in mathematics. *Necatibey Faculty of Education Journal of electronic Sciences and Mathematics Education, 12*(2), 31-59.

Koehler, M. J. & Mishra, P. (2005). Teachers learning technology by design. *Journal of Computing in Teacher Education. 21*(3), 94–102.

Koehler, M. J. & Mishra, P. (2008). Introducing TPCK. in AACTE committee on innovation and technology. (Ed.), *Handbook of technological pedagogical content knowledge (TPCK)*. New York: Routledge

Kokol-Voljc, V. (2007). *Use of mathematical software in pre-service teacher training: The case of DGS*. Faculty of Education, University of Maribor, Slovenia.

Koyuncu, İ., Akyuz, D. & Çakiroglu, E. (2015). Investigating plane geometry problem solving strategies of prospective mathematics teachers in technology and paper and pencil environments. *International Journal of Science and Mathematics Education, 13*(4), 837-862

*Kutluca, T., Hacıömeroğlu G., & Gündüz, S. (2016). Evaluation of basic field studies on computer assisted mathematics teaching in Turkey. *Journal of Theory and practice in Education, 12*(6), 1253-1272.

Kök, A., Dalgıç H. & Şahin İ. (2012). *Study of GeoGebra studies*. 6. International Computer and Instructional Technologies Symposium, Gaziantep University, Gaziantep.

Ministry of National Education [MoNE]. (2013). *Secondary mathematics course (9, 10, 11 and 12. classes) curriculum,* Ankara

National Council of Teachers of Mathematics [NCTM]. (2000). *Principles and standards for school mathematics*. Reston Virginia: NCTM.

Öksüz, C., Ak, Ş., & Uça, S. (2009). A perceptıon scale for technology use in the teachıng of elementary mathematıcs. *Journal of The Faculty of Education of Centenary University, 6*(1), 270-287.

Silverman, D. (2001). *Interpreting qualitative data: Methods for analysing talk, text and ınteraction*. London: SAGE Publication.

Stone, P.J, Dunphy, D.C, Marshall, S.S, & Ogilvie, D.M (1966). *The general inquirer: A computer approach to content analysis*. The M.I.T. Press, Massachusetts.

Stoilescu, D. (2011). *Technological pedagogical content knowledge: secondary school mathematics teachers' use of technology*. Doctoral dissertation, University of Toronto, Canada.

*Şimşek, N. & Yaşar, A. (2019). A thematic and methodological review of theses related to GeoGebra: A content analysis. *Turkish Journal of Computer and Mathematics Education, 10* (2), 290-313.

*Tabuk, M., Aydoğdu, A. A., Kalyoncu, A., İlter-Erten, D., Arslan, K., Kara, N. & Arslan T. (2018). Computer-assisted mathematics teaching in Turkey: Content analysis of theses and dissertations. *Mediterranean Journal of Educational Research, 12*(25), 16-38.

*Tabuk, M. (2019). Computer Assisted Mathematics Teaching in Dissertations: A Meta-Synthesis Study. *Journal of Theoretical Educational Science, 12*(2), 656-677.

Tatar, E. (2013). The effect of dynamic software on prospective mathematics teachers' perceptions regarding information and communication technology. *Australian Journal of Teacher Education, 38*(12), 1-16.

*Tatar, E., Kağızmanlı, B-T. & Akkaya, A. (2013). Content analysis of the researches on technology-assisted mathematics instructıon in Turkey. *Buca Journal of The Faculty of Education, 35*, 33-50.

Üredi, L. (2006). *Investıgatıon of primary education teachers' teaching profession perceptions wıth respect to teaching styles preference*. PhD Thesis, Marmara University Institute of Educational Sciences, Istanbul.

Wu, H.-K., Hsu, Y. S., & Hwang, F. K. (2008). Factors affecting teachers' adoption of technology in classrooms: Does school size matter? *International Journal of Science and Mathematics Education, 6*(1), 63-85.

Yıldırım, A. ve Şimşek, H. (2011). Qualitative research methods in social sciences. Ankara: Seçkin.Publishing.

(*These articles are used in content analysis)