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Examination of Action Research Articles in the Field of Mathematics Education in Türkiye

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Abstract

This study aims to analyze articles containing action research in the field of mathematics education in Türkiye and present them from a holistic perspective. For this purpose, action research articles published between 2007 and 2022 were reviewed in ERIC, Google Scholar, and ULAKBİM databases. Fifty-seven articles were reached due to the review and constitute the research sample. Document review, one of the qualitative research methods, was used. Articles are classified according to the year of publication, publication language, research model, subject, action research type, whether the cycle is specified or not, application period, researcher role, learning areas, study group and size, sampling method, data collection tools, validity and reliability, and data analysis methods. As a result of the research, it was seen that the qualitative research model was mainly used. The studies were primarily conducted with undergraduate students. While geometry is the most preferred learning area, it has mainly been studied in technology-supported learning environments. Interviews and observations were mainly used in data collection, expert evaluation was taken to ensure validity and reliability, and coder agreement was checked. Content analysis, one of the most qualitative techniques, was used to analyze the data obtained. Based on the research results, it is recommended that mixed-pattern action research be conducted and that the number of studies involving students at different education levels and learning areas be increased.

Keywords: Mathematics Education, Action Research, Descriptive Content Analysis.

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Türkiye'de Matematik Eğitimi Alanında Yapılan Eylem Araştırması Makalelerinin İncelenmesi

Özet

Bu araştırmada Türkiye'de matematik eğitimi alanında eylem araştırmalarını içeren makaleleri analiz etmek ve bütüncül bir bakış açısı ile sunmak amaçlanmıştır. Bu amaç doğrultusunda 2007-2022 yılları arasında yayınlanan eylem araştırması makaleleri ERIC, Google Akademik ve ULAKBİM veri tabanlarında taranmıştır. Yapılan tarama sonucunda ulaşılan 57 makale araştırmanın örneklemini oluşturmaktadır. Araştırmada nitel araştırma yöntemlerinden biri olan doküman incelemesi kullanılmıştır. Makaleler yayınlandığı yıl, yayın dili, araştırma modeli, konusu, eylem araştırması türü, döngünün belirtilip belirtilmemesi, uygulama süresi, araştırmacı rolü, öğrenme alanları, çalışma grubu ve büyüklüğü, örnekleme yöntemi, veri toplama araçları, geçerlik ve güvenirlik, veri analiz yöntemleri çerçevesinde sınıflandırılmıştır. Araştırma sonucunda en çok nitel araştırma modelinin kullanıldığı görülmüştür. Çalışmalar en fazla lisans öğrencileri ile yürütülmüştür. Geometri en çok tercih edilen öğrenme alanı iken çoğunlukla teknoloji destekli öğrenme ortamları konusunda çalışılmıştır. Verilerin toplanmasında en çok görüşme ve gözlemlerden faydalanılmış, geçerlik ve güvenirliği sağlamak için uzman değerlendirmesi alınmış ve kodlayıcılar arası uyuşuma bakılmıştır. Elde edilen verilerin analizinde en çok nitel analiz tekniklerinden içerik analizi kullanılmıştır. Yapılan araştırmanın sonuçlarından yola çıkarak karma desenli eylem araştırmalarının yapılması, farklı öğretim kademesindeki öğrenciler ile farklı öğrenme alanlarını içeren çalışma sayısının arttırılması önerilmektedir.

Anahtar Kelimeler: Matematik Eğitimi, Eylem Araştırması, Betimsel İçerik Analizi.

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1. Introduction

Kurt Lewin is often referred to as the father of action research because he emphasizes involving real practitioners at all stages of research conducted within the social sciences (McKernan, 1991). However, evidence suggests that some social reformists preceding Lewin also used action research (Lewin, 1946; McKernan, 1991), and Jacob L. Moreno (1892–1974) is the true originator of action research (Altrichter & Gstettner, 1993; Gunz, 1996). Despite these uncertainties in its origins, action research has been accepted in the field of social sciences and has been used as a research model by many researchers.

Action research typically begins with defining a problem, assessing the effectiveness of efforts to solve this problem, and taking action to solve it again, depending on the situation (O'Brien, 2001). Action research, which provides an understanding of a problem that has arisen or will arise during the implementation process, is also defined as a research approach that includes deliberately collecting and analyzing data to solve the problem (Yıldırım & Şimşek, 2013). Thus, it aims to change the practices of practitioners, their understanding of their practices, and the conditions under which they practice (Kemmis, 2009). In this respect, action research, which is a type of research conducted by a person or persons that helps find a solution to the current situation (Beverly, 1993), is also expressed by many other names such as (a) participatory research, (b) collaborative inquiry, (c) emancipatory research, (d) action learning, and (e) contextual action research (O'Brien, 2001).

Studies are ongoing to produce effective solutions to problems encountered in the classroom or school environment. These studies are sometimes conducted on teachers and administrators and sometimes on students. However, these studies need to be more comprehensive, and teachers themselves need to research them (Stenhouse, 1975). These studies to be conducted by teachers should be based on critical and scientific foundations (Carr & Kemmis, 1986). Stephen Corey (1949) was one of the first researchers to use action research in the field of education, considering the need for educators to participate in research and practice (Kemmis, 1980). The reasons for conducting action research in the field of education were addressed by Johnson (1995) in three categories: (a) to promote personal and professional development, (b) to develop practice to improve student learning, and (c) to advance the teaching profession. For this reason, action research will contribute to the school, the teachers who are practitioners, and the

education process in terms of personal, practice, and evaluation (Çalışkan & Serçe, 2018). Since teachers also take on the role of researchers in this process, action research is also expressed in the literature with terms such as teacher research or classroom research (Mertler, 2021).

Action research is typically a cyclical process (Mertler, 2021). In this context, action research can be used for actions or cycles of actions that group members in a specific environment have taken to address a problem in a specific situation (Herr & Anderson, 2015). McNiff and Whitehead (2010) express the steps of a cycle as observing, reflecting, applying, evaluating, organizing, and moving toward new directions. Mertler (2021) states that when a cycle consisting of the planning, implementation, development, and reflection steps ends, the next cycle begins according to the evaluation made.

The method may vary in action research depending on the researcher's choice (Dickens & Watkins, 1999). Accordingly, qualitative and quantitative analysis methods can be used to analyze the data collected during the research process (Hendricks, 2006). When the studies conducted in the field of education in Türkiye are examined, action research is the least used research method (Göktaş et al., 2012; Karatay & Taş, 2021; Selçuk et al., 2014). In addition, the action research method is less preferred in content analysis studies in the field of mathematics education (Dağ & Horzum, 2022; Ertane et al., 2021; Özey, 2019; Şimşek & Yaşar, 2019; Toptaş & Kuşdemir, 2021). In this direction, it is important to attract the interest of mathematics education researchers, especially teacher researchers, in action research and encourage them.

There are content analysis studies examining doctoral dissertations (Turhan Türkkan et al., 2019) and articles (Çalışkan & Serçe, 2018) containing action research in the field of educational sciences in Türkiye. However, no study has been found examining action research articles in mathematics education. For this reason, examining action research articles published in mathematics education can contribute to the source of action research, determining existing deficiencies and needs and shedding light on future studies. In this context, the study aims to examine action research articles conducted in mathematics education in the Turkish sample and present them holistically. In line with this purpose, the following questions were tried to be answered:

How are action research articles in mathematics education distributed according to;

1. the years they were published?
2. the languages they were published in?

3. research designs?
4. the types of research (quantitative, qualitative, mixed)?
5. whether cycles are specified in action research?
6. the main topics they address?
7. the learning areas they focus on?
8. the participants?
9. the size of the participants?
10. the sampling methods used?
11. the duration of the research?
12. the roles of the researchers?
13. the data collection tools?
14. validity and reliability processes?
15. the data analysis methods used?

2. Method

In this study, document analysis, one of the qualitative research methods, was used to examine action research articles in mathematics education. The document analysis method allows the analysis of various documents such as books, newspaper articles, academic journal articles, and institutional reports (Morgan, 2022). In alignment with the research objective, the study focuses on academic articles.

2.1. Determining the Studies to be examined

To determine the study sample, ERIC (Education Resources Information Center), Google Scholar Database, and National Academic Network and Information Center Database were scanned for one month from 01.05.2022 to 01.06.2022. During the scan, the keywords "eylem araştırması," "aksiyon araştırması", "matematik eğitimi" (in Turkish), "action research", and "mathematics education" were scanned throughout the text. The articles included in the study were determined through criterion sampling, one of the purposive sampling methods. The following criteria were taken into consideration in determining the studies to be included in the study:

- the sample being in Türkiye,
- being an article published in a scientific journal,
- being conducted in the field of mathematics education and
- including action research as a method

In the context of the criteria, articles between 2007 and 2022 were reviewed using keywords. As a result of the scan, 57 articles determined to meet the criteria (see Appendix 1) were examined within the scope of the study.

2.2. Data Collection Process

The document analysis method was used in the data collection process. Document analysis is the process of collecting and reviewing written materials containing information on the topic under investigation, such as official notes, minutes, records, and archival documents. This type of analysis is carried out in five stages: (i) accessing the documents, (ii) checking their originality, (iii) understanding the documents, (iv) analyzing the data, and (v) using the data (Yıldırım & Şimşek, 2016). The research began by reviewing action research articles published in mathematics education between 2007 and 2022. The information on the 57 articles reached was recorded in the Microsoft Excel program by the items in the Classification Form of Action Research Articles Conducted in the Field of Mathematics Education (see Appendix 2). This form primarily aims to determine the year each article was published, the language of publication, its subject, and the learning field it is related to. In addition to these, the method of the study, which action research types were preferred, whether the action research cycle was specified, the size of the study group, the participants, and the sampling method were also examined. In addition, the classification form included data collection tools, the application process, data analysis techniques, validity and reliability, and the role of the researcher. Thus, the data were made ready for the analysis process.

2.3. Data Analysis

The study data were analyzed using descriptive content analysis. The descriptive content analysis method means the in-depth examination and organization of qualitative and quantitative studies conducted independently on a specific subject or field (Ültay et al., 2021). The steps given in Figure 1 were followed in the analysis of the data (Yıldırım & Şimşek, 2016).

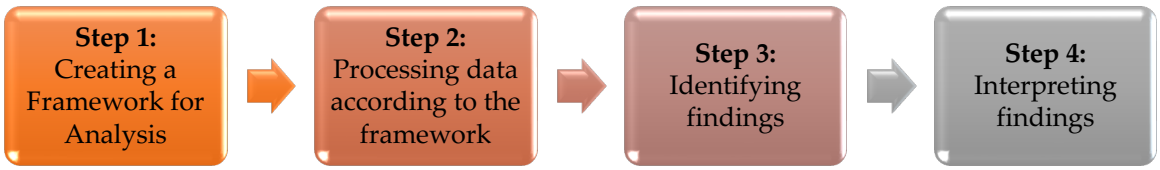

Figure 1. Descriptive Content Analysis Implementation Steps

During the analysis process, the studies included in the research were coded separately by two different coders, and then the codes were compared. The inconsistent parts were discussed, and a common opinion was reached, thus supporting the reliability of the research. The themes created as a result of the coding were presented using tables. The findings were presented in tables by calculating frequencies and percentages.

3. Result

Action research articles conducted in the field of mathematics education in Türkiye have been examined within specific categories, and a general framework has been presented in this section. In this context, the distribution of the studies according to the years they were published is given in Table 1.

Table 1.

Distribution of Articles by Year

Year	f	%
2007	1	1,75
2008	1	1,75
2009	1	1,75
2013	2	3,50
2014	2	3,50
2015	4	7,02
2016	8	14,04
2017	5	8,78
2018	7	12,29
2019	9	15,79
2020	8	14,04
2021	6	10,53
2022	3	5,26

When the distribution of articles by year is examined, there are 57 articles related to action research conducted in the field of mathematics education in our country between 2007-2022. While there were no action research articles in mathematics education in 2010, 2011, and 2012, most of them were published in 2019. The distribution of the action research articles in question according to publication language is presented in Table 2.

Table 2.

Distribution of Articles by Publication Language

Publication Language	**f**	**%**
Turkish	54	94,74
English	3	5,26

It is seen that 54 of the action research articles conducted in Türkiye in the field of mathematics education were published in Turkish and 3 in English. The research topics of these articles were also examined, and the resulting categories are presented in Table 3.

Table 3.

Distribution of Articles by Subject

Subject	f	%
Technology-supported learning environments	14	24,58
Mathematical modeling	8	14,04
Teacher training and professional development	7	12,29
Overcoming student difficulties	6	10,53
Material usage	3	5,26
STEM applications	2	3,50
Concept cartoon-supported learning	2	3,50
Lesson design based on the 5E teaching model	2	3,50
Proof teaching	2	3,50
Other	11	19,30

In mathematics education, action research has been primarily conducted to examine technology-supported learning environments (f=14). The articles on this subject investigated learning environments where software such as GeoGebra, Cabri Geometry, and BCS and technological tools such as interactive e-books, interactive boards, and tablet PCs were used. In addition, studies on mathematical modeling (f=8), teacher education and professional development (f=7), and overcoming student difficulties (f=6) were studied more than other subjects. Two studies were included in the categories of STEM applications, concept cartoon-supported teaching, lesson design based on the 5E teaching model, and proof teaching. In the other category, there were studies on topics such as the flipped classroom model, realistic mathematics education, multiple intelligence theory, mathematical literacy, and mathematical habits of mind. Since there was only one study on these topics, they were included in the other category. Action research articles on mathematics education were also examined according to learning areas (see Table 4).

Table 4.

Distribution of Articles by Learning Areas

Learning areas	f	%
Geometry	13	22,81
Numbers and operations	10	17,54
Numbers and algebra	7	12,29
Analytical geometry	5	8,78
Algebra	3	5,26
Calculus	2	3,50
Statistics and probability	1	1,75
Other	16	28,07

According to Table 4, action research articles in mathematics education are most frequently conducted in the field of geometry (f=13). Action research studies were also conducted in the learning areas of numbers and operations (f=10), numbers and algebra (f=7), analytic geometry (f=5), algebra (f=3), and calculus (f=2). The least number of studies were conducted in the learning area of statistics and probability (f=1). In 14 studies in the category of other, no learning area was selected due to the research subject (STEM, modeling, implementation of professional development program, realistic mathematics education, mathematical literacy, use of materials, etc.). The two studies examined were included in the other category because they included all fifth-grade learning areas. The distribution of action research articles in mathematics education according to the research model is presented in Table 5.

Table 5.

Distribution of Articles by Research Model

Research model	f	%
Qualitative	54	94,74
Mixed	2	3,50

It is seen that 94.74% of the articles used the qualitative research method. The number of articles using the mixed method was two (3.50%). However, action research articles were only found in which the quantitative method was used. The research method needed to be clearly stated in one of the articles. The type of action research in the articles examined within the scope of this study was also examined, and the findings are presented in Table 6.

Table 6.

Distribution of Articles by Action Research Types

Action research types	f	%
Not specified	49	86,00
Technical/scientific/collaborative action research	2	3,50
Participatory action research	2	3,50
Practical action research	2	3,50
Classical and individual action Research	1	1,75
Collaborative action research	1	1,75

The type of action research was not specified in 49 articles (86%). In contrast, the type of action research was mentioned in 8 studies. Two articles were published in technical/scientific/collaborative action research, participatory action research, and practical action research. In addition, classical and individual action research and collaborative action research types were used in one article. While the action research cycle was specified in some of these action research articles conducted in mathematics education, it was not specified in others. In this context, the findings regarding the status of action research cycles in the articles are presented in Table 7.

Table 7.

Distribution of Articles by Action Research Cycle

Action research cycle	f	%
Specified	37	64,91
Unspecified/ Undetermined	20	35,09

In 37 reviewed studies, the action research phases, or action plans, were included, and the research cycle was detailed. In 20 studies, the action research cycle was not included. In these studies, the data collection or implementation process was generally explained, but no information was given about the phases of the research or the action plans implemented. Action research articles conducted in mathematics education were also examined according to the study group, and their distribution is presented in Table 8.

Table 8.

Distribution of Articles by Study Group

Study group	f	%
Student	50	87,72
Elementary school students	3	
Middle school students	17	
High school students	7	
Undergraduate students	22	
Vocational school students	1	
Teacher and student	5	8,78
Mathematics teacher	2	3,50

It was determined that 50 articles (87.72%) were studied with students. These articles were studied with primary school, secondary school, high school students, undergraduate students, and vocational school students. It was determined that most studies were conducted with undergraduate students among these student groups. While five articles were studied with teacher and student groups, only two were studied with high school mathematics teachers. The findings regarding the number of people studied from these study groups are presented in Table 9.

Table 9.

Distribution of Articles by Number of People

Number of people	f	%
1-10 people	9	15,79
11-20 people	13	22,81
21-30 people	8	14,04
31-40 people	13	22,81
41-50 people	6	10,53
51-60 people	4	7,02
61-70 people	2	3,50
71-80 people	1	1,75
Unspecified	1	1,75

The number of participants in the study was coded in groups of ten. Nine articles were determined for the study group with 1-10 participants, eight articles for 21-30 participants, six articles for 41-50 participants, 13 articles for 11-20 participants and 31-40 participants. No study was found where the number of participants in the study group was over 80. However, the sample size was not specified in one study. The sampling method used in action research

articles conducted in mathematics education was also examined. In this context, the distribution of articles according to the sampling method is presented in Table 10.

Table 10.

Distribution of Articles by Sampling Method

Sampling method	f	%
Purposive sampling	24	42,11
Criterion sampling	10	
Convenience sampling	5	
Typical sampling	2	
Maximum variation sampling	2	
Convenience sampling and maximum variation sampling	1	
Unspecified	4	
Convenience sampling	1	1,75
Unspecified	32	56,14

In the articles on action research in mathematics education conducted in our country, the study group is determined using the purposeful sampling method (45.11%). Among the articles where the purposeful sampling method was used, the criterion sampling method was used the most, and the methods of easy-to-reach situation sampling, typical situation sampling, and maximum variation sampling were preferred, respectively. In the four articles where the purposeful sampling method was used, it was not stated which sampling type was used. In 32 of the 57 articles examined (56.14%), no explanation was made regarding the sampling method. The data collection tools used in the action research articles conducted in mathematics education were also examined. As a result of this examination, different data collection tools were used (Table 11).

Table 11.

Distribution of Articles by Data Collection Tools

Data collection tools	f	%
Interviews	32	26,45
Observations	25	20,67
Open-ended questions	15	12,4
Diaries	14	11,57
Worksheets	9	7,44
Tests/Scales	8	6,62
Readiness test	2	
Holistic and analytical thinking scale	1	
Proof test	1	
Mathematical estimation ability level test,	1	
Algebraic reasoning and mathematical reasoning assessment tool	1	
Van Hiele geometric thinking level test	1	
Mathematical literacy test	1	
Project and performance tasks	4	3,3
Activities	4	3,3
Homework	2	1,65
Scenarios	2	1,65
Solution papers	2	1,65
Multiple choice questions	2	1,65
Screen printouts	2	1,65

Interviews (f=32) and observations (f=25) were the articles' most commonly used data collection tools. In most of these articles, video and audio recordings obtained by recording the interviews and observations were also used as data collection tools. Studies were also conducted, and data were collected with open-ended questions, diaries, and worksheets. Data were collected using various tests or scales in eight articles. In addition, project and performance tasks, activities, homework, scenarios, solution papers, multiple choice questions, and screen printouts are among the data collection tools of articles conducted using the action research method in mathematics education.

The implementation periods of action research articles conducted in the field of mathematics education were also considered within the scope of the research. Since these periods were mainly expressed every week, categories were created as weeks (Table 12). However, studies whose implementation periods were specified as course periods, course hours, months, or hours were considered in the other category.

Table 12.

Distribution of Articles by Implementation Duration

Implementation duration	f	%
1-4 weeks	11	19,30
5-9 weeks	9	15,79
10-14 weeks	9	15,79
15-19 weeks	2	3,50
Unspecified	7	12,29
Other	19	33,33

When action research articles conducted in mathematics education were examined in terms of the implementation period, it was seen that the week with the least percentage was 15-19 weeks, and the implementation period with the most percentage was other.

The techniques used in data analysis in action research articles conducted in mathematics education were examined. The analyses were carried out in the context of the types of qualitative and quantitative analysis techniques. In this direction, the distribution of the articles according to data analysis techniques is presented in Table 13.

Table 13.

Distribution of Articles by Data Analysis Techniques

Data analysis techniques	f	%
Qualitative analysis techniques	47	73,43
Content	23	
Descriptive	15	
Unspecified	7	
Other	2	
Quantitative analysis techniques	12	18,75
Frequency/percentage	7	
t-test	3	
Mean/ss	1	
z-test	1	
Qualitative and quantitative data analysis techniques	2	3,13
Unspecified	3	4,69

In some of the action research in mathematics education, qualitative and quantitative analysis techniques were used simultaneously. 73.43% of the articles used qualitative data analysis. The most commonly used qualitative data analysis technique was content analysis, while descriptive analysis was used second. Quantitative data analysis was used in 18.75% of the studies, and frequency-percentage calculations were used the most. The data technique used

was not specified in 4.69% of the studies, and it was determined that both qualitative and quantitative data analysis techniques were used together in two studies.

The validity and reliability measures of action research articles conducted in mathematics education were examined. In this context, the distribution of articles according to validity and reliability measures is presented in Table 14.

Table 14.

Distribution of Articles by Validity and Reliability

Validity and reliability	f	%
Expert opinion	35	31,82
Intercoder agreement	22	20
Pilot application	18	16,36
Method variation	13	11,81
Participant confirmation	3	2,73
Content validity	3	2,73
Construct validity	1	0,91
Reliability coefficient	4	3,64
Kuder-Richardson 20 (KR-20)	2	
Cronbach alpha	1	
Unspecified	1	
Unspecified	11	10

According to Table 14, expert evaluation (f=35) was mainly used, and intercoder agreement (f=22) was examined to ensure validity and reliability in the studies. In addition, validity and reliability measures were taken for the articles using the pilot application, method variation, participant confirmation, or reliability coefficient calculation methods such as KR-20 and Cronbach alpha. In 11 articles, no explanation was made regarding the validity and reliability of studies.

The role of researchers in action research articles conducted in mathematics education was also determined. In this context, the distribution of articles according to the role of the researcher is presented in Table 15.

Table 15.

Distribution of Articles by Role of the Researcher

Role of the researcher	f	%
Teacher	26	45,63
Academician	10	17,54
Observer	1	1,75
Teacher-academician	1	1,75
Unspecified	19	33,33

In almost half of the action research articles (45.63%), the researcher was also a teacher. In 10 articles, the role of the researcher was undertaken by an academic. In 19 of the articles examined, the role of the researcher was not specified.

4. Discussion and Conclusion

This study aims to provide a comprehensive perspective on mathematics education by examining 57 action research articles published in Türkiye between 2007 and 2022. Fifty-four of these articles were published in Turkish and 3 in English. In this context, it is recommended that the number of English studies be increased to contribute to the international field and the contribution made to Turkish literature. Action research articles published in mathematics education were published at least in 2007, 2008, and 2009, and a significant increase was observed in the number of studies in 2016, 2019, and 2020. Similarly, Turhan Türkkan et al. (2019) concluded that the number of studies on action research has increased in the last five years in their content analysis in the field of educational sciences.

This study found that most action research articles in mathematics education use qualitative research methods, while very few use mixed methods. It can be said that this situation is because action research is primarily one of the qualitative research methods (Ferrance, 2000; Kuzu, 2009; Yıldırım & Şimşek, 2016). Similarly, it has been determined that most studies do not specify the type of action research. Çalışkan and Serçe (2018) also found that the type of information is generally not specified in action research articles in the field of education conducted in our country. However, clearly stating the type of action research can support the comprehensibility of the research.

Although the cycle, stage, or action plans of the research are specified in most of the action research studies conducted, some studies need to be clearly specified. In these studies, the data

collection or implementation process is explained, but no information is given about the stages of the research or the action plans implemented. Considering that action research progresses in a particular cycle, clearly stating the action plans to be implemented in each cycle can help other researchers in their implementation.

When action research is examined according to their subjects, most studies are on technology-supported learning environments. In addition, geometry is the field studied the most compared to other learning areas. This situation may be due to the transformation of learning environments from traditional learning environments to new learning environments equipped with technology in recent years and the widespread use of dynamic geometry software. In addition, many studies in the field of mathematics education have stated that most studies are on the geometry learning field (Topuz & Cantürk Günhan, 2021; Yücedağ, 2010). The least studied learning area is seen as statistics and probability. Studies on different learning areas of mathematics, such as statistics and probability, can be conducted, and the deficiencies in the literature can be eliminated.

It was determined that the articles examined within the scope of the study mostly worked with students and that students from all levels except preschool students were included in the study groups. The undergraduate level was the most preferred in these studies. Similarly, Turhan Türkkan et al. (2019) stated that they mostly worked with undergraduate-level students in their content analysis of action research. Considering that preschool education is the fastest development of children and dramatically affects the following periods (Karaoğlu & Çoban Esen, 2019), increasing the number of studies conducted with preschool-level students can contribute to the literature.

When the findings regarding the sample size are examined, the number of participants in the studies conducted is low. This situation is likely because almost all the articles examined are qualitative. More than one data collection tool was used in most articles examined. Among these tools, interviews were used the most. The most preferred data collection tool after the interview was observation. In order to ensure validity and reliability in the studies conducted, expert evaluation was mostly made, and agreement between the coders was applied. Similar findings were also reached in content analyses conducted on action research (Çalışkan & Serçe, 2018; Turhan Türkkan et al., 2019). When the distribution of articles according to data analysis

methods was examined, content analysis, one of the qualitative analysis techniques, was used the most. It can be said that this situation is because the data collection tools used are primarily interviews and observations. Hendricks (2006) also stated that in action research studies, data were analyzed through techniques such as descriptive analysis, content analysis, and inductive analysis.

The following suggestions are made for future research based on the results of the study:

• In addition to qualitative research designs, action research with mixed patterns can be conducted.

• The quality of research can be increased by clearly stating the type of action research, the research cycle, including action plans, the role of the researcher, the sampling method, and the implementation period.

• Research involving students at different education levels and learning areas can be multiplied.

• Different data collection tools and data analysis methods can be used to ensure data diversity. Future studies and articles examining theses conducted with action research may contribute to the literature by expanding the scope of the research.

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Appendixes

Appendix 1. Year, Author and Title Information of the Articles Reviewed

Year	Authors	Title
2007	İsmail Özgür Zembat	The main tenets of direct instruction and constructivism: The Case of Translations
2008	İ. Elif Yetkin Özdemir	Prospective elementary teachers' cognitive skills on using manipulatives in teaching mathematics
2009	Nilüfer Yavuzsoy Köse, Aynur Özdağ	How do the fifth-grade primary school students determine the line of symmetry in various geometrical shapes using Cabri Geometry software?

2013	Tamer Kutluca, M. Faysal Akın	Teaching of mathematics with concrete materials: Qualitative study on using four-quadrant algebraic scales
	Sabri Sidekli, Yasin Gökbulut, Nail Sayar	How to improve the number operations skills
2014	Ayten Pınar Bal, Ahmet Doğanay	Mathematical modelling skills of primary teacher candidates: the practising of fermi problems
	Berna Tataroğlu Taşdan, Adem Çelik	A professional development program prototype towards mathematics teachers
2015	Ali Delice, Gökhan Karaaslan	Investigation of the effects of the dynamic geometry software tasks on students' performance: Lineer equations
	Berna Tataroğlu Taşdan, Adem Çelik	Development of mathematics teachers' knowledge of representations towards function concept
	Ayşe Tekin Dede, Süha Yılmaz	How can the 6th grade students' modelling competencies be developed?
	Güler Tuluk	The evaluation of the concept maps created by future middle school mathematics teachers in regard to the concept of angle
2016	Ebru Aylar, Yeter Şahiner	An analysis of seventh-grade students' proof skills and preferences
	Serdal Baltacı, Adnan Baki	An investigation of the use of the dynamic mathematics software in teaching the translation and rotation transformations in terms of contextual learning
	Bahattin İnam, Işıkhan Uğurel	The difficulties towards proof comprehension tests in a teaching implication and the ways that interfere the process
	Fatma Canan Göksu, Necla Köksal	Teaching the lines, angles and polygons according to constructivism supported by concept cartoons
	Tamer Kutluca, İlhami Bulut, Zülküf Kılıç	An analysis of students' views about the usability of multiple intelligence theory: linear equations and coordinate system
	Bengüsu Uğur, Selin Urhan, Selay Arkün Kocadere	Teaching geometric objects with dynamic geometry software
	Çiğdem Tekin Aytaş, Işıkhan Uğurel	The effects of an instruction practice based on the writing activities on students' learnings in a mathematics class
	Tuba Ada, Aytaç Kurtuluş	Determination of the relative positions of three planes: Action research
2017	Arzu Aydoğan Yenmez	The effects of technology on the mathematical modeling
	Elif Bahadır, İrem Demir	Analyzing of usability of transformation wheel material developed for teaching transformation geometry
	Serdal Baltacı, Adnan Baki	The role of GeoGebra software in constructing a contextual learning environment: The case of ellipse
	Suna Dağdelen, Menderes Ünal	Problems and suggestions in mathematics teaching and learning process
	Burcu Nur Baştürk Şahin, Gökhan Şahin, Menekşe Seden Tapan Broutın	Teaching the concept of prime numbers regarding to the theory of didactical situations: An action research
2018	Zeynep Aydın Aşk, Erdal Bay	Evaluation of authentic task-oriented learning processes in 7th grade mathematics (action research)

	Serdal Baltacı, Adnan Baki	The role of dynamic mathematics software in the development of contextual learning environment during teaching of the parabola concept
	Gözde İşçi, Ayten Erduran	Determination of student opinions on tablet pc use in secondary mathematics courses
	Cennet Gizem Karataş, Elif Bahadır	Analyzing of usability of algebra presentation pad material developed for teaching algebraic expressions
	Seda Özer Şanal, Yalın Kılıç Türel	Teaching "functions" with the interactive e-book developed on the arcs model: Action research
	Emine Nur Ünveren Bilgiç	Investigation of mathematical mind habits of preservice elementary mathematics teacher in problem solving
	Merve Zihar, Alper Çiltaş	An action research on the teaching of the 8th grade exponentials by mathematical modeling
2019	Ercan Atasoy, Mehmed Emre Konyalıhatipoğlu	Investigation of students' holistic and analytical thinking styles in learning environments assisted with dynamic geometry software
	Hasan Altun	Enrichment of teaching secondary mathematics education program: Action research
	Meltem Birinci, Müjgan Baki	Reflections from a secondary school mathematics teacher's professional development: Implementation the skill of noticing in teaching fractions
	Özgül Demir, Aytaç Kurtuluş	The effect of 5E learning model on 7th grade students' Van Hiele transformation geometry levels in teaching transformation geometry
	Beyza Koç, İsa Korkmaz	An action research on teaching addition and subtraction to an illiterate student with Dyscalculia
	Timur Koparan	Examination of perceptions of university students on non-Euclidean geometries and reflections from designed learning environments
	Neslihan Şahin, Ali Eraslan	Middle-school prospective mathematics teachers' opinions on the use of modeling activities at the course of mathematics applications
	Baki Şahin	The effect of the inquiry based mathematics approach on the development of the mathematical thinking processes of prospective teachers: In action research study
	Hanife Şermetoğlu, Müjgan Baki	Investigation of the rate and ratio's teaching process in the context of a mathematics teacher's noticing
2020	Taner Arabacıoğlu, Ersen Yazıcı, Deniz Özen-Ünal	Flipped classroom experiences of preservice teachers: Implications from a mathematics course
	Derya Aygün, Mihriban Hacısalihoğu Karadeniz, Suphi Önder Bütüner	Reflections of concept cartoons applications to 5th grade students' use of mathematical symbols, terms / concepts
	Elif Ertem Akbaş, Adnan Baki	Evaluation of students' learning the subject of "limit-continuity" in a computer-aided environment according to the SOLO Taxonomy: Action research
	Gülay Bozkurt, Melike Yiğit Koyunkaya	How does the level of technology usage of mathematics teacher candidates change with micro-teaching method?
	Erdem Çekmez	Examining the performances of prospective mathematics teachers in constructing the different representations of two-variable inequalities

	Zekeriya Demetgül, Adnan Baki	Reflections on instruction of inequality and absolute value in a technology-equipped classroom: An action research
	Özlem Tomooğlu, Aytaç Kurtuluş	Using the 5E model in area measurement on 6th grade students: An action research
	Mehmet İhsan Yurtyapan, Menekşe Seden Tapan-Broutın, Gül Kaleli-Yılmaz	An action research aligned with the REACT+G teaching approach: "Thales' intercept theorem"
2021	Özde Ceylan, Engin Karahan	The effects of STEM-focused mathematics applications on mathematics attitudes and knowledge of 11th grade students1
	Zeynep Çakmak Gürel, Ahmet Işık	An analysis of pre-service mathematics teachers' behavior on mathematical modeling cycle
	Ayşegül Karakaş, Rıdvan Ezentaş	Planning, implementation and evaluation of mathematical literacy education provided to seventh grade students
	Pelin Kösece, Ahmet Doğanay	An action research to improve prediction skills through realistic mathematics education
	Seyhan Paydar, Adem Doğan	An analysis of primary first grade students' readiness in natural numbers
	Muhammet Şahal, Ahmet Şükrü Özdemir	The contribution of mathematical modeling course to pre-service mathematics teachers' knowledge about the nature of mathematical modeling: An action research
2022	Zeynep Çakmak Gürel, Ahmet Işık	Applications based on atomic supported holistic approach fostering the modeling competencies of preservice mathematics teachers
	Yusuf Erkuş, Cenk Keşan	Use of video simulations to prepare pre-service mathematics teachers for technology-based mathematics teaching
	Şule Koçyiğit, Kürşat Yenilmez	Investigation of students' mathematical reasoning skills in STEM-focused teaching processes

Appendix 2. Classification Form for Action Research Articles Conducted in the Field of Mathematics Education

1. Year
2. Publication language
Turkish English
3. Subject
Technology-supported learning environments Mathematical modeling Teacher training and professional development Overcoming student difficulties Material usage STEM applications Concept cartoon-supported learning Lesson design based on the 5E teaching model Proof teaching Other
4. Learning areas
Geometry Numbers and operations Numbers and algebra

Analytical geometry
Algebra
Calculus
Statistics and probability
Other
5. Research model
Qualitative
Mixed
6. Action research types
Not specified
Technical/scientific/collaborative action research
Participatory action research
Practical action research
Classical and individual action Research
Collaborative action research
7. Action research cycle
Specified
Unspecified/ Undetermined
8. Study group
Student
Elementary school students
Middle school students
High school students
Undergraduate students
Vocational school students
Teacher and student
Mathematics teacher
9. Number of people
1-10 people
11-20 people
21-30 people
31-40 people
41-50 people
51-60 people
61-70 people
71-80 people
Unspecified
10. Sampling method
Purposive sampling
Criterion sampling
Convenience sampling
Typical sampling
Maximum variation sampling
Convenience sampling and maximum variation sampling
Unspecified
Convenience sampling
Unspecified
11. Data collection tools
Interviews
Observations
Open-ended questions

Diaries
Worksheets
Tests/Scales
Readiness test
Holistic and analytical thinking scale
Proof test
Mathematical estimation ability level test,
Algebraic reasoning and mathematical reasoning assessment tool
Van Hiele geometric thinking level test
Mathematical literacy test
Project and performance tasks
Activities
Homework
Scenarios
Solution papers
Multiple choice questions
Screen printouts
12. Implementation duration
1-4 weeks
5-9 weeks
10-14 weeks
15-19 weeks
Unspecified
Other
13. Data analysis techniques
Qualitative analysis techniques
Content
Descriptive
Unspecified
Other
Quantitative analysis techniques
Frequency/percentage
t-test
Mean/ss
z-test
Qualitative and quantitative data analysis techniques
Unspecified
14. Validity and reliability
Expert opinion
Intercoder agreement
Pilot application
Method variation
Participant confirmation
Content validity
Construct validity
Reliability coefficient
Kuder-Richardson 20 (KR-20)
Cronbach alpha
Unspecified
Unspecified
15. Role of the researcher

Teacher
Academician
Observer
Teacher-academician
Unspecified