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Thematic Analysis of Studies on Interdisciplinary Approach in Mathematics Education in Türkiye

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Abstract

This study analyses recent articles published in Türkiye on interdisciplinary approaches in mathematics education, focusing on publication trends, aims, methods, samples, data analysis techniques, findings, and recommendations to provide valuable research insights. In the study, 49 articles originating from Türkiye were searched in TR index, Google Scholar, DergiPark, Scopus and WoS databases and examined by thematic analysis method. As a result of the study, it is seen that articles have been published in the relevant field since 2005, the number of publications has been increasing since 2017, and the highest number of publications was published in 2021. When these studies were examined in terms of their aims, they generally aimed to improve students' problem solving, critical thinking and mathematical thinking skills. In terms of their aims, explanatory studies were mostly preferred according to research types. In terms of levels, intervention studies were mostly preferred according to research types. In terms of research methods, case study design from qualitative research methods was mostly preferred. The sample groups consisted mostly of secondary school students. The results of the articles analysed in this study shows that interdisciplinary approaches are an effective method to increase students' skills and attitudes in mathematics education.

Key Words

Interdisciplinary approach • Mathematics education • Thematic analysis

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Introduction

The 21st century requires individuals to collaborate across disciplines to address complex issues like global warming, epidemics, and pollution (Derin & Aydın, 2020). Interdisciplinary education is essential for preparing individuals to tackle these challenges. TÜSİAD (Turkish Industrialists' and Businessmen's Association) report on the necessity of STEM (Science, Technology, Engineering, Mathematics) in Türkiye towards 2023 states that STEM meets the expectations of the business world as well as improving the quality of education (TÜSİAD, 2017). In order to adapt to the rapidly changing and developing world, Türkiye has also emphasised the importance of interdisciplinary approach with the Ministry of National Education's The Türkiye Century Maarif Model in its curricula and included the processing of lessons with different disciplines in learning objectives (Ministry of National Education [MEB], 2024). UNESCO's sustainable development goals (UNESCO, 2017) address the dissemination of interdisciplinary practices in education as a necessity. In short, interdisciplinary approaches increase the quality of education and meet the problems of the age.

Interdisciplinary approach is the use of methods and knowledge from two or more disciplines in analysing a concept, subject or problem (Jacobs, 1989). There are various ways in which disciplines can work together. The interdisciplinary delimitation in problem solving created by Williams et al. (2016) is given in Figure 1. The steps of this classification are single discipline, multidisciplinary, interdisciplinary, transdisciplinary, and transdisciplinary, respectively.

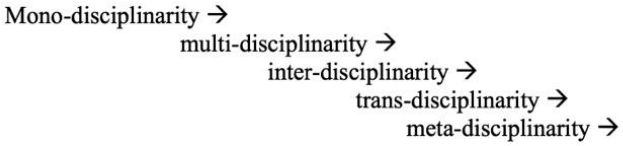

Figure 1. *Interdisciplinary classification in problem solving (Williams et al., 2016)*

The focus of this study is the interdisciplinary approach. Interdisciplinary approach is the use of two or more disciplines to solve a problem. Interdisciplinary way of working brings together two or more different disciplines in a more complex way (Kızılay, Kırmızıgül & Çevik, 2023). Williams et al. (2016) presented the visualisation in Figure 2 as creating a product by using the activity systems of two different disciplines together in the interdisciplinary approach.

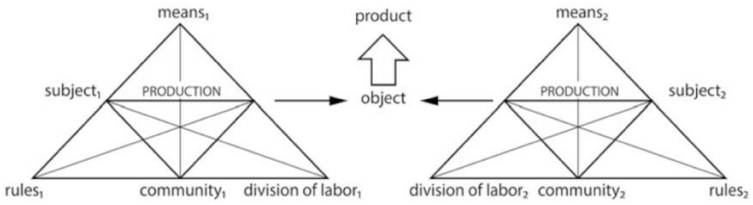

Figure 2. *Collaboration of two different activity systems in interdisciplinary projects (Williams et al., 2016)*

Interdisciplinary teaching involves integrating multiple disciplines to address a problem throughout the teaching process (Yıldırım, 1996). It combines the knowledge and methods of different fields to provide comprehensive learning experiences (Kızılay et al., 2023). This approach enables students to apply what they learn to real-life problems and develop innovative solutions. Interdisciplinary methods, especially in STEM fields, are crucial for addressing the complex challenges of modern education systems, encouraging students to adopt a multidisciplinary perspective.

Interdisciplinary education encourages students to combine knowledge from various fields to develop innovative solutions (Wang, He, Li & Zhang, 2019). It fosters a broad perspective, creative and critical thinking skills, and innovative problem-solving abilities (Yıldırım, 1996; Williams et al., 2016). Adopting such approaches can prepare individuals to tackle the complex, multidisciplinary challenges of the modern era (Coşkun & Altun, 2012).

Mathematics education stands out as a field that should be addressed in interaction with other disciplines. The nature of mathematics allows for connections with other fields (Aslan-Tutak, 2020). An interdisciplinary approach enables students to apply the knowledge and skills gained in mathematics to real-life problems (Leahey, 1999), fostering deeper understanding of mathematical concepts and enhancing problem-solving abilities by associating mathematics with other disciplines (Williams & Roth, 2016).

Interdisciplinary mathematics activities aim to develop not only mathematical process skills but also 21st-century skills such as creative, critical, and innovative thinking, literacy, productivity, and higher-order thinking (Aslan-Tutak, 2020; Bahadır & Karakuş, 2017; Çakır & Ozan, 2018; Derin & Aydın, 2020; Özkaya, Bulut & Şahin, 2023). This approach enriches students' learning processes and encourages active participation. Methods like project-based learning, problem-based learning, and mathematical modeling allow students to integrate mathematical concepts with other disciplines. Furthermore, it helps them develop mathematical thinking in diverse cultural and social contexts, enabling deeper comprehension of concepts and more effective responses to real-world problems.

Thematic Analysis and Descriptive Content Analysis

Systematic review is a research approach based on a comprehensive and detailed review of the studies conducted in a field or subject, determination of the studies to be included in the review using various selection criteria, evaluation and synthesis of the identified studies (Yılmaz, 2021). There are various types of systematic reviews. One of them is thematic analysis studies. Thematic analysis is a research method study with a qualitative approach (İnan & Uyangör, 2022). Thematic analysis involves synthesising and interpreting the research on a specific topic with a critical approach by creating themes (Çalık & Sözbilir, 2014). This process facilitates a deeper understanding of the general structure of the researched topic (Au, 2007) and the identification of priority areas from a holistic perspective. At the same time, synthesising the common and similar aspects of the studies that address the same subject from different dimensions in a qualitative way and supporting them with examples provides a valuable reference source for researchers, teachers and decision makers who do not have access to all studies (Çalık, Ayas & Ebenezer, 2005; Ültay & Çalık, 2012).

While conducting thematic analysis, the studies are analysed by descriptive content analysis method. Descriptive content analysis is a data analysis method (Yılmaz, 2021). Descriptive content analysis is the analysis of data by creating categories and codes within the framework of certain themes (Cohen, Manion & Morrison, 2007; Fraenkel, Wallen & Hyun, 2012; Silverman, 2014). This study focuses on thematic analysis research method and descriptive content analysis data analysis method.

Research Methods Theoretical Framework

Since the articles examined in this study will be analysed according to research methods and techniques, a literature review on research methods was conducted and a theoretical framework was created. When the literature is analysed, research methods are classified according to different criteria. Robson and McCartan (2011) categorise research types according to their purposes. He stated that there are three types of research types as exploratory, explanatory and descriptive. Exploratory research is research conducted to collect basic information about a new topic or problem and to create a general understanding in areas that are missing in the literature. This type of research has a flexible structure and is usually carried out with qualitative methods. The aim of the research is to generate questions and prepare the ground for hypothesis development rather than reaching definite conclusions. Data usually form theories. Explanatory research aims to understand the causes of events or situations and to reveal cause-effect relationships. In this type of research, quantitative methods are at the forefront and hypothesis testing is aimed. Data are mostly supported by statistical analyses. Descriptive research aims to take a detailed picture of an event, situation or process. It aims to understand the current situation objectively. Descriptive research, which is carried out through methods such as questionnaires, observations and analyses of existing data, provides supportive information in decision-making processes by describing events and processes in detail.

Fraenkel and Wallen (1932) classified research types according to their levels. These levels are descriptive, associational and intervention. Descriptive research is a type of research that explains a given situation (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz & Demirel, 2021). Survey, ethnographic and historical studies are usually categorised at this level. Relational studies are types of research in which possible relationships are examined. Correlation and causal comparison studies are generally classified at this level. Intervention studies are types of research in which the effects of methods or practices are examined (Büyüköztürk et al., 2021). In other words, it is expected to reach one or more results. Experimental research and action research are generally classified at this level.

Researches are divided into three methods as quantitative, qualitative and mixed methods according to the philosophy they are based on (Büyüköztürk et al., 2021). Quantitative research methods are used when generalisable studies based on statistical analyses are conducted. Qualitative research methods are preferred when it is aimed to understand the events from the perspective of the participants and when a small study group is specially studied. Mixed method studies are studies that use the advantages of both qualitative research methods and qualitative research methods (Creswell, 2017). In addition to these three research methods, there are also design-based research. Design-based research is used to create the most appropriate intervention programme to eliminate problems on a

topic (Aşık & Yılmaz, 2017). In these research methods, the design that is a solution to the problem situation is developed and applied in the research process.

The process of systematic planning and application of research methods is called research design. Quantitative research methods consist of experimental designs, survey designs, correlational (relational survey) designs. Qualitative research methods consist of grounded theory designs, ethnography designs, narrative designs, case study designs, action research designs. Mixed research methods consist of convergent parallel design, explanatory parallel design, exploratory sequential design, embedded design, transformational design, multi-stage design. Design-based research methods consist of instructional design, instructional experiment and instructional engineering designs (Büyüköztürk et al., 2021; Creswell, 2017; Arslan & Arslan, 2016).

Literature Review

A literature review was conducted on the reviews of studies on interdisciplinary approaches in mathematics education. Goos, Carreira, and Namukasa (2023) reviewed recent developments and trends in interdisciplinary STEM approaches in mathematics education. Czerniak, Weber, Sandmann, and Ahern (1999) presented a review on the integration of mathematics and science. Maass, Geiger, Ariza, and Goos (2019) presented a review on the role of mathematics in interdisciplinary STEM education. Jankvist, Rørbech, and Bremholm (2021) presented the interdisciplinary approach between mathematics and literature with thematic analysis. Becker and Park (2011) presented the effect of STEM on learning with meta-analysis method. Çınar and Çiftçi (2016) presented the content analysis of studies on interdisciplinary STEM approach. Özarslan and Özcan (2021) presented a content analysis of studies in which mathematics and science education were used together in Türkiye. Therefore, there is no research in Türkiye in which the interdisciplinary approach in mathematics education is analysed in a holistic manner.

Importance and Purpose of the Study

Studies on the interdisciplinary approach in mathematics education in Türkiye constitute an important basis for understanding the trends and practices in this field. Today, mathematics education stands out as an important part of the education system. In this context, interdisciplinary approaches offer innovative and effective methods in mathematics teaching. Examining interdisciplinary approaches in mathematics education in Türkiye requires an in-depth analysis of the literature in this field. This study aims to thematically analyse the research on interdisciplinary approaches in mathematics education in Türkiye. In line with this purpose, the research questions are given below.

(i) What are the years?
(ii) What are the aims?
(iii) What are the research types?
(iv) What are the research methods?
(v) What are the sample and sample sizes?
(vi) What are the results?
(vii) What are the recommendations?

Method

In this section, information about the research design, selection of data, ayalysis of data is given.

Research Design

In this study, thematic analysis research method, which is one of the systematic review studies, was used. The thematic analysis method is used as one of the types of content analysis (İnan & Uyangör, 2022). Thematic analysis research method involves organising the studies into themes, synthesising and interpreting the data, and comparing similar or different aspects in the results (Çalık & Sözbilir, 2014). This process facilitates a deeper understanding of the general structure of the researched topic (Au, 2007) and the identification of priority areas from a holistic perspective. With this method, the common trends of the studies are analysed in a comprehensive and interpretative way (Kabar, 2023). Thus, the studies in the related field are synthesised by examining them in a holistic way. In this study, studies on interdisciplinary approach in the field of mathematics education in Türkiye were investigated by thematic analysis method. With this method, the articles on interdisciplinary approach in mathematics education in Türkiye were analysed in a holistic manner.

Selection of Articles

In this study, studies on interdisciplinary approach in mathematics education in Türkiye were reviewed. The search was conducted in TR index, Google Scholar, DergiPark, Scopus and WoS databases on 04.12.2024. The keywords “mathematics education” AND “interdisciplinary”, “mathematics education” AND “STEM”, “mathematics education” AND “STEAM”, “matematik eğitimi” AND “disiplinler arası”, “matematik eğitimi” AND “STEM”, “matematik eğitimi” AND “STEAM”, “matematik eğitimi” AND “FeTeMM” were used. These keywords were chosen because they represent the intersection of mathematics education and interdisciplinary teaching approaches, which is the focus of this study. Both Turkish and English resources were accessed to ensure comprehensive coverage of the literature. The word ‘AND’ was included to narrow the focus specifically on interdisciplinary approaches within the field of mathematics education. STEM and STEAM approaches were included because they are well-established interdisciplinary teaching models. Additionally, in Türkiye, the term “FeTeMM” is used as the equivalent of STEM; therefore, it was added to the search keywords to ensure that all relevant local studies were included.

Studies unrelated to mathematics education were excluded to maintain the focus and relevance of the review. In addition, only journal articles were included. By limiting the search to article studies, the objective was to gather peer-reviewed, credible sources that represent the current state of research in this area. As a result of the search, 49 articles from Türkiye on the related topic were identified. This selection provides a comprehensive foundation for analysing interdisciplinary approaches in mathematics education in Türkiye.

Analysis of Articles

The articles on interdisciplinary approach in mathematics education were analysed by descriptive content analysis method. Descriptive content analysis is the analysis of data by creating categories and codes within the framework of certain themes (Cohen, Manion & Morrison, 2007; Fraenkel, Wallen & Hyun, 2012; Silverman, 2014).

With descriptive content analysis, data are examined systematically, and general trends are identified (Bellibaş, 2018). While analysing the articles, themes, categories and codes were created. Firstly, all articles were coded according to their publication years from A1 to A49. The studies were read and categorised according to their purpose, research type, research method and design, sample, sample size, results and recommendations. Themes were determined with the categories created.

Results

The findings of this study consist of the results of the descriptive content analysis of the articles on interdisciplinary approach in the field of mathematics education in Türkiye. In the findings of the study, the distribution of the articles dealing with interdisciplinary approach in terms of publication years, aims, research types, research methods and designs, samples, sample sizes, results and recommendations are presented.

Distribution of Articles by Years

Firstly, the articles on interdisciplinary approach were analysed according to the years of publication. The codes and frequencies of the analysed articles according to the years of publication are presented in Table 1.

Table 1

Distribution of articles according to years of publication

Years of Publication	f	Codes
2005	1	A1
2011	1	A2
2012	1	A3
2013	1	A4
2016	1	A5
2017	6	A6, A7, A8, A9, A10, A11
2018	5	A12, A13, A14, A15, A16
2019	4	A17, A18, A19, A20
2020	4	A21, A22, A23, A24
2021	9	A25, A26, A27, A28, A29, A30, A31, A32, A33
2022	5	A34, A35, A36, A37, A38
2023	7	A39, A40, A41, A42, A43, A44, A45
2024	4	A46, A47, A48, A49

When Table 1 is examined, the highest number of publications on the interdisciplinary approach in mathematics education was recorded in 2021, with a total of nine articles. This peak marks a significant moment in the growing scholarly interest in the field. Following 2021, the momentum continued, with seven articles published in 2023 and four in 2024, the latter likely reflecting an incomplete publication year. These figures indicate that research on the interdisciplinary approach has maintained a relatively high level of interest in recent years. In contrast, the number of publications prior to 2016 was quite low, with only four articles published between 2005 and 2015. This limited output suggests that the interdisciplinary approach had not yet gained widespread attention or integration within the

mathematics education research community in Türkiye during that period. A turning point appears in 2016, which, although marked by just a single publication, represents the beginning of a noticeable upward trend. The following years—2017 (f = 6), 2018 (f = 5), and 2019 (f = 4)—witnessed a steady increase in publication frequency. This gradual growth reflects a developing recognition of the interdisciplinary approach as both relevant and valuable within the context of mathematics education. Overall, the findings indicate that the interdisciplinary approach has transitioned from a relatively underexplored concept to a prominent and actively researched theme. The consistent rise in publications since 2016 supports the conclusion that the interdisciplinary approach has become increasingly popular and influential in mathematics education research in Türkiye.

Distribution of Articles by Aims

Articles on the interdisciplinary approach were analysed in terms of their intended objectives. Codes, categories, and purpose themes were created sequentially. Table 2 presents the distribution of the articles based on their intended aims.

Table 2

Distribution of articles according to aims of publication

Aims of Publication	Categories	f	Codes
To examine its effect on skill development	Creative problem-solving skills Problem-solving skills Reflective problem-solving skills Critical thinking skills Mathematical thinking skills Mathematical modeling competence Mathematical literacy Mathematics self-efficacy Mathematical leadership	11	A1, A2, A5, A6, A12, A23, A25, A43, A46, A47, A48
To examine its effect on teaching mathematical concepts	Data analysis Geometry Probability Factors and multiples Fractions	6	A4, A5, A6, A24, A31, A34
To examine its effect on mathematical achievement		4	A3, A12, A25, A27
To examine its effect on attitudes toward mathematics	Motivation	6	A12, A17, A18, A28, A37, A40

To analyse the process	Attitude Mathematical modeling Cognitive, affective, and behavioral	5	A7, A15, A29, A39, A48
To present a model		10	A4, A6, A8, A23, A25, A26, A34, A36, A37, A40
To identify perspectives		11	A9, A10, A14, A16, A20, A32, A35, A38, A42, A46, A47
To conduct document analysis		6	A11, A13, A19, A22, A30, A49
To analyse relationships	Mathematical achievement and problem-solving skills Mathematical achievement and attitude toward STEM Pedagogical development and STEM awareness Perception of 21st-century competencies and attitude toward STEM Computational thinking and STEM self-efficacy	4	A21, A33, A41, A44

When Table 2 is examined, it shows that the most common objectives of the articles are focused on skill development, particularly problem-solving, mathematical thinking, and critical thinking, with 11 articles addressing this aim. The second most frequent objective is presenting a model (10 articles), mainly in the context of instructional design and teaching experiments. Other common aims include exploring the impact on mathematical concepts (6 articles), attitudes toward mathematics (6 articles), and analysing the cognitive, affective, and behavioral processes involved (5 articles). However, articles examining the impact on mathematical achievement and analysing relationships between variables are less frequent, indicating these areas are not as widely researched.

Distribution of Articles by Search Type

The articles on interdisciplinary approaches have been examined according to the approach that limits the types of articles based on the objectives of Robson and McCartan (2011). When Robson and McCartan (2011) classified research types according to their objectives, they stated that there are three types of research: exploratory, explanatory, and descriptive. Therefore, three themes have been identified: exploratory, explanatory, and descriptive. The codes and frequencies of the distributions according to the research types based on the objectives of the articles are presented in 3.

Table 3

Distribution of articles according to research types based on aims of publication

Research types based on aims	f	Codes
Exploratory	5	A7, A31, A39, A41, A48
Explanatory	24	A1, A2, A3, A4, A5, A6, A12, A16, A17, A18, A19, A23, A24, A25, A27, A28, A32, A34, A37, A38, A40, A43, A46, A47
Descriptive	20	A8, A9, A10, A11, A13, A14, A15, A20, A21, A22, A26, A29, A30, A33, A35, A36, A42, A44, A45, A49

When Table 3 is examined, it shows that the majority of the studies fall under explanatory (24 articles) and descriptive (20 articles) research types, with exploratory research being relatively limited (5 articles). This indicates that most of the research aims to explain or describe phenomena related to interdisciplinary approaches in mathematics education, rather than exploring new or emerging concepts.

The articles on interdisciplinary approaches have been examined according to Fraenkel and Wallen's (1932) approach, which limits article types based on their levels. Fraenkel and Wallen (1932) classified research types into three categories: descriptive, associational and intervention. Therefore, three themes have been identified: descriptive, relational, and experimental. The codes and frequencies regarding the distribution of articles by research type are presented in Table 4.

Table 4

Distribution of articles according to research types based on levels of publication

Research types based on levels	f	Codes
Descriptive	18	A8, A9, A10, A11, A13, A14, A15, A20, A22, A26, A33, A35, A36, A39, A42, A44, A45, A49
Associational	4	A21, A29, A30, A41
Intervention	27	A1, A2, A3, A4, A5, A6, A7, A12, A16, A17, A18, A19, A23, A24, A25, A27, A28, A31, A32, A34, A37, A38, A40, A43, A46, A47, A48

When Table 4 is examined, it becomes clear that the majority of the research falls under the intervention category, with 27 articles, indicating that the focus of most studies is on experimental research, where interventions are made to examine the effects or outcomes of interdisciplinary approaches in mathematics education. Descriptive research follows with 18 articles, which typically aim to describe various aspects of the interdisciplinary approach. Associational research is the least represented, with only 4 articles, highlighting fewer studies that focus on examining relationships between variables without direct interventions. This distribution suggests that there is a strong emphasis on intervention-based research, where active experiments or interventions are conducted, followed by descriptive studies that focus on characterizing and explaining phenomena related to interdisciplinary approaches.

Distribution of Articles by Search Method

The articles on interdisciplinary approaches have been examined based on their underlying philosophy, research methods, and designs. The research methods are categorised into four themes: quantitative, qualitative, mixed, and design-based. The categories, codes, and frequencies regarding the distribution of articles by research methods and designs are presented in Table 5.

Table 5

Distribution of articles according to research methods

Research methods	Research Design	f	Codes
Quantitative	Quasi-experimental	8	A2, A3, A4, A5, A17, A18, A19, A24,
	Weak experimental	2	A1, A12
	Relational exploratory	5	A21, A33, A41, A44, A45
Qualitative	Case study	12	A6, A10, A13, A14, A15, A16, A20, A29, A32, A35, A39, A40
	Phenomenology	3	A9, A38, A42
	Document analysis	2	A11, A22
	Action research	1	A28
	Narrative	2	A30, A49
Mixed	Simultaneous	3	A23, A46, A47
	Sequential exploratory	1	A27
	Nested	2	A37, A43
Design-based	Instructional experiment	3	A7, A31, A48
	Instructional design	5	A8, A25, A26, A34, A36

When Table 5 is examined, it is clear that qualitative research methods are the most frequently employed in studies on interdisciplinary approaches in mathematics education. Case study is the most popular design within this category, with 12 articles, indicating that researchers often focus on in-depth, contextual investigations. Other qualitative designs, such as phenomenology (3 articles), document analysis (2 articles), action research (1 article), and narrative (2 articles), are used less frequently.

Quantitative research methods also feature prominently, particularly in quasi-experimental designs (8 articles), suggesting that many studies are focused on evaluating the effects of interventions. Other quantitative designs, such as weak experimental (2 articles) and relational exploratory (5 articles), are used to a lesser extent. Mixed methods research is the least used approach, with only 6 articles in total. Within this category, designs like simultaneous (3 articles), sequential exploratory (1 article), and nested (2 articles) are employed to combine qualitative and quantitative elements. Finally, in terms of design-based research, both instructional experiment (3 articles) and instructional design (5 articles) are used to a moderate extent. These designs focus on creating and testing instructional materials or strategies. In summary, qualitative methods dominate the research landscape, with case

study being the most common design, followed by quasi-experimental and instructional design approaches. Mixed methods are the least used, indicating a preference for more traditional qualitative or quantitative methods.

Distribution of Articles by Sample

The articles on interdisciplinary approaches have been examined based on their samples. The frequencies and codes regarding the distribution of articles by their samples are presented in Table 6.

Table 6

Distribution of articles according to sample

Sample	Categories	f	Codes
Teacher	Mathematics Elemantary Science	8	A9, A10, A14, A15, A20, A39, A42, A45
Pre-service Teacher	Mathematics Elemantary	9	A13, A19, A23, A35, A41, A43, A44, A46, A47
Student	Elemantary School Middle School High School	26	A1, A2, A3, A4, A5, A6, A7, A12, A14, A16, A17, A18, A21, A24, A25, A27, A28, A29, A31, A32, A33, A34, A37, A38, A40, A48
None		7	A8, A11, A22, A26, A30, A36, A49

When Table 6 is examined, it is observed that students constitute the most frequently studied sample group. In contrast, research involving teachers and pre-service teachers is more limited. Furthermore, some studies did not specify a sample, indicating a possible focus on theoretical, conceptual, or document-based analyses.

Articles on interdisciplinary approaches have been analysed based on sample size. Table 7 presents the frequency and codes related to the distribution of articles according to sample sizes.

Table 7

Distribution of articles according to sample size

Sample size	f	Codes
1-10	9	A7, A10, A14, A29, A31, A35, A38, A42, A48
11-50	22	A1, A6, A9, A13, A15, A16, A17, A18, A19, A21, A23, A24, A25, A27, A28, A34, A37, A39, A40, A43, A46, A47
51-100	7	A2, A3, A5, A12, A20, A32, A44
101-250	2	A4, A41
251-500	2	A33, A45
Yok	7	A8, A11, A22, A26, A30, A36, A49

When Table 7 is examined, it becomes evident that the most commonly used sample size in interdisciplinary research studies falls within the 11–50 participant range (f = 22). This suggests a tendency toward small-scale

studies, likely due to the nature of the research designs employed—often qualitative or quasi-experimental in format—which prioritize depth over breadth. A notable portion of studies (f = 9) utilized very small samples (1–10 participants), commonly seen in case studies, phenomenological research, or action research, where intensive data collection and individual-focused analysis are central. In contrast, studies with larger sample sizes (51–100: f = 7; 101–250: f = 2; 251–500: f = 2) were relatively few, indicating that broader generalizability has not been a primary aim in most of these works. Additionally, seven articles did not specify sample size, which likely reflects research employing document analysis, narrative inquiry, or design-based approaches where participant data was either not central or not clearly reported. These findings highlight a broader trend in interdisciplinary education research: the predominance of small, focused sample groups, aligned with exploratory and design-oriented inquiry, rather than large-scale, generalizable studies.

Distribution of Articles by Results

Articles on interdisciplinary approaches have been analysed based on their results. Themes and categories related to the results have been created. Table 8 presents the categories and codes related to the distribution of articles based on their results.

Table 8

Distribution of articles according to results

Results	Categories	f	Codes
Effective in skill development	Creative problem solving Mathematical thinking Analytical thinking Social interaction and communication Creativity Mathematical modeling Problem solving Critical thinking Reasoning Mathematical literacy Higher-order thinking Collaborative learning Mathematical leadership Reflective problem solving	14	A1, A6, A7, A10, A12, A23, A27, A29, A33, A38, A40, A43, A47, A48
Not effective in skill development	Critical thinking	1	A2
Effective in increasing success	Mathematics	6	A3, A5, A12, A24, A25, A37
Not effective in increasing success	Mathematics	1	A27

Effective in teaching mathematical concepts	Data analysis Fractions Probability Factors and multiples	6	A4, A6, A12, A24, A31, A34,
Effective in improving attitude towards mathematics	Motivation Reducing math anxiety Positive attitude	11	A5, A6, A16, A17, A20, A22, A27, A28, A39, A40, A42
Not effective in improving attitude towards mathematics	Motivation Positive attitude	4	A12, A18, A37, A38
Modelling activities are effective in presenting the interdisciplinary approach context		1	A7
Interdisciplinary mathematics activities have been designed	Art and mathematics Coins Ethnomathematics Science and origami Music and mathematics	5	A8, A25, A26, A34, A36
Readiness for interdisciplinary approaches is limited	Teachers' and prospective teachers' knowledge and skills are limited Space and materials are limited Time management is an issue The curriculum is dense Some concepts and topics are abstract Students' mathematical skills are limited The questions asked by ÖSYM are not suitable	12	A9, A10, A11, A13, A14, A15, A20, A29, A33, A39, A40, A42
Readiness for interdisciplinary approaches has increased	The knowledge and skills of prospective teachers have increased Mathematics and science success with problem-solving skills	3	A19, A35, A46
There is a relationship between the variables	Mathematics and science success, mathematics and science attitude with 21st-century skills Pedagogical development in mathematics teaching with STEM awareness	5	A21, A33, A41, A44, A45

	STEM attitude and 21st-century skills		
	Mathematics teaching and STEM self-efficacy		
	Computational thinking and STEM self-efficacy		
Interdisciplinary approach and mathematics education have been addressed from a critical perspective		2	A30, A49

When Table 8 is examined, it is evident that most studies report positive outcomes from interdisciplinary approaches in mathematics education. A large number of articles highlight their effectiveness in developing skills such as creative problem-solving, analytical thinking, reasoning, and collaboration (f = 14). Several studies also found improvements in mathematics achievement (f = 6) and positive attitudes toward mathematics, including increased motivation and reduced mathematics anxiety (f = 11). However, a few studies reported limited or no effects, especially concerning critical thinking and attitude (f = 1 and f = 4 respectively), suggesting that outcomes may vary depending on context and implementation. Some articles also focused on the design of interdisciplinary activities (e.g., combining mathematics with art, music, or science) and their potential in enriching learning experiences. On the other hand, many studies (f = 12) pointed to limited teacher and pre-service teacher readiness, citing factors such as lack of resources, abstract content, and dense curricula. A few studies (f = 3) showed that readiness improved with training. Lastly, some research established positive correlations between interdisciplinary practices and various educational variables, while a small number offered a critical perspective on their integration.

Distribution of Articles by Recommendations

Articles on interdisciplinary approaches have been analysed based on their recommendations. Themes related to the recommendations have been created. Table 9 presents the frequency and codes related to the distribution of articles based on their recommendations.

Table 9

Distribution of articles according to recommendations

Recommendations	**f**	**Codes**
Recommendations for the field of practice	44	A1, A2, A3, A4, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17, A19, A20, A21, A22, A23, A24, A25, A26, A28, A29, A30, A31, A32, A34, A35, A36, A37, A38, A39, A40, A41, A42, A43, A44, A45, A47, A48, A49
Recommendations for the field of research	32	A2, A3, A5, A6, A7, A8, A12, A13, A15, A17, A20, A21, A23, A24, A25, A27, A29, A31, A33, A34, A35, A37, A38, A39, A41, A42, A43, A44, A45, A46, A48, A49
No recommendations	1	A18

When Table 9 is examined, it is seen that nearly all studies (f = 44) offer recommendations for the field of practice, indicating a strong emphasis on improving educational implementation. In contrast, recommendations for

further research are present in fewer studies (f = 32), suggesting a relatively lower focus on advancing the research base. Only one study (A18) provided no recommendations.

Discussion, Conclusion & Suggestions

The requirements of the age we live in necessitate the use of an interdisciplinary approach in education. Given the nature of mathematics education, it is particularly important to adopt an interdisciplinary approach. Scientific studies conducted in this field are key to meeting this requirement of the age. For educators, curriculum developers, and education policymakers, these scientific studies serve as guiding resources. The scientific studies not only shed light on where we have reached but also on where we want to go. Therefore, providing a systematic compilation of scientific studies periodically becomes an important source in the literature. This study presents a thematic analysis of the articles published on the interdisciplinary approach in mathematics education in Türkiye. The findings of the study consist of a holistic and critical evaluation and compilation of the publication years, objectives, research types, research methods and designs, samples, sample sizes, results, and recommendations of the articles discussing the interdisciplinary approach.

Looking at the distribution of publication years, the first study was conducted in 2005 (Özkök, 2005). After 2016, the number of studies increased, reflecting a shift in Türkiye's perspective on interdisciplinary approaches, likely driven by the rise of STEM education and related projects. Arslan, Kızılay, and Hamasoğlu (2022) note that studies on technology integration in education began in 2015, while Altan and Bahadır (2023) highlight the rise of research on the use of EBA (Educational Informatics Network) in mathematics education from 2015 onwards. The growing integration of technology in education has facilitated cross-disciplinary connections, such as between mathematics and other fields. Notably, there was a significant rise in publications in 2021 and 2023, largely due to the increased recognition of STEM's importance in Türkiye. This trend is also reflected in TÜSİAD's (2017) report, which underscores the role of STEM fields, and UNESCO's (2017) sustainable development goals, which call for promoting interdisciplinary practices in education. The influence of the project "Design, Implementation, and Evaluation of a Learning Environment Through Mathematical Modeling: Interdisciplinary Transition" (Gürbüz, Çalık, Çelik, Doğan & Çavuş Erdem, 2019), which produced four publications between 2017-2019, likely contributed to the surge in interdisciplinary research. These developments have sparked greater interest among educators and researchers in interdisciplinary approaches, particularly in mathematics education. The Türkiye Century Maarif Model (MEB, 2024) emphasizes the importance of this approach, and it is expected that research in this area will continue to grow starting in 2024.

According to the distribution of the objectives of the articles, studies on the interdisciplinary approach generally focus on goals such as skill development and expressing opinions. In most studies, the primary goals are the development of skills such as creative thinking, problem-solving, mathematical thinking, and critical thinking (Bahadır & Karakuş, 2017; Coşkun & Altun, 2011; Çakır & Ozan, 2018; Derin & Aydın, 2020; Özkaya, Bulut & Şahin, 2023; Özkök, 2005). This indicates the potential of interdisciplinary approaches to promote innovative learning experiences. In the literature, interdisciplinary teaching is recommended to equip students with complex problem-solving, integrating different perspectives, and developing creative thinking skills (Repko, 2012). However, it has been observed that these skills are often discussed only in theoretical terms, and practical examples are limited.

Especially, skills such as creative problem-solving and mathematical thinking are considered important for students to meet the demands of the global workforce, often referred to as 21st-century skills (OECD, 2018). In this context, prioritizing creative problem-solving and critical thinking in studies is related to the pedagogical flexibility offered by interdisciplinary approaches. These methods allow students to engage in richer learning experiences by combining knowledge and methods from different disciplines rather than being limited to a single discipline. However, challenges in the application of these methods hinder the widespread adoption of the interdisciplinary approach, and further research in this area is necessary. On the other hand, the prevalence of opinion-based studies indicates that interdisciplinary practices are still considered a new pedagogical paradigm, and more research is needed to shape teachers' attitudes toward this approach. This suggests that teachers require more professional development opportunities regarding interdisciplinary teaching. Studies aimed at establishing relationships are also quite few. This may be because there has not been enough scale development in the field. The limitation of existing scales highlights the need for the development of more comprehensive tools in this area. As a result, the focus on skill development and opinion expression in the objectives of these studies suggests the need for broader and more systematic research on the adoption of interdisciplinary approaches at both pedagogical and practical levels.

Looking at the distribution of the research types based on the objectives of the articles, it is seen that most studies are explanatory and descriptive, while exploratory research is relatively limited. This limitation is likely due to the nature of exploratory research, which is more challenging to conduct compared to the other two approaches. Another reason for the limited number of exploratory studies could be the greater uncertainty and complexity in the application phase of such studies. However, exploratory research is necessary for the development of a conceptual framework or theory regarding interdisciplinary approaches in mathematics education. Regarding the level of the articles, the most common research type is intervention studies, followed by survey research, while relational research is the least common. The large number of intervention studies is important for demonstrating the applicability of this approach in education. The lack of relational studies, on the other hand, is considered a shortcoming in the field. This indicates that the interactive and interconnected outcomes of interdisciplinary approaches have been less explored, and more focus should be placed on such studies. In terms of research methods and designs, qualitative methods, particularly case study design, are more commonly used. However, the limited use of mixed methods and design-based research suggests that this field has more research potential. The limited use of mixed methods is a significant barrier to increasing methodological richness in this field (Creswell, 2017).

Examining the sample groups of the articles, it is noteworthy that the majority focus on elementary school students, while studies conducted on teacher candidates and teachers are limited. This indicates that more emphasis should be placed on teacher education and professional development in interdisciplinary approaches. More research on improving the competency of teacher candidates regarding the interdisciplinary approach is needed. The European Commission's teacher education report (European Commission, 2019) points out that professional development opportunities for teachers in interdisciplinary approaches need to be increased. When examining the sample sizes of the articles, it can be seen that the sample sizes are mostly between 11-50, with very few studies using a sample size of 100 or more. Large-scale, generalizable quantitative studies are thought to contribute significantly to the field. The TIMSS 2023 reports show that large-scale studies play a critical role in shaping

education policies and determining teaching strategies (IEA, 2023). Sample size is an important factor for the validity and reliability of studies, and larger sample sizes increase the generalizability of research findings (Creswell, 2017). The lack of large-scale studies limits the generalizability of findings in this field, and such studies are needed to expand the scope of research. Quantitative studies with sample sizes that are representative of the population are needed.

When examining the results of the articles, it is generally found that interdisciplinary approaches have a positive contribution to skill development, fostering positive attitudes, and improving mathematics achievement, but this potential has not yet been fully realized. Another result is the necessity of teacher training and professional development for the interdisciplinary approach. Therefore, it can be said that there is a need for studies focusing on teacher education.

Regarding the recommendations of the articles, those aimed at practical application are the most common. When examining the practical recommendations, it is clear that suggestions to increase the usability of the interdisciplinary approach are very popular. Although there are recommendations for researchers, these are generally not sufficiently clear. Most of the recommendations suggest conducting the same study with different groups, which is not necessarily appropriate. More specific and guiding recommendations should be provided.

This study offers recommendations for future research on interdisciplinary approaches in mathematics education. It suggests conducting instructional design studies based on The Türkiye Century Maarif Model, developing scales for interdisciplinary approaches, and creating conceptual theories in the field. Research using structural equation modeling to explain these theories, as well as relational studies, is encouraged. Professional development for teachers and teacher candidates can be explored, along with the creation of resources and textbooks for educators, students, and parents. Large-scale quantitative studies and research on strategies for effective interdisciplinary adoption are recommended. Additionally, this study can be replicated as a systematic review of international literature, and meta-analysis or meta-thematic studies on effective concepts in mathematics education can be conducted.

Ethics

I declare that the research complies with the ethical standards of the institutional and national research committee, the 1964 Declaration of Helsinki and its subsequent amendments or comparable ethical standards. Since the study was a literature review, ethics committee approval was not required.

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This article was co-authored by two authors.

Conflict of Interest

The authors declare that they have no conflict of interest.

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