NEF EFMED

Cilt 17 - Sayı 1 - Haziran 2023

Necatibey Eğitim Fakültesi

Elektronik Fen ve Matematik Eğitimi Dergisi

Necatibey Faculty of Education
Electronic Journal of Science and Mathematics Education

Volume : 17
Issue :1

Date : June 2023
ISSN : 1307-6086

NEF-EFMED (NFE-EJSME)

ISSN: 1307-6086

Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi (Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education) Internet üzerinden ücretsiz yayın yapan yılda bir cilt, en az her ciltte iki sayı olarak yayımlanan, hakemli ve online bir fen ve matematik eğitimi dergisidir. Hedef kitlesi fen ve matematik eğitimcileri, fen ve matematik eğitimi öğrencileri, öğretmenler ve eğitim sektörüne yönelik ürün ve hizmet üreten kişi ve kuruluşlardır. Dergide, bu hedef kitlenin yararlanabileceği nitelikteki bilimsel çalışmalar yayımlanır. Yayın dili İngilizcedir.

Necatibey Faculty of Education, Electronic Journal of Science and Mathematics Education is an international on-line, refereed science and mathematics education journal that is published at least two issues in a year. NFE-EJSME is firmly established as the authoritative voice in the world of science and mathematics education. It bridges the gap between research and practice, providing information, ideas and opinions. It serves as a medium for the publication of definitive research findings. Special emphasis is placed on applicable research relevant to educational practice, guided by educational realities in systems, schools, colleges and universities. The journal comprises peer-reviewed general articles, papers on innovations and developments, research reports.

All research articles in this journal have undergone rigorous peer review, based on initial editor screening and anonymized refereeing by at least two anonymous referees. NEF-EFMED is an open access journal which means all content freely available without any charge. We support the rights of users to "read, download, copy, distribute, print, search, or link to the full texts of these articles".

Editör Kurulu

Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education
Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi
Volume 17 Issue 1 June 2023 / Cilt 17 Sayı 1 Haziran 2023

CONTENTS / İÇİNDEKİLER

Önsöz

Herkese Merhabalar,

On on yedinci yılımızın ilk sayısında toplam dokuz makale yer almaktadır.

Bu sayıda katkıda bulunan gerek yazarlarımıza gerekse hakemlerimize çalışmalarından dolayı teşekkür ederiz.

Saygılarımla.

Editör

Dr. Gülcan ÖZTÜRK

Preface

Greetings to everyone,

In this edition of our journal, we have a total of nine articles related to science and mathematics education.

Thanks to everyone for contributing and/or becoming the reviewer of our journal.

Editor

Dr. Gülcan ÖZTÜRK

Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi
Cilt 17, Sayı 1, Haziran 2023, sayfa 1-25. ISSN: 1307-6086
Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education
Vol. 17, Issue 1, June 2023, pp. 1-25. ISSN: 1307-6086

Research Article

Investigation of CEIT Undergraduate Program According to Teachers' and Academicians' Views

Eyüp YÜNKÜL [1], Ahmet Melih GÜNEŞ[2]

[1] Balıkesir University, Necatibey Faculty of Education, Balıkesir, eyunkul@balikesir.edu.tr, http://orcid.org/ 0000-0002-6177-3766

[2] Balıkesir University, Necatibey Faculty of Education, Balıkesir, melihgunes@gmail.com, http://orcid.org/ 0000-0002-7484-5685

Received : 08.05.2023 Accepted : 29.06.2023

https://doi.org/10.17522/balikesirnef.1294187

Abstract – This study aims to reveal the effectiveness of the CEIT undergraduate program in line with the views of teachers and academicians. Phenomenology design, one of the qualitative research designs, was used in the study. The study group consisted of 14 individuals selected via multistage sampling. Of the participants, 8 were teachers who graduated from CEIT undergraduate program and 6 were academicians working in the CEIT program. In the study, a semi-structured interview form developed by the researcher was used as the data collection tool. The data obtained in the study were analyzed using the content analysis technique. In the study, both teachers and academics mentioned the computer class problems, insufficient class hours and lack of applied courses during the implementation of the program Regarding the distribution of the courses in the program, teachers stated that training on current software and field courses should be emphasized; academics stated that the number of field elective courses and the weekly hours of field elective courses should be increased.

Key words: CEIT program, teacher, academician

Corresponding author: Eyüp YÜNKÜL, Balıkesir University. This study was funded by Balikesir University Scientific Research Projects Unit (2022/045)

Introduction

Innovations in Information Technology (IT) in the 21st century have allowed countries to progress and have a competitive advantage. IT has changed many aspects of our lives. Considering fields such as medicine, tourism, travel management, commerce, law, banking, engineering, and architecture, the impact of IT over the last twenty or twenty-five years has been enormous. The way these fields operate and their organization is very different from the

structures and methods used in the past. These dramatic changes require societies and individuals to adapt to and keep up with innovations. In other words, the digitization of society and individuals has become an undeniable fact and all areas of life have been digitized.

Digital individuals are described as individuals with the knowledge and skills required by the information age. Digital literacy is the ability to consciously and purposefully use digital tools and resources to acquire and use information, analyze and manage information, create new ideas and products, and communicate (Martin, 2005). Digital literacy, which includes skills such as accessing information, using information, critical thinking, and problem-solving in online environments, also means exhibiting ethical behaviors in accordance with social rules. Therefore, it is important to be digitally literate to benefit from the digital world and avoid its harm.

Today, developments in technology also affect the quality of educational institutions. One of the most important roles expected from educational institutions is to raise children as individuals who use technology effectively. In our country, the work of raising digitally literate individuals required by the information age is carried out by Information Technologies Counselor Teachers (ITCTs) who are graduates of the Computer and Instructional Technologies (CEIT) program. Considering the mission they undertake, it can be said that ITCTs perform a very critical task. The establishment purpose of CEIT departments is to train "computer teachers" for primary and secondary education institutions (YÖK [Counsil of Higher Education], 1998). In other words, it is aimed to train experts who integrate information and communication technologies into educational environments and to bring them into schools. In this direction, teachers have conducted Computer, Software, and Microsoft Office courses in the relevant schools, and can also work as a Formatter teacher/IT Counselor Teacher.

It is observed that there has been a decrease in the quota of Information Technologies (IT) teachers in teacher appointments made by the Ministry of National Education in recent years (Kurtoğlu-Erden & Seferoğlu, 2015). This can be explained by the decrease in the number of compulsory courses in schools affiliated with the Ministry of National Education. In addition, the decrease in the number of appointments has also reduced interest in CEIT undergraduate programs. As a result, it can be said that the success level of the incoming student gradually decreases, which may negatively affect the coursework of the academicians working in the CEIT undergraduate program.

Similar to other departments in education faculties, the curriculum of CEIT departments has been updated and regulations have been made in vocational knowledge, content knowledge,

and general culture courses. Accordingly, new courses have been added, the contents of the courses have changed, and the weekly course numbers have been updated. In the program, vocational knowledge courses have been given more place than other courses (Meşe et al., 2014). In addition, flexibility has been provided with the elective courses in the program. A total of 4 years have passed following this change. In this direction, it is important to determine the views of academicians about the new program implemented in this process. In today's information age, it is inevitable to update the curriculum of CEIT by making various improvements in a dynamic structure (Bardakçı et al., 2017).

In studies, it has been determined that there are problems such as the lack of technical equipment required for the course and teachers having to waste time on technical work in schools within the body of the Ministry of National Education (Perkmen & Dağistanlı, 2012). Accordingly, it is also important to determine the lessons that ICT teachers conduct at schools, the problems they experience in these lessons, and the situations needing to be dealt with. The fact that there are hardly any studies examining the undergraduate CEIT program and addressing the problems experienced by ICT teachers in schools with application areas increases the importance of the study.

When the literature is examined, it is seen that the studies are mostly conducted by taking the opinions of the students. Accordingly, students have considered themselves inadequate in terms of both software and hardware knowledge (Semerci, 2012; Akgün et al., 2020). In addition, it has been shown that students' thoughts on choosing teaching as a profession are also in the foreground (Şahin et al., 2018), and students need vocational guidance services for their career planning (Ünal, 2012). Finally, it has been explained that the courses that novice teachers think will contribute the most to them while they are teaching are vocational knowledge courses (Akgün et al., 2020).

The education that teachers receive at the undergraduate level plays a key role in their professional success (Lautenbach & Heyder, 2019). Positive changes to be made in the teacher training process will minimize the negative effects of the process and content (Biesta et al., 2021). For this reason, identifying the effectiveness of CEIT undergraduate programs has constituted the starting point of this study. In this direction, the study aims to determine the effectiveness of the CEIT undergraduate program according to the views of academicians working in CEIT departments and Information Technologies teachers working in K12 schools. Therefore, it is thought that this study will provide important data in determining the effectiveness of CEIT programs in line with stakeholder views.

For this purpose, answers to the following questions are sought:

1. What are the problems experienced by the participants during the implementation of the CEIT program and what are the solution suggestions?

2. What are the views of the participants about the program meeting the interests and needs of the students?

3. What are the problems experienced by the participants during the teaching process and what are the solution suggestions?

4. What are the views and suggestions of the participants regarding the distribution of the courses in the program?

5. What are the views of the participants about the Teaching Practice course?

6. What are the views of participants about the adequacy of computer classes in their institutions?

Method

Research Design

In this study, we tried to describe the effectiveness of the CEIT program with a qualitative approach based on the views of teachers and academicians. Phenomenology, one of the qualitative research designs, was used in the data collection and interpretation stages. Phenomenology studies focus on how people perceive a phenomenon, how they describe it, how they feel about it, how they judge it, how they remember it, and how they make sense of it (Bogdan & Biklen, 1992; Patton, 2014). Van Mannen (2016) also mentioned that the experiences of individuals in phenomenological studies are both the starting point and the ending point of the study. The views and feelings of teachers and academics who were directly affected by this phenomenon were tried to be described in depth.

Participants

In phenomenological studies, data sources are individuals or groups that experience the phenomenon on which the research focuses and those who can express or reflect this phenomenon (Yıldırım & Şimşek, 2011). Criterion sampling, one of the purposeful sampling methods, was used in the selection of teachers and academicians participating in the research. In the first stage, the criterion that teachers and academicians should work for at least 5 years was adopted. In the second stage, convenience sampling, in which participants are aware of the purpose of the research and participate in the study voluntarily and willingly, and which is used

in appropriate situations in terms of time and cost (Hatch, 2002; Johnson & Christensen, 2004) was preferred. It is very important to present in-depth information about the individuals participating in the study in the convenience sampling method (Johnson & Christensen, 2004). In this study, a total of 14 people were reached, including 8 teachers who graduated from the CEIT program and 6 academicians working in the CEIT program. The seniority was between 12-18 years for the teachers participating in the study and it was between 11-28 years for the academicians.

Data collection

In qualitative research, interviews can be used alone or together with other data collection techniques (Bogdan & Biklen, 1992; Hatch, 2002). The main data collection tool of this study was determined as interviews with people who experienced this phenomenon directly. According to Rubin and Rubin (2005), in-depth interviews can be used in situations where what is wanted to be learned is not answered simply and clearly, individuals' experiences are needed, and answers to the questions asked to individuals are required. In the interviews with the participants during the research process, a semi-structured interview form developed by the researchers by scanning the relevant literature was used. The questions prepared during the determination of the questions were sent to the field experts. As a result of the feedback, some questions were deleted and some questions were merged.

Before the interview, the participants were informed about the purpose of the research and it was stated that their personal information would not be shared with third parties. To adopt the interview form approach during the interview process, the questions were asked in a mixed manner. Each interview lasted between 15-20 minutes on average.

Data Analysis

The data obtained in this study, which aims to determine the effectiveness of the CEIT program in line with the views of teachers and academicians, were analyzed using the content analysis technique. The main themes and codes were identified in the analysis of the semi-structured interviews prepared by the researchers. The interviews that were transcribed during the interview were then transferred to the computer environment, a file was created for each question, and the answers of the participants were read and coded many times. As a result, the main theme, problems, and patterns were determined. The determined themes and patterns were discussed by the researchers, and categories and main themes were reached (Miles & Huberman, 1994).

While developing the semi-structured interview form to ensure validity, a conceptual framework was created by scanning the relevant literature. The results obtained and the codes reached were constantly compared with each other, interpreted and conceptualized, and tried to reveal some patterns that even the participants of the research were not clearly aware of (Yıldırım & Şimşek, 2011). It is thought that obtaining deeply focused data in this way will contribute to the reliability of the study. In the study, it was also tried to increase the credibility of the research with "researcher triangulation" and the percentage of agreement between coders was determined as .90. In the study, the teachers were coded as Teacher 1: T1, and academicians were as Academician 1: A1.

Findings and Discussions

In this section, the answers given by the teachers and academicians to the questions in the interview form were analyzed and presented in line with the purposes of the study.

What are the problems experienced by the participants during the implementation of the CEIT program and what are the solution suggestions?

In the study, the problems experienced by the participants during the implementation of the CEIT program are given in Table 1 and Table 2 while suggestions for the solution of the problems are presented in Table 3 and Table 4.

Table 1 Teachers' views on the problems experienced during the implementation of the program

Theme	Category	Code	*(f)*
Program	Course	Insufficient class hours	2
		Lack of applied courses	2
	Material	Lack of computer at home	1
		Lack of textbooks	1
		Licensed software	1
	Physical condition	Lack of laboratory	3
		Lack of infrastructure	1
		Lack of hardware	1
		Down-level computers	1
		Crowded classrooms	1

Teachers' views on the problems experienced during the implementation of the CEIT program were gathered under the categories of "course", "material" and "physical condition" under the theme of "program". When the answers for the course category are examined, the

teachers consider the insufficient class hours and the lack of applied courses as problems. When the answers to the material category are examined, it is seen that teachers believe that not having a computer at home, lack of student textbooks, and the supply of licensed applications are the main problems. When the answers to the Physical Condition category are examined, teachers mostly see the lack of laboratories as an important problem.

The views of the teachers regarding the findings are given below.

T4 …*inability to practice on subjects that require practice due to insufficient class hours.* (Course / Insufficient class hours)

T1 … *the absence of textbooks causes chaos for students.* (Material / Lack of textbooks)

S2 … *Crowded classrooms and lack of laboratory are a problem in itself.* (Physical condition / Lack of laboratory - Crowded classrooms)

Table 2 Views of academicians about the problems experienced during the implementation of the CEIT program

Theme	Category	Code	*(f)*
Program	System	Unpopularity of the department	1
		Outdated curriculum	1
	Course	Excess of elective courses	1
		Insufficient class hours	1
		Lack of applied courses	1

When the views of the academicians about the problems experienced during the implementation of the CEIT program are explored, the answers given by the academicians are clustered under the categories of "system" and "course" within the theme of "program". When the answers for the system category are examined, the academicians believe that the department's not being preferred by students and the curriculum's not being updated as problems. When the answers for the course category are investigated, the academicians consider the excess of elective courses, the insufficient class hours, and the lack of applied courses as the main problems.

The views of the academicians regarding the findings are given below.

A3 … *However, in general, the biggest challenge for the program was the change in the score type in the university entrance exam in the past. Afterward, potential (successful) students who could choose the department started to prefer other departments*. (System / Unpopularity of department)

A4 … *Since the curriculum does not comply with the requirements of the era, it does not attract the attention of students, thus making it difficult to implement*. (System / Outdated curriculum)

A5 … *In the curriculum that started to be implemented in 2018, the number of weekly hours of the courses decreased*. (Course / Insufficient class hours)

Table 3 Views of teachers on the solution to the problems experienced during the implementation of the CEIT program

Category	Code	*(f)*
Innovation	Software applications should be included	6
	The program should be updated	3
	Hardware / Electronics should be emphasized	2

Teachers' views on the solution to the problems experienced during the implementation of the CEIT program were gathered under the category of "Innovation". When the answers for this category are examined, the teachers consider that software applications should be mostly included in the program as a solution.

The views of the teachers regarding the findings are given below.

T4 ... *I think that coding should be included more in the curriculum*. (Software applications should be included)

T7 ... *It is not necessary to add or delete, it is necessary to develop a new curriculum from the beginning.* (The program should be updated)

Table 4 Views of academicians on the solution to problems experienced during the implementation of the CEIT program

Theme	Category	Code	*(f)*
Update	Change	Increasing class hours	2
		Changing course periods	1
	Innovation	Adding current practices to the program	1
		Adding new compulsory courses	1

When the views of the academicians on the solution to the problems experienced during the implementation of the CEIT program are investigated, the answers given by the academicians are collected under the categories of "change" and "innovation" within the theme of "update". When the answers to the change category are examined, academicians consider an increase in the course hours and changing the course periods as solutions. When the answers to

the innovation category are explored, the academicians propose the addition of current practices to the program and the addition of new compulsory courses as solutions.

The views of the academicians regarding the findings are given below.

A1 … *In the CEIT program, it would be better if the Programming Teaching Approaches course in the first-year spring semester were taken to the third-year fall semester, and the Informatics Curriculum course in the third-year fall semester were taken to the fourth-year fall semester.* (Change / Changing course periods)

A6 … I *think that up-to-date software/programming languages should be added*. (Innovation / Adding current practices to the program)

A3 *... I think it would be useful to add one more compulsory course on Open and Distance Learning to the program. Currently, there is a course called Open and Distance Learning. With good planning, this course can be divided into two, and more detailed topics in this field can be discussed.* (Innovation / Adding new compulsory courses)

What are the problems experienced by the participants during the teaching process and what are the solution suggestions?

Table 5 Teachers' views on the distribution of the courses in the program

Theme	Category	Code	*(f)*
Contribution	Scope	Training for up-to-date software	4
		Courses for programming languages	2
	Expertise	Focusing on field courses	3
		Focusing on applied courses	2
		Adding new courses	1

Teachers' views on the distribution of the courses in the CEIT program were gathered under the categories of "scope" and "expertise" under the theme of "contribution". When the answers to the scope category are examined, the teachers state that training should be provided for up-to-date software and there should be courses for programming languages. When the answers for the specialization category are investigated, the teachers mostly explain that more emphasis should be put on field courses and applied courses.

The views of the teachers regarding the findings are given below.

T1… *The courses taught in the department were mathematics, physics, chemistry, and lab courses that were not useful to us. Instead, courses for ever-evolving programming languages could have been given.* (Scope / Courses for programming languages)

T3 …*I think it is necessary to focus on the field knowledge.* (Expertise/ Focusing on field courses)

T2 … *Today, software has gained great importance. We provide training on block coding and robotics at schools.* (Scope / Training for up-to-date software)

Table 6 Views of academicians regarding the distribution of the courses in the program

Theme	Category	Code	*(f)*
Contribution	Quantity	The number of field elective courses should be increased	2
		The number of field elective course hours should be increased	2
	Expertise	Lack of applied courses	1
		Insufficient number of vocational courses	1

When the views of the academicians on the distribution of the courses in the CEIT program are examined, the answers given by the academicians are gathered under the categories of "quantity" and "expertise" within the theme of "contribution". When the answers to the quantity category are explored, the academicians suggest that the number of field elective courses and the number of field elective course hours should be increased. When the answers for the expertise category are inspected, the academicians believe that the applied courses are missing and the number of vocational courses is low.

The views of the academicians regarding the findings are given below.

A7 … *I think that the hours of the field courses are insufficient.* (Quantity/ The number of field elective course hours should be increased)

A5 … *However, I think that the number of field electives should be increased.* (Quantity/The number of field elective courses should be increased)

A4 … *due to the fact that very few elective vocational courses are offered each semester, some of my students had taken the current open courses in previous semesters and there were no courses to choose from.* (Expertise/Insufficient number of vocational courses)

What are the views of the participants about the program meeting the interests and needs of the students?

Table 7 Teachers' views about the program meeting the interests and needs of students

Theme	Category	Code	*(f)*
Expectation	Content	The software through which products can be obtained	6
		Fun/Interesting software	5
	Variation	Course contents should be updated	1
		Variations in student requests	1
		Lack of technological material	1
		In-depth training in the programming language	1

Teachers' views on meeting the interests and needs of the students in the CEIT program are gathered under the "Expectation" theme and under the categories of "content" and "variation". When the answers to the content category are examined, the teachers state that to meet the interests and needs of the students, mostly software by which products can be obtained and fun/interesting software should be included in the program. When the answers to the variation category are investigated, the teachers consider that the students have various requests during the lesson and that they have problems meeting the interests and needs of the students due to the lack of technological materials. They also state that there should be in-depth training in the programming language in the program.

The views of the teachers regarding the findings are given below.

T3 … *Unfortunately, the informatics course curriculum in secondary schools is on the way to becoming a course that includes too many verbal subjects and absurd and unnecessary definitions. I think that all the content of the course should be organized directly as algorithmic thinking and coding*. (Content / Software through which products can be obtained)

T5 … *Students prefer visual and entertaining lessons. My students, with whom we are trying to learn Python, get bored of writing code in front of the screen after a certain period of time.* (Content / Fun/Interesting software)

S7 … *While students are more enthusiastic about mobile applications, they cannot show the same enthusiasm in a Python software course. In particular, our female students are more interested in visual programming tools, while male students want to use text-based coding tools such as Python. Male students frequently ask questions about game development tools such as the Unreal engine, and they become more participatory in this regard*. (Variation / Variations in student requests)

Table 8 Views of academicians regarding the program meeting the interests and needs of students

Theme	Category	Code	*(f)*
Expectation	Impact	Need/Demand orientation	4
		Ineffectiveness of online lessons	1
	Content	Uninteresting content	1
		Higher level content	1

The views of the academicians about the CEIT program meeting the interests and needs of the students are clustered under the "expectation" theme and under the categories of "impact" and "content". When the answers to the impact category are inspected, the academicians state that the program should be mostly need-/demand-oriented to meet the interests and needs of the students. When the answers to the content category are examined, the academicians see the uninteresting and higher-level content as an important problem in meeting the interests and needs of the students.

The views of the academicians regarding the findings are given below.

A1 … *It is possible to talk about the needs of the profession and/or the sector rather than the interest and needs of the student*. (Impact / Need/Demand orientation)

A5 … *The interests and needs of the students are not met due to the high number of distance education courses in the program.* (Content / Uninteresting content)

A2 *... I don't see a very demanding approach for our current students. The available content exceeds our students.* (Content / Higher level content)

What are the solutions and suggestions for the problems experienced by the participants during the teaching process?

Table 9 Teachers' views on the problems experienced during the teaching process

Theme	Category	Code	*(f)*
Quality	Environment	Lack of computer laboratory	3
		Lack of infrastructure	3
		Outdated infrastructures	2
	Student	Lack of student textbooks	1
		Lack of interest	1
		Readiness	1
	Teaching	Lack of applied courses	1
		Inadequate class hours	1
		Considered as a technician	1

The views of the teachers regarding the problems experienced during the teaching process are collected under the categories of "environment", "student" and "teaching" within the theme of "quality". When the answers for the environment category are examined, the teachers explain that the lack of computer laboratories in their schools and the lack of infrastructure are important problems. When the answers for the student category are investigated, the teachers declare that the lack of student textbooks, lack of interest, and students' readiness are among the important problems. When the answers to the teaching category are inspected, the teachers claim that they see the lack of applied courses, inadequate class hours, and being considered a technician instead of a teacher are basic problems.

The views of the teachers regarding the findings are given below.

T2 … *The infrastructure in my school is unfortunately insufficient…* (Environment / Lack of infrastructure)

T6 … *Students are uninterested in doing homework. They come without doing most of the homework I give them.* (Student/ Lack of interest)

T1 … *not being able to practice on issues that require practice.* (Teaching / Lack of applied courses)

Table 10 Views of academicians regarding the problems experienced during the course teaching process

Theme	Category	Code	*(f)*
Quality	Environment	Lack of technological tools	3
		Lack of computer laboratory	2
		Lack of computer	1
	Student	Students' readiness	1
		Crowded classrooms	1
	Program	Outdated program	1
		Inability to adapt to the program	1

The views of the academicians regarding the problems experienced during the teaching process are clustered under the categories of "environment", "student" and "program" within the theme of "quality". When the answers to the environment category are examined, the academicians mostly state the lack of technological tools and the lack of computer laboratories in their schools as important problems. When the answers to the student category are investigated, the academicians mention the readiness of the students and the crowdedness of

the classes as important problems. When the answers to the program category are inspected, the academicians explain that they see outdated programs and not being adapted to them as the main problems.

The views of the academicians regarding the findings are given below.

A2 … *The inadequacy of the computer laboratory in terms of hardware and software during the application process of my course challenges me*. (Environment/Lack of technological tools)

A3 … *It is not easy for pre-service teachers who cannot keep up with the latest technology and are educated with the past technology to adapt to future developments.* (Student / Students' readiness)

A1 ... *Since the program does not comply with the requirements of the era, it does not attract the attention of the students, and therefore it makes its implementation difficult.* (Program / Outdated program)

Table 11 Views of teachers and academicians regarding the solution to the problems experienced during the teaching process

Category	Participant	Code	*(f)*
Suggestion	Teacher	In-service training	1
		Compulsory courses	1
		Increased class hours	1
		Project-oriented training	1
	Academician	Out-of-school solution	1

The views of teachers and academicians regarding the solution to the problems experienced during the course teaching process are collected under the category of "suggestion". The teachers propose that the course hours should be increased, compulsory courses should be given, in-service training should be provided, and students should be given project-oriented training as solutions to the problems experienced during the course process. When the answers of the academicians are examined, only one academician state that the students should bring their own computers to the school for the solution.

Participants' views regarding the findings are given below.

T7 … *I believe that special in-service training should be organized not only remotely, but mostly face-to-face to update the knowledge of CEIT teachers over time*. (Teacher/In-service training)

A3 … *The inadequacy of the computer laboratory in terms of hardware and software during the application process of my course makes it difficult for me. As a solution, I want students to bring their laptops*. (Academician/Out-of-school solution)

What are the views of the participants about the Teaching Practice course?

Table 12 Teachers' views on the effectiveness of the teaching practice course

Category	Code	*(f)*
Solution	Increased number of courses	2
	In schools with different opportunities	1
	Teaching different methods and techniques to preservice teachers	1

Teachers' views on the effectiveness of the teaching practice course are gathered under the category of "solution". Teachers suggest that for the effectiveness of the teaching practice course, the number of teaching practice courses should be increased, it should be done in schools with different opportunities, and different methods and techniques should be taught to teacher candidates in universities.

The views of the teachers regarding the findings are given below.

T1 ... *If there is no teaching practice course, I believe that the teaching methods used in the application of other educational sciences courses should change. Because innovations are still being taught to students with classical methods. In this respect, I believe that educational science teachers should conduct their lessons with more interactive and innovative approaches.* (Teaching different methods and techniques to preservice teachers)

T4 ... *I think it is appropriate to give teaching practice courses in various schools according to different hardware, software, class size, and environmental factors.* (In schools with different opportunities)

Table 13 Views of academicians on the effectiveness of the teaching practice course

Theme	Category	Code	*(f)*
Application	Problem	Failure in the evaluation process	1
		Lack of laboratories in practice schools	1
	Solution	It should be spread over every period	1
		Care must be taken	1

The views of the academicians on the effectiveness of the teaching practice course are collected under the "problem" and "solution" categories under the "application" theme. When

the answers to the problem category are examined, the academicians utter that the problems experienced in the evaluation process should be eliminated and that there is a lack of laboratories in the practice schools. When the answers to the solution category are explored, the academicians propose that the teaching practice course should be extended to each semester and that the necessary care should be given to this course.

The views of the academicians regarding the findings are given below.

A2 *... Although there is certain cooperation between the MoNE and education faculties in this regard, I think that there are uncertainties about the reporting and evaluation of the activities that students will follow, which causes confusion. There is also confusion about how the evaluation made by the Ministry of National Education will affect the course grades of the students at the university.* (Problem / Failure in the evaluation process)

A6 *... However, most of the secondary schools do not have computer labs. In fact, there are no computer labs in the schools our students attend this semester. Our students experience how to teach information technologies without a laboratory. They cannot experience lecturing in a laboratory environment in the field.* (Problem /Lack of laboratories in practice schools)

A5 *... Teaching practice course is only available in the last year, I think it should be included in the education program every year*. (Solution / It should be spread over every period)

What are the views of participants on the adequacy of computer classes in their institutions?

Table 14 Teachers' views on the adequacy of computer classes in their institutions

Category	Code	*(f)*
Situation	Lack of computer laboratory	4
	Outdated/Unlicensed software	4
	Down-level computers	2

Teachers' views on the adequacy of computer classes in their institutions are gathered under the category of "situation". They state that most of the teachers do not have computer laboratories in their institutions, the computers in schools with laboratories are old and they use outdated or unlicensed software.

The views of the teachers regarding the findings are given below.

T2 *... However, we have some shortcomings in software in our laboratories. While our ministry used to supply Adobe products, today it does not offer license support for any current program.* (Outdated/Unlicensed software)

T6 ... *The building of our institution was decided to be demolished 5 years ago because it was not earthquake resistant. We are temporarily using the building of another school. That's why we don't have an IT class.* (Lack of computer laboratory)

S1 … *There are 15+1 computers in our IT classroom... They are not very efficient because they are old.* (Down-level computers)

Table 15 Academicians' views regarding the adequacy of computer classes in their institutions

Theme	Category	Code	*(f)*
Need	Status	Down-level computers	3
		Neglected computers	1
	Material	Outdated/Unlicensed software	4
		Software diversity	2
		Insufficient course materials	1

The views of the academicians regarding the adequacy of computer classes in their institutions are clustered under the category of "status" and "material" under the theme of "need". When the answers for the situation category are examined, the academicians mostly claim that the computers in the laboratories are down-level. When the answers to the material category are investigated, the academicians state that outdated/unlicensed software is mostly used on computers.

The views of the academicians regarding the findings are given below.

A3 ... *I do not find it sufficient since there is no employee dealing with computer laboratories in the institution. Two of the laboratories have better computers in terms of hardware, but most of them do not work properly*. (Status / Neglected computers)

A1 ... *There are four computer laboratories and 120 computers in our institution. The newest of these computers (16 units) was purchased about five years ago. The remaining hundred are more than ten years old, and some are not even working.* (Status / Down-level computers)

A4 .... *It is not enough in terms of budget to install all the software necessary for the courses on the computers under license. It is essential that more resources are allocated by the university on this subject* (Material / Outdated/Unlicensed software).

Conclusions and Suggestions

Education undergraduate programs significantly affect the training of teachers who take an active role in today's education (Orhan, 2017). In this respect, considering that the field of education has a dynamic and changing structure, it is necessary to maintain the constant up-to-dateness of teacher training programs and determine their effectiveness to achieve the desired goals. Therefore, it is important to determine the views of the academicians who are the building blocks of the theory part, and the teachers who are the fundamental elements of the implementation part.

In line with the purpose of the study, the effectiveness of the CEIT program is tried to be determined by taking the views of teachers and academicians. Three categories are reached under the "program" theme, determined according to the views received from the teachers. These are course, material, and physical condition. Considering the results obtained from these categories, it is noteworthy that the number of applied courses in the program in the course category should be increased. Under the material category, the lack of a computer at home and the need for licensed applications are mentioned. In the category of physical condition, it is stated that there is a lack of computer laboratories in schools and a lack of equipment and infrastructure in existing laboratories.

According to the views received from the academicians, it is explained under the system category that the department is no longer preferred as much as it used to be and the program is not up-to-date enough. In addition, in the course category, it is claimed that the number of elective courses is excessive, the course hours are insufficient, and the number of applied courses is insufficient. Considering the view of teachers and academicians, it is seen that the low number of applied courses is expressed as a common problem in secondary schools and CEIT departments. Although the expression "research and practice-based teacher education" (YÖK, 2018) was emphasized in the teaching undergraduate programs renewed in 2018, it is stated by teachers and academics that the number is still insufficient.

According to the views of the teachers about the solution to the problems experienced during the implementation of the CEIT program, the innovation category is reached. Under this category, teachers state that software/coding, hardware/electronics subjects should be taught in lessons and the program should be updated. According to the views of the academicians, the sub-categories of change and innovation are reached under the current theme. Accordingly, it is suggested to increase the class hours and change the periods of some courses. It is also proposed that current practices and new compulsory courses should be added. This result is

similar to the study of Yükseltürk and Altok (2015). Considering that the program has been updated relatively recently, it is a striking result that teachers and academicians said that the programs are insufficient in terms of up-to-dateness. We can attribute this situation to the fact that the CEIT field is based on technology that is constantly changing and renewed.

When the views of the teachers on the distribution of the courses in the program are examined, the categories of scope and expertise are reached under the theme of contribution. In the scope category, it is explained that the weight of the field courses in the program is insufficient and the up-to-dateness of the taught software is insufficient. In the expertise category, it is proposed that applied courses should be added. According to the views of the academicians, the categories of quantity and expertise are reached under the theme of contribution. It is suggested that the number of elective courses in the quantity category and the number of weekly courses should be increased. In the expertise category, it is proposed that the number of vocational knowledge courses should also be increased. Considering the views of teachers and academicians, it is seen that the common point is that field courses should be given more place in the program. Despite the increase in the number of content knowledge courses in the CEIT undergraduate program, which was renewed in 2018 (YÖK, 2018), it is stated that this number is still insufficient. This result is in line with the studies of Altun and Ateş (2008) and Önal (2017). Contrary to this result, there are also studies stating that the current program has a sufficient number of content knowledge courses, which may be due to the practice-based structure of the CEIT field.

When the views of the teachers regarding the program's meeting the interests and needs of the students are examined, the categories of content and variation are reached under the theme of expectation. In the content category, it is stated that funny software through which products can be obtained can attract the attention of the students. In the variation category, it is seen that the students are interested in programming languages/software and they make different requests such as the lack of necessary materials in the lessons. When the views of the academicians regarding the program's meeting the interests and needs of the students are explored, the categories of impact and content are reached under the theme of expectation. In the impact category, it is stated that it is not aimed at students' needs, and in the content category, the content of the program is above the student's level and does not attract attention. When the views of teachers and academicians are compared, it is seen that there is no structure that can attract the attention of the students in terms of content. This may be due to expectations for coding skills, which are among students' 21st-century skills (Akgün et al., 2019). Similar results

are found in the studies of Hamutoğlu (2022), Kayak (2019), Yaşar (2019), and Gülcü et al. (2013).

In determining the views of the teachers about the problems experienced during the teaching process, the environment, student, and teaching categories under the quality theme are reached. It is stated that there are no computer labs in the environment category and that there are infrastructure problems. Lack of interest and lack of student readiness are in the student category. In the category of teaching, it is stated that there is a lack of applied courses and inadequate class hours. When we look at the views of the academicians about the problems experienced during the course teaching process, the categories of environment, student, and program under the theme of quality are reached. It is explained that laboratory and materials are lacking in the environment category. In the student category, student readiness is insufficient. In the program category, it is seen that the program is not up-to-date and there is a difficulty in adaptation. When we look at the opinions of academicians and teachers, it is found that the readiness of the students and the lack of tools and materials in the laboratory are expressed as common problems, which constitute an obstacle to the implementation of the program. One of the important factors affecting student success is the level of readiness (Kearney & Garfield, 2019). The lack of student readiness at the desired level may be due to the student and the program. This result is in parallel with the study of Osman and Kurt (2017).

When the views of the teachers on the effectiveness of the teaching practice course are examined, the solution category is reached. In this context, it is stated that the number of classes should be increased, they should be held in schools with various abilities, and different methods and techniques should be included in the lessons. When the views of academicians on the effectiveness of the teaching practice course are investigated, problem and solution categories are reached under the application theme. In the problem category, the lack of an application laboratory and the problems in the evaluation process are stated, while in the solution category, it is suggested that more attention should be paid to the lesson and the lesson should be included in every semester. There are studies similar to these findings (Aslan & Sağlam, 2018; Aydın & Akgün, 2014; Gökmen, 2015; Köse & Caner, 2022; Yakar et al., 2021). By conducting and evaluating teacher candidates in accordance with the characteristics of the field in which they are educated, the teaching practice course will enable the training of competent teachers (Odabaşı et al., 2011). In this context, views received from teachers and academicians are important.

When the views of the teachers about the adequacy of the computer classes in their institutions are examined, the status category is reached. Accordingly, it is asserted that there is no laboratory, and the computers with laboratories are either old or have outdated and unlicensed software. When the views of academicians about the adequacy of computer classes in their institutions are examined, the fact that the computers are old and have out-of-date and unlicensed software are among the striking results that overlap with the views of the teachers. This is an important handicap in the teaching of the courses and the implementation of the program (Muskin, 2015). In the literature, there are studies showing that this problem has been going on for a long time (Akgün et al., 2019; Bakar-Çörez & Geçer, 2022; Bardakçı et al., 2017; Süme & Aslan, 2022).

Based on these results, the following recommendations can be made:

For practitioners;

- Minimizing physical infrastructure problems in the department by faculty administrators,

- Emphasizing coding and hardware/electronics courses in the program,

- Increasing the number of elective courses in the program and the number of weekly courses,

- Include interesting and current topics in the lessons,

- Giving more importance to the teaching practice course and applying it in different periods,

For researchers;

- Conducting mixed-method studies to analyze the needs of the department in future research.

- Comparisons can be made by carrying out studies in different universities and cities.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest

No conflict of interest.

Funding

None.

CRediT author statement

The article was collaboratively written by two authors, with each contributing equally to its content.

Research involving Human Participants and/or Animals

The study involves human participants. Ethics committee permission was obtained from Balıkesir University, Social and Human Sciences Research Ethics Committee.

Acknowledgements

This study was funded by Balikesir University Scientific Research Projects Unit (2022/045).

BÖTE Lisans Programının Öğretmen ve Akademisyen Görüşlerine Göre İncelenmesi

Özet:

Bu çalışma, öğretmen ve akademisyenlerin görüşleri doğrultusunda BÖTE lisans programının etkililiğini ortaya koymayı amaçlamaktadır. Çalışmada nitel araştırma desenlerinden fenomenoloji deseni kullanılmıştır. Çalışma grubu çok aşamalı örnekleme yoluyla seçilen 14 kişiden oluşmaktadır. Katılımcıların 8'i BÖTE lisans programından mezun öğretmenler, 6'sı ise BÖTE programında görev yapan akademisyenlerdir. Araştırmada veri toplama aracı olarak araştırmacılar tarafından geliştirilen yarı yapılandırılmış görüşme formu kullanılmıştır. Çalışmada elde edilen veriler içerik analizi tekniği kullanılarak analiz edilmiştir. Çalışmada hem öğretmenler hem de akademisyenler programın uygulanması sırasında bilgisayar sınıfı sorunlarına, ders saatlerinin yetersizliğine ve uygulamalı derslerin eksikliğine değinmişlerdir. Programdaki derslerin dağılımına ilişkin olarak öğretmenler güncel yazılımlar ve alan derslerine yönelik eğitimlere ağırlık verilmesi gerektiğini; akademisyenler ise alan seçmeli derslerinin sayısının ve haftalık saatlerinin artırılması gerektiğini belirtmişlerdir.

Anahtar kelimeler: BÖTE programı, öğretmen, akademisyen

References

Akgün, Ö. E., Topal, M., & Kıyıcı, M. (2019). Investigation of the effectiveness of a CEIT undergraduate program on students' competencies. *Journal of Higher Education (Turkey), 10*(1), 12-26. https://doi.org/10.2399/yod.19.010

Aslan, M., & Sağlam, M. (2018). Evaluation of teaching practice course according to opinions of student teachers. *H. U. Journal of Education, 33*(1),144-162. https://doi.org/10.16986/HUJE.2017030313

Aydın, F., & Akgün, Ö. E. (2014). Problems of senior teacher students in on-site school training. *Sakarya University Journal of Education Faculty, 28,* 1-14. https://dergipark.org.tr/tr/download/article-file/115885

Altun, E., & Ateş, A. (2008). The problems and future concerns of computer and instructional technologies preservice teachers. *Elementary Education Online, 7*(3), 680-692. https://dergipark.org.tr/tr/download/article-file/90928

Bakar-Çörez, A., & Geçer, A. K. (2020). Academicians' views of the department of computer education and instructional technologies. *Kastamonu Education Journal, 28*(1), 17-35. https://doi.org/10.24106/kefdergi.3325

Bardakcı, S., Kılıçer, K., & Özeke, V. (2017). A projection from computer education & instructional technologies departments in Turkey. *Educational Technology Theory and Practice, 7*(2), 123-148. https://doi.org/10.17943/etku.286627

Bogdan, R. C., & Biklen, S. K. (1992). *Qualitative research for education.* Allyn and Bacon.

Gökmen, Ö. F. (2015). The computer education and instructional technology teacher candidates' views about teaching practice. *Mersin University Journal of the Faculty of Education, 11*(1), 96-115. https://dergipark.org.tr/tr/download/article-file/161072

Gülcü, A., Aydın, S., & Aydın, Ş. (2013). Evaluation of the new teaching programme developed under the name of svet in informatics technologies lesson in the vocational high schools via the teachers' point of view. *The Black Sea Journal of Social Sciences, 5*(8), 73-92. https://dergipark.org.tr/en/download/article-file/149897

Hamutoğlu, N. B., Sezen-Gültekin, G., & Kıyıcı, M. (2022). In-depth evaluation of the CEIT profession profile within the scope of managerial education policies in the COVID-19 pandemic process: The case of Sakarya University. *Manisa Celal Bayar University Journal of Social Sciences, 20*(1), 223-242. https://doi.org/10.18026/cbayarsos.1032987

Hatch, J. A. (2002). *Doing qualitative research in education settings.* State University of New York Press.

Kayak, S. (2019). *Examination of the new CEIT undergraduate major area courses in terms of teaching profession efficiency*. 1st International Science, Education, Art & Technology Symposium UBEST 2019, İzmir, Turkey.

Kearney, W. S., & Garfield, T. (2019). Student readiness to learn and teacher effectiveness: Two key factors in middle grades mathematics achievement. *RMLE Online, 42*(5), 1-12. https://doi.org/10.1080/19404476.2019.1607138

Köse, E., & Caner, H. N. (2022). Content analysis of studies published between the years 2015 and 2020 on teaching practice in Turkey. *Ahi Evran University Journal of Kırşehir Education Faculty, 23*(1), 1221-1267. https://dergipark.org.tr/en/download/article-file/1731333

Kurtoğlu-Erden, M., & Seferoğlu, S. S. (2015). Examination of department of computer education and instructional technology students' perception towards their department's future. *Eğitim Teknolojileri Araştırmaları Dergisi*, 6(2), 1-20. https://www.idealonline.com.tr/IdealOnline/pdfViewer/index.xhtml?uId=6135&ioM=Paper&preview=true&isViewer=true#pagemode=bookmarks

Meşe, C., Özer, S., Dindar, M., & Odabaşı, H. F. (2014). "Interest" and the domains of interest in the curricula of CEIT departments. *Journal of Theory and Practice in Education, 10*(1), 143-170. https://dergipark.org.tr/tr/download/article-file/63377

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: A sourcebook.* Sage.

Muskin, J. A. (2015). *Student learning assessment and the curriculum: Issues and implications for policy, design and implementation.* UNESCO International Bureau of Education. https://unesdoc.unesco.org/ark:/48223/pf0000235489

Odabaşı, H. F., Kurt, A. A., Haseski, H. İ., Mısırlı, Ö., Ersoy, M., Karakoyun, F., & Günüç, S. (2011). Field factor in teaching practicum: A sample from CEIT. *Educational Technology Theory and Practice*, *1*(1), 24-40. https://dergipark.org.tr/en/download/article-file/71831

Orhan, E. E. (2017). What do teacher candidates in turkey think about their teacher education? A qualitative study. *Education and Science*, *42*(189), 197-216. http://dx.doi.org/10.15390/EB.2017.4661

Osman, E., & Kurt, A. A. (2017). Investigation of CEIT students' attitudes towards programming. *Mehmet Akif Ersoy University Journal of Education Faculty*, *1*(41), 314-325. https://doi.org/10.21764/efd.64721

Önal, N. (2018). What do information technology teacher candidates think about their professional education? *The Journal of Turkish Social Research*, *22*(1), 299-322. https://dergipark.org.tr/en/download/article-file/453727

Patton, M. Q. (2014). *Nitel araştırma ve değerlendirme yöntemleri [Qualitative research & evaluation methods]* (Trans. Bütün, M., & Demir, B. S.). PegemA Yayınları.

Rubin, H. J., & Rubin, I. S. (2005). *Qualitative interviewing: The art of hearing data*. Thousand Oaks, CA: Sage.

Semerci, Ç. (2012). The evaluation of students on ideas about the department of computer education and instructional technology (CEIT) according to Rasch measurement

model. *NWSA-Education Sciences, 7*(2), 777-784. https://dergipark.org.tr/tr/download/article-file/185460

Süme, G., & Aslan, H. (2022). Problems experienced by information technology teachers and solution suggestions. *International Anatolian Journal of Social Sciences, 6*(4), 1285-1298. https://doi.org/10.47525/ulasbid.1186681

Şahin, M., Keskin, S., & Yurdugül, H. (2018). Determination of the learning priorities of students in department of CEIT based on their career preferences using AHP. *Bartın University Journal of Faculty of Education, 7*(3), 745-764. https://doi.org/10.14686/buefad.372453

Van Manen, M. (2016). *Researching lived experience: Human science for an action sensitive pedagogy*. Routledge.

Yakar, Z. Y., Uzun E., & Tekerek, B. (2021). Problems encountered within the scope of teaching practice course and solution suggestions. *Kahramanmaraş Sütçü İmam University Journal of Social Sciences, 18*(1), 220-245. https://doi.org/10.33437/ksusbd.655590

Yaşar, Ç. (2019). *An investigation of the effect of social media platforms on ICT teacher candidate's career trends & instructional activities* [Unpublished master's thesis]. Balıkesir University.

Yıldırım, A., & Şimşek, H. (2011). *Sosyal bilimlerde nitel araştırma yöntemleri [Qualitative research methods in the social sciences]*. Seçkin.

Yükseltürk, E., & Altıok, S. (2015). Pre-service information technologies teachers' views on computer programming teaching. *Amasya Education Journal, 4*(1), 50-65. https://dergipark.org.tr/en/download/article-file/19646

Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi
Cilt 17, Sayı 1, Haziran 2023, sayfa 26-45. ISSN: 1307-6086
Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education
Vol. 17, Issue 1, June 2023, pp. 26-45. ISSN: 1307-6086

Review

Educational Capacity of Botanical Gardens: What do the research results say?*

Dilan BAYINDIR [1]

[1] Balıkesir University, Necatibey Faculty of Education, Department of Primary Education, Balıkesir/Türkiye, dilan.bayindir@balikesir.edu.tr, http://orcid.org/ 0000-0002-6081-3690

Received : 23.05.2023 Accepted : 29.06.2023
https://doi.org/10.17522/balikesirnef.1301444

Abstract – Considering that they have been visited by more than 750 million people each year (BGCI, 2023), botanical gardens can play an important role in solving the global problems we face such as climate change, food security, and loss of biodiversity. To achieve this, it is recommended to strengthen the educational role of botanical gardens, review the research results made so far in this field, and support new research. Within the scope of this study, it is aimed to review the scientific research on the education and public awareness role of botanical gardens. Within the scope of this research, scientific studies published in peer-reviewed scientific journals on educational aspects of botanical gardens were reviewed. Thirty-two studies were reached as a result of the literature review carried out in accordance with the determined criteria. With the content analysis, the educational role of botanical gardens was systematically analyzed and interpreted according to research findings.

Key words: botanical gardens, education, content analysis

Corresponding author: Dilan BAYINDIR, Balıkesir University, Necatibey Faculty of Education, Department of Primary Education, Balıkesir/Türkiye, dilan.bayindir@balikesir.edu.tr

*Note: This study is an expanded version of the presentation named "The Educational and Public Awareness Enhancement Capacity of the Botanical Gardens: What do the research results say?" that was presented as an oral presentation at the 3rd National Botanical Gardens Arboretums Herbariums and Botanical Museums Workshop held in Gaziantep, Turkey on March 23-25, 2022.

Introduction

Many scientists argue that we have entered the sixth great mass extinction and that anthropogenic climate change is one of the greatest threats to global biodiversity (Maclean &

Wilson 2011). It is seen that plant biodiversity also faces this threat. About one-third of the world's vascular plant species are threatened with extinction due to overharvesting, destructive agricultural and forestry practices, urbanization, environmental pollution, land use changes, various destructive activities including exotic invasive species, and global climate change (Chen & Sun, 2018).

One of the important steps in the protection of plant biodiversity is the "Global Plant Conservation Strategy-Global Strategy for Plant Conservation" (GSPC, 2011) adopted on 19 April 2002. The strategy, which was unanimously adopted by 187 countries including Turkey, has committed to achieving 16 goals by 2010. Goal 14 emphasizes the importance inclusion of plant diversity and the need to protect these plant diversity topics in education programs. Mounce and his colleagues (2017) argue that the role of botanical gardens is extremely important in the future conservation of biodiversity and in preventing extinction through integrated conservation action. Similarly, Williams and her colleagues (2015) highlight the value and importance of botanical gardens as catalysts that positively influence visitors' environmental attitudes.

Botanical gardens, by definition, are multidimensional institutions that house collections of living plants for scientific research, conservation, display, and education (Jackson, 1999). One of the most important functions of the first botanical gardens established in Europe was to maintain a scientific plant collection for the education of medical students (Heywood, 1991; Willison & Green, 1994). When we look at the establishment purposes of these premier institutions, it is seen that education is a priority, but they are especially focused on adult education. From the first half of the 20th century, however, some notable examples of botanical garden education programs have emerged. For example, the Brooklyn Botanic Garden, which was made available to the public in 1910, has focused on developing educational programs from its earliest years (Avery, 1971). Educational programs implemented in this garden have been developed to include young children and teachers. The International Botanical Gardens Conservation Organization (BGCI) was established in 1987, and this institution played a role in establishing the educational goals of botanical gardens. BGCI sees environmental education, and especially education for sustainable development, as the main responsibility of botanical gardens (Willison 2006; Willison & Green 1994). In 1990, an educational journal called 'Roots', affiliated with BGCI started to be published. This journal has pioneered the sharing of projects and studies carried out in botanical gardens in different parts of the world. Since 1991, under the leadership of BGCI, the Education Congress in the International Botanical Gardens has

started to be organized. All these processes have brought the educational role of botanical gardens to the forefront. Today, besides plant protection, research, and recreation, education is one of the functions of botanical gardens (Galbraith, 2003). In a survey conducted by Kneebone (2006) with more than 120 representatives of 117 botanical gardens, it is seen that 91% of today's botanical gardens have education among their targets.

Botanical gardens provide stimulating learning environments by documenting plant collections, conducting scientific activities on plant and animal life, and providing educational opportunities. These features make botanical gardens excellent informal learning institutions that attract many people to visit, learn, and have fun in the physical environment. However, the number of studies examining the effectiveness of the training conducted in the botanical garden and its effects on visitors is quite limited. Within the scope of this study, it is aimed to review scientific studies on the educational role of botanical gardens.

Method

Research Design

This study is a qualitative research aiming to review the findings of studies evaluating the educational capacity of botanical gardens. The publications about the educational capacity of botanical gardens were examined by the content analysis method. The content analysis aims to give a holistic, in-depth, and detailed description of the situation (Fraenkel et al., 2011). The method is based on the systematic analysis and interpretation of what is stated in the documents examined.

Literature Review

To provide a comprehensive literature review, several terms and phrases related to botanical gardens were searched in the widely used “ScienceDirect” online database. Identified terms and word sets include: “botanical garden”, “botanical garden education”, and “botanical education”. The search was extended by scanning the references of the accessed articles. Since there is limited research published in peer-reviewed journals on the educational role of botanical gardens, the search was not limited in terms of publication date. However, it was limited to publications in peer-reviewed journals, in English and Turkish languages so that the researcher could review them. At this stage, only articles that present results on the educational capacity of botanical gardens were selected.

Following these criteria, 32 studies were obtained. The publication year interval of these studies varies between 2001 and 2023. Considering the publication languages, it is seen that all the selected publications were published in English. In terms of country of publication, 7 of the studies were in England, 5 in Germany, 3 in America, 3 in Turkey, 3 in Australia, 2 in Taiwan, 1 in Canada, 1 in Greece, 1 in Italy, 1 in China, 1 in South Africa, 1 in Ethiopia, 1 in Malaysia 1 in Portugal, and 1 research was conducted at international level.

Analysis

The analysis of selected studies was carried out in two stages. In the first phase, three key aspects of all the studies included in the review were summarized: (1) participants (2) research focus (3) results. Accordingly, the studies are divided into adult, teacher, family and child, students, and non-participant research (document analysis, applications, etc.) according to their participant characteristics. Afterward, each category was examined in itself depending on the research focus and results. Research results in which there was more than one publication and research focus and results differed were categorized within themselves. For example, research with visitors was categorized as (1) adult visitor opinions of botanical gardens, (2) the effects of adult visits to botanical gardens, and (3) the effects of adult education programs conducted in botanical gardens, and they were analyzed and interpreted depending on the results.

Findings and Discussions

Thirty-two studies which were reached as a result of the literature review and carried out in accordance with the determined criteria, were examined by content analysis method in accordance with the criteria described above, and the results are presented in this section.

Studies with Adult Visitors

13 different studies were procured with adult visitors of botanical gardens. The list of these studies is shown in Table 1.

Table 1 Studies with Adult Visitors

	Authors	Publication Year	Number of Participants	Age Group	Country
1	Ballantyne et al.	2008	150	30-60 and above	Australia
2	Murray et al.	2007	319	15 and above	Australia
3	Ward et al.	2010	336	30-59 (>%50)	S. Africa
4	He & Chen	2012	1865	<20->50	China
5	Vergou & Willison	2014	-	-	England
6	Williams et al.	2015	1054	46 and above (%60)	England
7	Wassenberg et al.	2015	83	18-78	USA
8	Razak et al.	2016	518	-	Malaysia
9	Zelenika et al.	2018	196+119	39-40 (ave.)	Canada
10	Catahan & Woodruffe-Burton	2019	582*	-	England
11	Salvarci & Aylan	2021	211*	-	Turkey
12	Funsten et al.	2022	276	19-50 (%63)	Italy
13	Truong et al.	2022	42	59 (ave.)	Australia

The majority of research with adults appears to be about adult views on visits (8 publications), the effects of adult visits to botanical gardens (2 publications), and studies (3 publications) examining the effects of adult education programs conducted in botanical gardens.

Studies examining the opinions of visitors in different parts of the world show that visitors focus less on the educational role of botanical gardens. For example, in Malaysia (Razak et al., 2016), Italy (Funsten, et al., 2022), and South Africa (Ward et al., 2010), the results of the studies showed that recreational purposes are more important for botanical garden visitors. Catahan and Woodruffe-Burton (2019) analyzed TripAdvisor reviews of two botanical gardens in England using Leximancer software. Reviews show that visitors clearly place greater emphasis on garden aesthetics, facilities, and services, supporting previous studies. Similarly, Ballantyne, Packer, and Hughes (2007) found that visitors to botanical gardens showed relatively low interest in conservation issues. The most important reasons for visiting the botanical gardens are having fun, admiring the landscape of the garden; spending quality time with family or friends; and enjoying being outdoors/in nature. It was seen that the participants of the research conducted by Wassenberg, Goldenberg, and Soule (2015) also emphasize learning experiences. Participants stated that visits to botanical gardens provide new experiences and learning for them, provide relief from stress and increase their quality of life. The analysis revealed no significant differences between men and women. Murray, Price, and Crilley (2007) studied a sample of 319 visitors to an Australian botanical garden in one study.

It was determined that a component of the service quality in the botanical garden is educational services. The provision of learning environments related to education and the presence of information boards are the items under the education factor. Salvarci and Aylan (2021) who investigated the opinions of adult visitors in Turkey found that, similar to the results of studies conducted abroad, visitors' opinions about their visit to botanical gardens contain very limited information about the flora. The study data were obtained from 81 visitor reviews on the TripAdvisor website for "Ankara Botanical Park", "Atatürk Botanical Park", "Gaziantep Botanical Park", "Karaca Arboretum", and "Nezahat Gökyiğit Botanical Garden" in Turkey between May 2014 and November 2020. When the visitor comments were evaluated in the research, it was concluded that the comments about the botanical parks and gardens consisted of the codes of panoramic, peaceful/relaxing, lush green place, nostalgic, natural wonder, and tree museum. In addition to these, it was concluded that in these parks and gardens, activities such as walking and sports, picnics, taking pictures, watching the scenery, resting, and getting information about the flora can be done by the visitors.

In addition to the studies examining visitor opinions, research results examining the effects of visits on visitors were revealed. For instance, Williams and her colleagues (2015) investigated whether visits to botanical gardens changed visitors' ecological knowledge and environmental attitudes. Within the scope of this research, the use of information boards by visitors in botanical gardens was examined. A survey of 1054 visitors was conducted at five UK botanical gardens (Cambridge, Birmingham, Edinburgh, Kew, and Eden), half of whom were interviewed at the entrance and half at the departure. Research results show that there was a strong positive relationship between knowledge and attitudes. Botanical garden visits were found to have little effect on knowledge, but positive increases in environmental attitudes among those who left the botanical garden. This study provides quantitative evidence that botanical gardens can positively influence visitors' environmental attitudes. The research was conducted at five botanical gardens with visitor education centers in mainland China and found that these centers were highly functional (He & Chen 2012). In all five botanical gardens studied, those who visited the visitor education centers showed that they believed they had acquired significantly more information than those who did not visit these centers.

Additionally, it is seen that there are studies examining the effects of some programs developed for adults and applied in botanical gardens. Zelenika and her colleagues (2018) developed a new community-based education program to involve the public in sustainability, and the effects of the program were investigated. The content of the program consists of food

systems and choices, conservation of biodiversity, water conservation, and waste reduction. The present study examined the impact of the developed program on environmental knowledge, attitudes, and willingness to engage in pro-environmental behavior. The results showed that program participants were more knowledgeable about environmental issues after the tour than regular garden visitors who did not take the program, they were more connected to nature and showed more intention and willingness to participate in sustainability actions. The results show that interactive sustainability education in a botanical garden setting can be a useful educational model for mobilizing public participation in sustainability. Another program by Truong, Gray, and Ward (2022) investigated the effects of a horticultural program called "Community Greening" at the Royal Botanic Garden in Sydney, Australia. The narratives of respondents consulted to evaluate the program revealed themes such as gaining knowledge, connecting with nature, developing a sense of community, residents' sense of pride, and improving public perceptions of public housing. The study by Vergou and Willison (2014) presents the results of the evaluation of the results of the Communities in Nature initiative conducted by the University of Leicester Botanic Gardens (ULBG), RBGE, Westonbirt, The National Arboretum (Westonbirt) and Bristol Zoo Gardens (BZG). This study aims to provide evidence of how botanical gardens can address social roles and environmental and social inclusion issues by working with local communities. The findings are discussed for each project, and in summary, it has been revealed that environmental problems should be related to them and that the views of the groups should be included in the project in order to raise awareness and/or encourage participation in addressing environmental problems with groups facing social exclusion.

Studies with Teachers

Two publications about botanical garden education, attended by teachers, were found. The list of these studies is shown in Table 2.

Table 2 Studies with Teachers

	Authors	Publication Year	Number of Participants	Age Group	Country
1	Bayındır & Seggie	2015	149	39.8 (ave.)	Turkey
2	Tampoukou et al.	2015	154	44 (ave.)	Greece

The aim of the research conducted by Bayındır and Seggie (2015) is to determine the reasons why primary school teachers organize student trips to botanical gardens. The findings revealed that the following nine factors were effective for organizing student trips to botanical gardens. These are: to connect with the classroom curriculum, to provide students with an

overall learning experience, to encourage lifelong learning, to increase students' interest and motivation, to change the environment or routine, to have fun, to meet school expectations, to contribute to the socialization of students, and to enjoy the physical environment. In addition, a significant relationship was found between teachers' personal interests and their students' school trip experiences. Tampoukou and her colleagues (2015) conducted a survey on teachers working in Environmental Education Centers in Greece. The use of botanical gardens as an environmental education tool was investigated and the most important features of school environmental education programs were tried to be determined. The findings showed that the majority of environmental education center teachers (90.6%) did not develop environmental education programs involving the use of botanical gardens, but it was observed that botanical gardens were ranked as the most suitable among other green spaces to conduct such programs, especially for primary school students. Teachers stressed the need for botanical gardens to be designed accordingly and to provide the necessary infrastructure to facilitate teaching (eg, open spaces, gathering spaces, easy access roads, and indoor facilities). The results also found that although the majority of teachers (72.7%) knew of the existence of botanical gardens, only one-third (34.5%) visited them.

Studies with Families and Children

Two studies with the participation of families and children in botanical gardens were reached. The list of these studies is shown in Table 3.

Table 3 Studies with Families and Children

	Authors	Publication Year	Number of Participants	Age Group	Country
1	Eberbach & Crowley	2017	79 family	6-10 (child age)	A.B.D.
2	Haywood	2018	24 family	6.9 (child age ave.)	England

Eberbach and Crowley (2017) investigated two factors that may help children transition from seeing the natural world to observing the natural world. Specifically, they explored the potential roles played by differences in parental knowledge of pollination biology and differences in parental speech strategies. During a family visit to a botanical garden, the question was asked whether these factors could help children become more scientific in their observation of biological phenomena. 79 parent-child pairs with children aged 6-10 participated in a controlled study in which half of the parents used their natural speech styles and the other half were trained to use the four speech strategies during family pollination observations in a

botanical garden. The results showed that parents who received education left children with more learning from the botanical garden experience.

Haywood (2018) investigated adults' views on science learning at Kew Gardens. Participants in this study are 24 families who responded to an ad in the Kew Gardens newsletter. The findings showed that all families primarily referred to Kew's aesthetic beauty, but less accepted its function for science learning. The results showed that most families believe that no science learning takes place during unguided visits.

Studies with Students

Twelve studies conducted with students of different age groups in botanical gardens were reached. The list of these studies is shown in Table 4.

Table 4 Studies with Students

	Authors	Publication Year	Number of Participants	Age Group	Country
1	Tunnicliffe	2001	-	7-11	England
2	Bowker	2004	72	7-11	England
3	Sanders	2007	75	7-11	England
4	Chang et al.	2008	422	9-10	Taiwan
5	Morgan et al.	2009	5	9-10	A.B.D.
6	Wiegand et al.	2013	404	14.1 (ave.)	Germany
7	Sellmann & Bogner	2013	108+37	15-19	Germany
8	Sellmann & Bogner	2013	114	14-19	Germany
9	Sellmann	2014	114	14-19	Germany
10	Huang et al.	2016	21	High school	Taiwan
11	Kissi & Dreesmann	2018	192	10-12	Germany
12	Yılmaz et al.	2023	282	11-14	Turkey

Research with students seems to focus on guided tours (3 publications), evaluation of various short-term programs/activities developed for students in botanical gardens (6 publications), and examination of the effects of long-term programs conducted in botanical gardens (3 publications).

The activities most frequently attended by students in the botanical gardens are guided day school excursions. Part of the study published by Sanders (2007) involved 75 children from three primary schools who visited a botanical garden in London between 1997 and 2001. With the worksheets, both written and illustrated answers were obtained about the reasons for the children's interest in the botanical gardens or not, their favorite places in the botanical gardens, and their favorite plants. It is seen that the main factors in the visit preferences of the children

for visiting the botanical garden are entertainment and learning, and the main negative reasons are listed as only having plants and being boring. A similar study conducted in London was carried out by Tunnicliffe (2001). It was tried to determine what student groups were talking about during primary school visits to the Royal Botanic Gardens in Kew, England. The results showed that children spontaneously talked about easily observed characteristics of plants such as color, shape, and smell. When cues were given by adults or other children in the group, it was determined that the children paid attention to less obvious aspects of the plants. Another study conducted in England was conducted with a group of 7-11-year-old children guided by a teacher in the Eden Project. The aim of the study by Bowker (2004) was to reveal the most effective methods of taking a teacher-led field trip to improve children's perceptions of plants and their understanding of people's relationships with plants. Although most of the students showed interest in plants related to their lives, it was seen that most of them had low awareness about the relationships between plants, people, and resources.

It is seen that some researchers publish their studies on the programs they have developed on some special subjects. Chang, Bisgrove, and Liao (2008) conducted an empirical study to evaluate the educational effectiveness of using landscape narratives. To assess the impact of the narrative environment on students' learning efficiency and visual preferences, the views of each of the five selected theme shows were video recorded. It was found that when the content is associated and matched with the narrative setting, understanding and retention of the content increase significantly. The results of this research showed that using narrative landscapes for the design of display areas or theme gardens can increase the effectiveness of learning with appropriate information. Another program topic is climate change. Studies aiming to examine the effectiveness of the climate change education program in terms of various factors were carried out in a botanical garden in the south of Germany. Findings that combine a knowledge test, a psychometric questionnaire, and concept maps show that participants' level of knowledge has increased, their commitment to nature has increased, environmental attitudes have changed positively, and concepts related to climate change have developed towards a more scientific perspective (Sellmann & Bogner, 2013a; Sellmann & Bogner, 2013b; Sellman, 2014). It is seen that there are studies aiming to make students' visits to the botanical garden effective with technology integration. For example, Kissi and Dreesmann (2018) aimed to develop an application that combines mobile learning with plant education and to evaluate the effects of the application to positively affect students' knowledge and attitudes about plants and nature. Researchers have created an interactive treasure hunt-like quiz. Since the main topic is the

diversity of flowers, the practice is called flower hunting. In addition to understanding plant diversity, threats and protection, flower morphology and ecology, and systematics are also discussed. The results showed that students' motivation to participate was high, especially their knowledge of plant systematics. At the end of the application, although plant blindness did not disappear completely, it was determined that this application increased the environmental awareness of the students. A similar study was conducted by Huang, Chen, and Chou, (2016). Within the scope of the research, an augmented reality-based experiential learning model was developed.

In a field experiment in a botanical garden, 21 secondary school students formed three groups and participated in a learning activity using different learning types and environments. The quantitative results show that the technology-assisted model elicits positive emotions and improved learning outcomes among students when compared to the human guidance model alone. The authors interpreted the results as suggesting that the use of attractive technologies not only increases students' willingness to learn more about the environment but also to develop a more positive emotional bond with the environment.

Apart from daily visits, the effects of longer-term programs were also examined. For example, Wiegand, Kubisch, and Heyne (2013) compared teacher-centered and student-centered learning programs on plants and water heads. The effects of these programs on students' motivation and knowledge levels were investigated. Working together in small groups of 3-5 people, the students decided in what order they would attend the six compulsory learning stations. The subjects of the six learning stations are water absorption from root hairs, water transport in vein strips, root pressure, transpiration, succulence, and adaptation to the “pond” habitat. According to the results, the positive and negative effects of the two teaching approaches applied balanced each other, leading to equal knowledge gain for short-term and long-term learning outcomes. In addition, it was concluded that the internal motivation of the students was similar and high. Morgan, Hamilton, Bentley, and Myrie (2009) investigated the effects of the Brooklyn Botanic Garden's Green Reach Project. In this study, the authors used field observations, document analysis, and past participant interviews to document the impact of the program on urban youth. The effects of the program were revealed through seven themes. These are; the program offers participants the chance to get away from the challenging home and school environments, changes in academic and interdisciplinary skills, changes in science and horticulture skills, increased environmental awareness, social and personal development, a positive life experience, and cultural significance of the program. The findings of a study

conducted in Turkey by Yılmaz, Vural, and Yılmaz (2023), on the other hand, showed that environmental education conducted in a natural environment is more effective than education given in a classroom environment. The study investigated the differences that indoor and outdoor educational environments reveal in students' emotional, behavioral, and cognitive approaches. The story was read in two different environments, one in the closed classroom and the other in the botanical garden. Significant differences were found in the emotional, behavioral, and cognitive approaches of students in these two environments. These differences are in favor of children who listen to stories in a botanical garden setting. It was found that the negative emotions of the students studying in the botanical garden were lower, the environmental awareness and sensitivity levels were higher than the children participating in the indoor practice, and the behaviors indicating the value of not harming natural processes and living in harmony with nature were higher.

Studies Without a Participant Group

The related studies, whose participant group characteristics could not be determined, were examined under the general title since they also differ in focus. Three studies were examined under this title. The list of these studies is shown in Table 5.

Table 5 Studies Without a Participant Group

	Authors	Publication Year	Country
1	Argaw	2015	Ethiopia
2	Gaio-Oliveira et al.	2017	International
3	Postolache et al.	2022	Portugal

Within the scope of the research conducted by Gaio-Oliveira, Delicado, and Martins-Loução in 2017, 938 botanical gardens were contacted and 206 of these gardens (22% of the total) answered the questionnaire. More than half of the 206 botanical gardens studied have a teaching staff. It was observed that the vast majority (75%) of the botanical gardens that answered the questionnaire had interpretation boards for educational purposes apart from the scientific name and geographical distribution of the plants and the classical labels. Biodiversity and plant identification are the most discussed themes among both school visitors and the public. Endangered species, climate change, and pollution were the least mentioned themes. When the different types of visitors were examined, it was seen that in almost all botanical gardens, students made up less than half of the total visitors. While guided tours are the most

preferred type of visit by school visitors, it has been observed that the visitor people prefer to travel by themselves.

Argaw (2015) compared the education programs of a botanical garden in Ethiopia with the general education curriculum. 1-4, 5-8, and 9-12 according to analysis. 18.0 percent, 24.1 percent, and 19.3 percent of grade curricula were found to be related to botanical garden programs, respectively. The study by Postolache and his colleagues (2022) aimed to systematize a set of requirements that should be considered in the development of augmented reality applications that can be used by botanical garden visitors. It has been demonstrated that in the development of such applications, four elements should be identified, categorized as objectives, content, enabling technology, and other non-functional requirements. Since the data related to this application is limited, visitor opinions about the application are not included.

Conclusions and Suggestions

Connecting with nature, changing people's values and attitudes towards environmental issues, and focusing on ecosystem-centered rather than human-centered understandings of natural resource use can help them gain knowledge and develop nature-friendly attitudes on issues such as sustainability and global climate change. Botanical gardens are suitable places for people living in cities to connect with nature, and these features make botanical gardens important informal learning centers. The fact that they are located close to the cities, that their physical structures provide the advantage of attracting visitors, and that there are millions of people visiting the botanical gardens all over the world every year reveal the educational importance of these places. The plant collections of botanical gardens make it possible to share information with people about the plants on which life on Earth depends, plant biodiversity, ecosystems, the economic, cultural, and aesthetic importance of plants, and the relations between plants and local people (Willison, 2004). Although plant protection is the primary aim of botanical gardens, this aim evidently cannot be achieved without educational activities.

It is seen that 91% of today's botanical gardens rank education among their targets, and only a few botanical gardens have evaluated the effectiveness of the programs carried out in a comprehensive or experimental way (Kneebone, 2006). To evaluate learning outcomes, it is essential to evaluate the educational programs implemented in botanical gardens (Stern et al., 2008; Willison & Green 1994). However, many environmental education programs lack a systematic evaluation approach (Carleton-Hug & Hug 2010). Each botanical garden is of a different nature and exhibits different plant species, but often offers similar facilities and

amenities. For this reason, it may be recommended to determine the educational practices to be applied in botanical gardens and the evaluation standards for these practices. Botanical gardens are evaluated in the category of museums by the International Council of Museums. For this reason, the literature on museum education can guide those concerned in the evaluation of educational activities and activities to be carried out in botanical gardens. For example, Falk and Dierking (2000) developed a learning model called the Contextual Learning Model, which enables the examination of museum learning.

As stated above, botanical gardens are regarded as museums due to their structural and functional organization. However, botanical gardens, including the world-famous Kew Gardens, often have less informational content than other museums. The presentation of information is probably limited to preserve the beauty of the garden. Haywood (2018) considers this as a missed opportunity to support science learning. It is clear that research on information content and methods and their effects is limited and new research is needed. In particular, as the results of the research examined during this review study show, the interest of the young population in plants can be increased by technology integration.

Botanical gardens have a valuable and distinctive mix of staff skills, including people who do scientific studies, grow plants, and communicate about plants (Blackmore et al., 2011). It is essential that this capacity be used to enhance the educational role of gardens. However, to meet this role, it is necessary to employ experts with pedagogical knowledge in the gardens. One of the challenges faced by botanical gardens is that most staff working in botanical garden education are not professionally trained educators or teachers (Willison, 2004). Within the scope of the study by Zhai (2012), guided tours conducted by two educators in two botanical gardens in two different cities in England were observed, and they found that the processes took place as a structured, narrative-style and educator-oriented experience in which students and teachers act together as a whole. Bowker (2004) emphasized the importance of the educator guiding the group during the visit by asking quality questions that will attract the attention of the children to facilitate the understanding of plants and human society's relationship with plants. It seems that botanical garden educators should be given adequate opportunities to continuously improve their subject knowledge and pedagogical skills. Botanical gardens can establish a collaborative partnership with teacher training institutes to enable botanical garden educators to achieve continuing professional development. Teacher training can be organized in the gardens (Willison, 1993). Additionally, networking opportunities can make it easier for these educators to share their teaching experiences and thus reflect on their own practice.

Although botanical gardens around the world run several educational and community programs, research shows that most of them only appeal to a certain segment of the population, a large proportion of the population does not visit botanical gardens, and some often view them as privileged and elite institutions (Dodd & Jones, 2010). It is suggested that botanical gardens identify strategies to reach various segments of society. In particular, widespread effects can be increased by reaching socio-economically disadvantaged individuals who benefit the least from educational opportunities in general.

The main limitations of this research are that it is limited to 32 scientific articles selected depending on the determined criteria, and the three main aspects of all the studies included in the review are (1) the participants (2) the research focus (3) the results and the application of the content analysis method. Different studies addressing the educational aspect of botanical gardens can also be reviewed in sources other than peer-reviewed journals. For example, books or book chapters written on this subject (e.g., Michener & Schultz, 2002; Zhai, 2012), oral presentation papers (e.g., Stewart, 2002), and unpublished thesis (e.g., Vergou, 2010) can be analyzed by content analysis. During this content analysis study, it is seen that research on the educational role of botanical gardens has been published by experts from different disciplines. For this reason, facts such as the language of publication and the method used differed, which made the content analysis difficult. As discussed above, establishing, and following certain standards for research in this field can increase the widespread impact both academically and practically.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest

No conflict of interest.

Funding

None.

CRediT author statement

The study was single authored and the whole process was carried out by the corresponding author.

Research involving Human Participants and/or Animals

The study is a review study.

Botanik Bahçelerinin Eğitsel Kapasitesi: Araştırma sonuçları ne söylüyor?*

Özet:

Dünya genelinde botanik bahçelerinin, her yıl 750 milyondan fazla kişi tarafından ziyaret edildiği (BGCI, 2023) düşünüldüğünde, botanik bahçeleri iklim değişikliği, gıda güvenliği ve biyolojik çeşitlilik kaybı gibi karşı karşıya olduğumuz küresel sorunların çözümünde önemli bir rol oynayabilir. Bunu başarabilmek için botanik bahçelerinin eğitim rolünün güçlendirilmesi, bu alanda bugüne kadar yapılmış araştırma sonuçların derlenmesi ve yeni yapılacak araştırmaların desteklenmesi önerilmektedir. Bu çalışma kapsamında, botanik bahçelerinin eğitim ve kamu bilinci geliştirme rolü ile ilgili yapılmış bilimsel araştırmalar hakkında derleme yapılması amaçlanmıştır. Araştırma kapsamında, botanik bahçelerinin eğitsel yönünü ele alan hakemli bilimsel dergilerde yayınlanan bilimsel çalışmalar derlenmiştir. Belirlenen ölçütlere uygun şekilde yapılan literatür taraması sonucu, otuz iki araştırmaya ulaşılmıştır. Yapılan içerik analizi ile botanik bahçelerinin eğitsel rolü, araştırmaların sonuçlarına göre sistematik olarak analiz edilmiş ve yorumlanmıştır.

Anahtar kelimeler: botanik bahçeleri, eğitim, içerik analizi

*Not: Bu derleme çalışması, 23-25 Mart 2022 tarihlerinde, Gaziantep, Türkiye'de düzenlenen 3. Ulusal Botanik Bahçeleri Arboretumlar Herbaryumlar ve Botanik Müzeleri Çalıştayı'nda sözlü bildiri olarak sunulan "Botanik Bahçelerinin Eğitim ve Kamu Bilincini Geliştirme Kapasitesi: Araştırma sonuçları ne söylüyor?" adlı çalışmanın genişletilmiş şeklidir.

References

Argaw, T. (2015). Opportunities of botanical garden in environmental and development education to support school based ınstruction in Ethiopia. *Journal of Biology, Agriculture and Healthcare*, *5*(15), 92-110. Retrieved from https://core.ac.uk/download/pdf/234661624.pdf 14 May 2023.

Avery, G. S. (1971). Botanic gardens can develop environmentalists. *BioScience, 21* (14), 766-767. https://doi.org/10.2307/1295946

Ballantyne, R., Packer, J., & Hughes, K. (2007). Environmental awareness, interests and motives of botanic gardens visitors: Implications for interpretive practice. *Tourism Management 29* (3), 439-444. https://doi.org/10.1016/j.tourman.2007.05.006

Bayindir, D., & Seggie, F. N. (2015). Teachers' personal and professional use of informal learning institutions: Focus on a botanic garden. *Uluslararası Eğitim Bilimleri Dergisi* (4), 143-155. Retrieved from https://dergipark.org.tr/en/pub/inesj/issue/40013/475699 14 May 2023.

BGCI (2023). *BGCI Joins European Commission's Global Coalition for Biodiversity*, Retrieved from https://www.bgci.org/news-events/bgci-joins-european-commissions-global-coalition-for-biodiversity 14 May 2023.

Blackmore, S., Gibby, M., & Rae, D. (2011). Strengthening the scientific contribution of botanic gardens to the second phase of the Global Strategy for Plant Conservation. *Botanical Journal of the Linnean Society, 166* (3), 267-281. https://doi.org/10.1111/j.1095-8339.2011.01156.x

Bowker, R. (2004). Children's perceptions of plants following their visit to the Eden Project. *Research in Science and Technological Education, 22* (2), 227–243. https://doi.org/10.1080/0263514042000290912

Carleton-Hug, A., & Hug, J. W. (2010). Challenges and opportunities for evaluating environmental education programs. *Evaluation and Program Planning, 33*(2), 159-164. https://doi.org/10.1016/j.evalprogplan.2009.07.005

Catahan, N., & Woodruffe-Burton, H. (2019). The view, brew and loo: perceptions of botanic gardens? , *Journal of Place Management and Development, 12* (1), 20-38. https://doi.org/10.1108/JPMD-12-2017-0127

Chang, L. S., Bisgrove, R. J., & Liao, M. Y. (2008). Improving educational functions in botanic gardens by employing landscape narratives. *Landscape and Urban Planning, 86(*3-4), 233-247. https://doi.org/10.1016/j.landurbplan.2008.03.003

Chen, G., & Sun, W. (2018). The role of botanical gardens in scientific research, conservation, and citizen science. *Plant diversity, 40*(4), 181-188. https://doi.org/10.1016/j.pld.2018.07.006

Dodd, J., & Jones, C. (2010). *Redefining the role of botanic gardens – Towards a new social purpose.* Leicester: Research Centre for Museum and Galleries (RCMG) and BGCI.

Eberbach, C., & Crowley, K. (2017). From seeing to observing: how parents and children learn to see science in a botanical garden, *Journal of the Learning Sciences, 26*(4), 608-642. https://doi.org/10.1080/10508406.2017.1308867

Falk, J. H., & Dierking, L.D. (2000). *Learning from museums: visitor experiences and the making of meaning.* AltaMira Press.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2011). *How to design and evaluate research in education.* McGraw–Hill Companies.

Funsten, C., Di Franco, C., Borsellino, V., Surano, N., Asciuto, A., & Schimmenti, E. (2022). The recreational value of botanic garden events: A case study of the Zagara

plant fair in Palermo, Italy. *Journal of Outdoor Recreation and Tourism, 39*, 1-12. https://doi.org/10.1016/j.jort.2022.100565

Gaio-Oliveira, G., Delicado, A., & Martins-Loução, M. A. (2017). Botanic gardens as communicators of plant diversity and conservation. *The Botanical Review, 83*, 282-302. https://doi.org/10.1007/s12229-017-9186-1

Galbraith, J. (2003). Connecting with plants: Lessons for life. *Curriculum Journal, 62*, 82-83. https://doi.org/10.1080/09585170302833

GSPC (2011). *The targets 2011-2020*. Retrieved from https://www.cbd.int/gspc/targets.shtml 14 May 2023.

Haywood, N. (2018). Beauty in the foreground, science behind the scenes': Families' views of science learning in a botanic garden. *Environmental Education Research, 24*(8), 1085-1101. https://doi.org/10.1080/13504622.2018.1469116

He, H., & Chen, J. (2012). Educational and enjoyment benefits of visitor education centers at botanical gardens. *Biological Conservation, 149*(1), 103-112. https://doi.org/10.1016/j.biocon.2012.01.048

Heywood, V. H. (1991). The background for education in botanic gardens. In J. Willison & P. Wyse Jackson. (Eds.), *The First International Congress on Education in Botanic Gardens: A natural environment for learning* (pp. 16-25). Botanic Gardens Conservation International.

Huang, T. C., Chen, C. C., & Chou, Y. W. (2016). Animating eco-education: To see, feel, and discover in an augmented reality-based experiential learning environment. *Computers & Education, 96*, 72-82. https://doi.org/10.1016/j.compedu.2016.02.008

Kissi, L., & Dreesmann, D. (2018). Plant visibility through mobile learning? Implementation and evaluation of an interactive Flower Hunt in a botanic garden. *Journal of Biological Education, 52*(4), 344-363. https://doi.org/10.1080/00219266.2017.1385506

Kneebone, S. (2006). *A global snapshot of botanic garden education provision – 2006* Retrieved from http://www.bgci.org/education/global_snapshot_edu_provis.

Kohlleppel, T., Bradley, J. C., & Jacob, S. (2002). A walk through the garden: Can a visit to a botanic garden reduce stress? *HortTechnology, 12*(3), 489-492. https://doi.org/10.21273/HORTTECH.12.3.489

Maclean, I. M. D., & Wilson, R.J. (2011). Recent ecological responses to climate change support predictions of high extinction risk. *Proceedings of the National Academy of Sciences, 108*(30), 12337–12342. https://doi.org/10.1073/pnas.1017352108

Michener, D.C., & I.J. Schultz (2002). Through the garden gate: Objects and informal education for environmental and cultural awareness in arboreta and botanic gardens. In *Perspectives on object-centered learning in museums*, Scott G. Paris (Eds.)., 95–111. Lawrence Erlbaum.

Murray, D., Price, B., & Crilley, G. (2007). Advocacy and visitation levels in Australian Botanic Gardens: Process and outcome benefits. *Journal of Park & Recreation Administration,* 25(3), 67-88. Retrieved from https://www.researchgate.net/profile/Duncan-Murray-3/publication/43518405_Advocacy_and_visitation_levels_in_Australian_botanic_gardens_Process_and_outcome_benefits/links/5827940408ae950ace6cdb6b/Advocacy-and-visitation-levels-in-Australian-botanic-gardens-Process-and-outcome-benefits.pdf 14 May 2023.

Morgan, S. C., Hamilton, S. L., Bentley, M. L., & Myrie, S. (2009). Environmental education in botanic gardens: Exploring Brooklyn Botanic Garden's Project Green reach. *The Journal of Environmental Education, 40*(4), 35-52. https://doi.org/10.3200/JOEE.40.4.35-52

Mounce, R., Smith, P., & Brockington, S. (2017). Ex situ conservation of plant diversity in the world's botanic gardens, *Nature Plants, 3*(10), 795-802. https://doi.org/10.1038/s41477-017-0019-3

Postolache, S., Torres, R., Afonso, A. P., Carmo, M. B., Cláudio, A. P., Domingos, D., ..., & Redweik, P. (2022). Contributions to the design of mobile applications for visitors of Botanical Gardens. *Procedia Computer Science, 196*, 389-399. https://doi.org/10.1016/j.procs.2021.12.028

Razak, M. A. W. A., Othman, N., & Nazir, N. N. M. (2016). Connecting people with nature: Urban park and human well-being. *Procedia-Social and Behavioral Sciences, 222*, 476-484. https://doi.org/10.1016/j.sbspro.2016.05.138

Salvarci, S., & Aylan, F. K. (2021). Visitor comments about botanic parks and gardens in the context of botanical tourism. *Journal of Tourism Management Research, 8*(2), 173-183. https://doi.org/10.18488/journal.31.2021.82.173.183

Sanders, D. L. (2007). Making public the private life of plants: The contribution of informal learning environments, *International Journal of Science Education, 29* (10), 1209-1228. https://doi.org/10.1080/09500690600951549

Sellmann, D. (2014). Environmental education on climate change in a botanical garden: Adolescents' knowledge, attitudes and conceptions, *Environmental Education Research, 20* (2), 286-287. https://doi.org/10.1080/13504622.2013.870130

Sellmann, D., & Bogner, F.X. (2013a). Climate change education: quantitatively assessing the impact of a botanical garden as an informal learning environment, *Environmental Education Research, 19 (*4), 415-429. https://doi.org/10.1080/13504622.2012.700696

Sellmann, D., & Bogner, F. X. (2013b). Effects of a 1-day environmental education intervention on environmental attitudes and connectedness with nature. *European Journal of Psychology of Education, 28*, 1077-1086. https://doi.org/10.1007/s10212-012-0155-0

Stern, M.J., Powell, R.B., & Ardoin, N.M. (2008). What difference does it make? Assessing outcomes from participation in a residential environmental education program. *The Journal of Environmental Education 39* (4), 31–43. https://doi.org/10.3200/JOEE.39.4.31-43

Stewart, K. (2002). What learning? What theory? In *Proceedings of the 5th International Congress on Education in Botanic Gardens*, Sydney, Australia 2002.

Tampoukou, A., Papafotiou, M., Koutsouris, A., & Paraskevopoulou,A. T. (2015). Teachers' perceptions on the use of botanic gardens as a means of environmental education in schools and the enhancement of school student benefits from botanic garden visits, *Landscape Research, 40 (*5), 610-620. https://doi.org/10.1080/01426397.2014.947250

Truong, S., Gray, T., & Ward, K. (2022). Enhancing urban nature and place-making in social housing through community gardening. *Urban Forestry & Urban Greening, 72,* 1-8. https://doi.org/10.1016/j.ufug.2022.127586

Tunnicliffe, S.D. (2001). Talking about plants – comments of primary school groups looking at plant exhibits in a botanical garden. *Journal of Biological Education, 36 (*1), 27–34. https://doi.org/10.1080/00219266.2001.9655792

Vergou, A. (2010). *An Exploration of Botanic Garden – School Collaborations and Student Environmental Learning Experiences* [Unpublished doctoral disertation]. University of Bath.

Vergou, A., & Willison, J. (2014). Relating social inclusion and environmental issues in botanic gardens, *Environmental Education Research, 22*(1), 21-42. https://doi.org/10.1080/13504622.2014.984161

Ward, C. D., Parker, C. M., & Shackleton, C. M. (2010). The use and appreciation of botanical gardens as urban green spaces in South Africa. *Urban Forestry & Urban Greening, 9(*1), 49-55. https://doi.org/10.1016/j.ufug.2009.11.001

Wassenberg, C. L., Goldenberg, M. A., & Soule, K.E. (2015). Benefits of botanical garden visitation: A means-end study. *Urban Forestry and Urban Greening, 14*, 148-155. https://doi.org/10.1016/j.ufug.2015.01.002

Wiegand, F., Kubisch, A., & Heyne, T. (2013). Out-of-school learning in the botanical garden: guided or self-determined learning at workstations? *Studies in Educational Evaluation, 39*(3), 161-168. https://doi.org/10.1016/j.stueduc.2013.06.001

Willison, J. (2006). *Education for sustainable development: Guidelines for action in botanic gardens.* Botanic Gardens Conservation International.

Willison, J. (2004). *Education for sustainable development: Guidelines for action in botanic gardens*. Botanic Gardens Conservation International.

Willison, J. (1993). An environmental education strategy for botanic gardens. In Rodrigo Perez, J. D. (Ed.), *The Second International Congress on Education in Botanic Gardens: Cultivating green awareness* (pp.29-36). Botanic Gardens Conservation International.

Willison, J., & Green, J. (1994). *Environmental education in botanic gardens: Guidelines for developing individual strategies.* Botanic Gardens Conservation International.

Williams, S. J., Jones, J. P., Gibbons, J. M., & Clubbe, C. (2015). Botanic gardens can positively influence visitors' environmental attitudes. *Biodiversity and Conservation, 24*(7), 1609-1620. https://doi.org/10.1007/s10531-015-0879-7

Wyse Jackson, P. S. (1999). Experimentation on a large scale – An analysis of the holdings and resources of botanic gardens. *Botanic Gardens Conservation News*, *3*(3), 27–30. http://www.jstor.org/stable/24753880

Yilmaz, S., Vural, H., & Yilmaz, H. (2023). Effects of botanical gardens on student environmental perception. *Ecological Informatics, 73,* 1-11. https://doi.org/10.1016/j.ecoinf.2022.101942

Zhai J. (2012). Engaging Children in Learning Ecological Science: Two Botanic Garden Educators' Pedagogical Practices. In: Tan K., Kim M. (Eds.) *Issues and Challenges in Science Education Research*. Springer.

Zelenika, I., Moreau, T., Lane, O., & Zhao, J. (2018) Sustainability education in a botanical garden promotes environmental knowledge, attitudes and willingness to act, *Environmental Education Research, 24*(11), 1581-1596. https://doi.org/10.1080/13504622.2018.1492705

Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi
Cilt 17, Sayı 1, Haziran 2023, sayfa 46-65. ISSN: 1307-6086
Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education
Vol. 17, Issue 1, June 2023, pp. 46-65. ISSN: 1307-6086

Research Article

Investigation of Learning Experiences of Primary School Students with Mathematics Learning Disability with Authentic Activities

Seda ÖZER ŞANAL [1]

[1] Fırat University, Faculty of Education, Department of Computer Education and Instructional Technology, Elazığ/Türkiye, e-posta: sedaozer@firat.edu.tr, https://orcid.org/0000-0002-6260-9212

Received : 20.12.2022 Accepted : 11.04.2023

doi.org/10.17522/balikesirnef.1221775

Abstract –This study aimed to examine the primary school children learning experiences with mathematics learning difficulties in authentic contexts. Eight primary school students with mathematics difficulties participated in the research as multiple case studies. Research data were obtained with three different data collection methods. These were determined as semi-structured interviews (before and after observation), in-class observation and document review. At the end, as the result of the data collection process, which lasted for a total of five months, the students' opinions showed that; Mathematics teaching supported by authentic activities brought along features such as familiar problems, well-defined tasks, cognitive support, authentic assessment and reflection. In addition, it was seen from the student data who participated in all of the authentic tasks that; Students who participated in authentic tasks with their peers, teachers, or parents had higher completion rates.

Key words: Mathematics learning disability, authentic context, case study, constructivism, primary school student

.

Corresponding author: Seda ÖZER ŞANAL, Fırat University, Faculty of Education, Department of Computer Education and Instructional Technology, Elazığ/Türkiye.

Introduction

Mathematics, spread out of academic context, can be used in daily life (Jansen et al., 2016; McCloskey, 2007; Reyna & Brainerd, 2007; Ojose, 2011), business life (Cohen Kadosh et al., 2013; Geary, 2011), emotional well-being (Cohen Kadosh et al., 2007) is even an essential skill at the point of adaptation to social life. This skill is a composite discipline that includes areas such as arithmetic, statistics, algebra, and geometry. Each of these areas requires

developing different individual skills, such as understanding numbers and mathematical concepts and procedures (Aunola et al., 2004). Especially in mathematics and science, many students believe that in order to achieve success, innate talent, and even brilliance are required instead of perseverance, promising approaches, support from others, and learning over time (Hong & Lin Siegler, 2012). Mathematical performance depends on specific domain skills that also require the simultaneous development of general cognitive domain abilities. Disruption of these areas can determine a cascading effect on mathematics learning. A universal difficulty or poor performance in learning mathematics is on the agenda. The low mathematics performance experienced by students in the mathematics learning process can be explained by cognitive and neuropsychological profiles, low language skills, lack of prerequisite knowledge and skills for mathematics learning, and learning difficulties or disabilities (Krajewski & Schneider, 2009; Simms et al., 2013; De Smedt et al., 2013; Sharma, 2020).

Learning difficulties in mathematics have different forms, such as difficulty on acquiring learning procedures, basic conceptual processes, or both. A child with a diagnosis of mathematics learning disabilities exhibits a wide range of poor performance profiles related to basic numerical processing, counting, transcoding, arithmetic skills,and word problems (Butterworth, 2008; Kaufmann & von Aster, 2012). Similarly, there are difficulties in learning mathematics, such as delay in learning numbers, confusion in the digits of numbers, difficulty in solving problems, understanding the mathematical language, and forgetting the basic concepts of mathematics (Courtade et al., 2015). The mathematical difficulty is addressed as "dyscalculia" in the international literature and diagnostic guidelines. Geary (2011) emphasized that competencies in each mathematics area are based on different conceptual and procedural processes supported by different cognitive abilities. While the prefix "dys" in Greek means "bad", which forms the term dyscalculia, "calculia", that is, "calcculare" in Latin, means counting (Khing, 2016). This indicates that dyscalculia means counting badly, but it seems more complex. The initial definition of dyscalculia was made by Kosc (1974) as "a difficulty in mathematics as a result of impairment in certain parts of the brain related to mathematical cognition, but without an overall difficulty in cognitive function". It is used synonymously with a mathematics learning disability or arithmetic learning disability (Soares & Patel, 2015). It is used to describe specific difficulties related to mathematics as dyscalculia and difficulty in acquiring basic concepts that support the ability to perform mathematical procedures, not a lack of intelligence (Glynis, 2013), and this difficulty is neurologically based (Kucian & Von Aster, 2015; Wadlington & Wadlington, 2008). This is a learning disability, and dyscalculia affects

an individual's mathematical learning process and behavior in this process. It is claimed that the frequency of appearance in school-age children is between six-eight percent (Sharma, 2020). Dyscalculia is a difficulty with numbers, but it should be considered a deeper problem than just being bad at mathematics (Hornigold, 2015).

Furthermore, environmental factors such as low participation, inappropriate teaching style, lack of practice, poor curriculum and low standard of the subject create much more difficulty in learning mathematics during education (Sharma, 2020). It was known that learning difficulties are caused by certain reasons such as physical, educational, emotional or environmental factors and can be improved with effective educational interventions. Individuals with learning disabilities may not be mentally retarded; learning problems are likely the result of inadequate instructional design in curriculum materials (Carnine et al., 1997). A mathematical difficulty refers to poor mathematics achievement in children, which is hypothesized by an innate weakness in mathematical cognition. It is caused by ranging from poor teaching to environmental factors, but cannot be attributed to socio-cultural or environmental factors (Soares et al., 2018). So, can children with dyscalculia be supported in their mathematics processes? Or is it impossible to recover from this difficulty or its effects? Different interventions have been proposed for these children. It is stated in the literature that different methods and techniques are effective and applicable for these children (Shalev, 2004). Interventions adapted to learning needs and pace are effective (Moeller et al., 2012). Children with dyscalculia also benefit from structured, hierarchical designs and frequent and continuous repetition (Butterworth & Laurillard, 2010; Fuchs et al., 2005).

Authentic context in learning environments

Authentic learning describes as various teaching and learning techniques that integrate what students learn in school with real-world problems, issues, and related practices (Lombardi, 2007). If learning is natural, students can directly connect their learning materials and experiences and engage with real learning problems. Learning takes place in the real world, where learners adapt the learning content to the context in which they find themselves (Hwang et al., 2018, 2019). Students take an active role in authentic learning that adopts the constructivist approach (Shadiev et al., 2016; Tobias & Dufy, 2009). Authentic learning exposes students to real-world situations through various interactive and engaging learning activities (Lombardi, 2007). Students can think about a problem from different perspectives, evaluate, share, and create new meanings and solutions (Hsiao, 2004). In authentic learning, the most appropriate learning experience is created for students, and this approach environment

supports students in developing competencies applicable to various aspects of their lives (Gulikers et al., 2005). In authentic learning, the student determines a meaningful learning goal. In addition, the student forms his thoughts about new information, obtains new information in depth, discusses concepts, acquires information learning strategy, and presents and discusses information (Glatthorn, 1999). Authentic learning allows students to explore, explain, discuss, and construct concepts in a meaningful way and participate in real-life problems in the context of real-world problems relevant to their daily lives (Donovan et al., 1999). Authentic learning is learning the cognitive processes and culture of the professional environment by participating in real-life activities and tasks faced by an adult/expert (Woolley & Jarvis, 2007).

Authentic learning is seen as a response to the traditionally non-contextualized nature of learning or alternative teaching method (Meyers & Nulty, 2009). Real-life experiences increase students' motivation (Casaley, 2004, p.12). Even students' professional skills can be supported with authentic learning, which is related to the student's real life and keeps the student active in the learning process (Gulikers et al., 2005; Reeves et al., 2002). In authentic learning, the student constantly interacts with the world, reanalyzing and interpreting what they have learned (Lave & Wenger, 1991). When the activities used in authentic learning are examined, they should be divided into sub-tasks, well-defined, complex, supported by resources, connected with the real world, developed in cooperation, and provided skills and experiences (Borthwick et al., 2007). Renzulli (1997) listed the characteristics of real-life problems that can be used in the authentic learning process: Supporting personal responsibility and cognitive awareness, having multiple solutions, containing complex goals, reflecting beliefs and values, encouraging cooperation, supporting activities, and facilitating interdisciplinary relations. In this way, exploration and discussion become continuous (Donovan et al., 1999), real-life complexity is transferred to the classroom (Cholewinski, 2009), and it encourages a focus on social and political issues outside of school (Borthwick et al., 2007). Authentic learning has the potential to teach any content that can be associated with real life.

Authentic learning is the focus of this research, because authentic learning supports mathematics skills (Dolapçıoğlu & Doğanay, 2022; Ozkan & Kılıçoğlu, 2021; Uzunboylu et al., 2020; Wardani et al., 2021) and it is an effective approach that can be used in different groups, especially in need of special education (Jobling & Moni, 2004; Kang et al., 2022; Lichtinger & Kaplan, 2015). At this point, it would be beneficial to benefit from authentic learning to support the mathematics learning of students with reading difficulties. The motivation of this study was how the mathematics skills of children with mathematics learning

difficulties changed in authentic contexts. The study was designed around the following research questions: (1) What are the views of children with mathematics learning difficulties about authentic learning activities? (2) How do students with mathematics learning difficulties complete the tasks?

Method

A qualitative exploratory multiple case study approach was chosen to examine the learning experiences of primary school students with mathematics difficulties in authentic contexts (Yin, 2014). This study examined the situation in multiple cases and established contextualized experiences and systematic analysis procedures (Yin, 2014). In particular, case studies conducted within the framework of qualitative methodology are very suitable for examining practices and beliefs (Olafson et al., 2015). In this study, the case was defined as the experiences and beliefs of students with mathematics learning disability in authentic learning activities.

Study group

A qualitative exploratory multiple case study approach was chosen to examine the learning experiences of primary school students with mathematics difficulties in authentic contexts (Yin, 2014 Eight elementary school students with mathematics difficulties participated in this study. It is known that the sample size is sufficient for the multiple case study. Stake (2013) stated that less than four or more than fifteen situations may create limitations in similar case studies. Participants were reported under different names (Table 1).

Table 1 Participants demographic information

Student	Gender	Age	Ethnicity	Diagnosis
Ata	Male	9 years 3 months	Turkish	Special learning disability(SLD)
Burak	Male	9 years 7 months		
Sefa	Male	10 years 1 month		
Mehmet	Male	9 years 5 months		
Bahadır	Male	9 years 3 months		
Seda	Female	9 years 8 months		
Meliha	Female	9 years 9 months		
Fatma	Female	9 years 4 months		

In order to identify students, the student's family provides report information from the rehabilitation center which will be obtained after the diagnosis process in child psychiatry. The

student who receives a SLD report, in which area he has problems in reading, mathematics or writing that indicated. Students receive support training in special education counseling centers according to the situation specified in their reports. All students participating in the study were diagnosed with SLD and additionally stated in their reports that they had problems in the field of "mathematics".

Measures and procedures

The data of this study were obtained from three different data collection methods. These were determined as semi-structured interviews (before and after observation), classroom observation, and document analysis. Data were collected over five months in 2022.

Each student studied between 2-4 hours per week, with minimum of 40 and a maximum of 80 hours each student. A total of 22 activities were studied with each student. Together with the researcher and four special education instructors, these activities were created. The exercises included various forms of interaction where the student, peer, instructor, or parent complemented the mathematics in a way that was relevant to everyday life. Four of the activities were done alone, four with a peer, six with teachers and peers, and eight with parents. 22 activities were completed by each pupil, and the activity files were converted to digital. To guarantee that ethical and methodological standards were upheld, a different protocol was used for each method. Eight students were the subjects of a total of 16 interviews, all of which were performed in accordance with the pre- and post-observation interview protocols. By looking at studies in the literature on the design of the learning process with an authentic setting, the interview questions were developed. Pre-observation interview questions focused on how students could use authentic context activities in the lesson, and then pre-observation interviews lasted an average of 24 minutes. Post-observation interviews focused on students' participation in authentic activities, learning experiences, interaction, desire, and performance features. Post-observation interviews lasted an average of 42 minutes. After the draft of the observation questions was prepared by the researcher, it was checked by an academician in the special education and a special education teacher teaching in the field of SLD. Some revisions were made after the controls result. A total of nine hours and 36 minutes of classroom observation was made by a different researcher using the Classroom Observation Protocol to verify and complete the individual student interview data. The observation protocol covered the period from the beginning of the lesson in the classroom to the end. All interactions in the process were recorded. The elements, such as the teacher's content, presentation style, student activity, and out-of-class tasks were reported in detail in accordance with the protocol. Finally, 23

documents were requested from teachers, including lesson and unit plans, in-class activities and explanations, and student works that were considered descriptive of participants' experiences in the learning process. These documents were requested in order to verify whether the students did a similar study on mathematics, whether they had a different learning disability that would affect the results of the study, and to verify that the teacher worked with each student on similar content. In addition, the activity documents of the students in the application process were among these documents. Moreover, the documents were reviewed with two special education teachers independent of the study process. Scoring documents for students' activities in the lesson, students' notebooks, and activity sheets were examined in detail. Observation and documents were used to obtain data on students' completion of authentic tasks. Interview data were used to obtain students' views on authentic tasks.

Data analysis

Student interviews were recorded and written down. Using the fixed comparison technique, the researcher and two other researchers examined the transcribed data. (Strauss & Corbin, 1998). Additionally, analyses of the data within and between cases were carried out. (Yin, 2014). Individual interviews with participants were transcribed. The study used two data visualization approaches Miles et al. proposed (2014). Different representations of the findings were achieved through charts and tables. The flow chart of the analysis process can be examined as follows (Figure 1).

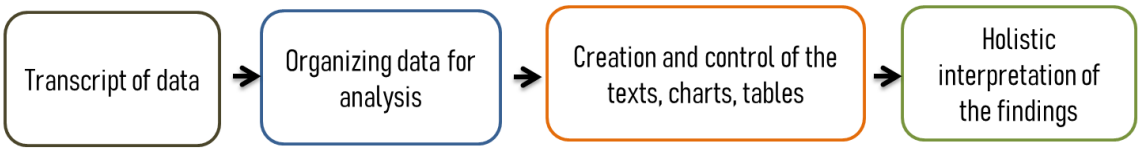


Figure 1 Flowchart of the analysis process

In this context, the activities are related to the real world; the activities are well defined, the activities include complex and continuous tasks, the activities support multiple perspectives, the activities are open to cooperation, allow students to reflect on their values, include/support an interdisciplinary perspective, include authentic evaluation, and multiple perspectives.

Coding

Inductive (Miles et al., 2014) and deductive (Miles et al., 2014) coding were used to answer the research questions. Inductive coding included two main processes: first coding (first loop) and pattern coding (second loop). First, the author reviewed the qualitative data provided by the participants. Once a consensus was made, these were further discussed, contrasted, and

refined with a researcher not affiliated with the study but skilled in qualitative work. When a complete understanding was achieved, the author coded all the data that had been verified by the coding researcher. Finally, a third researcher, independent of the study, coded the data from the author. For deductive coding, while performing classroom observations, Reeves et al. (2002) and Herrington et al. (2006) suggested that authentic learning environment features were examined and used as a framework for observations. Items were created to include possible outcomes. Deductive coding was carried out separately by the author and an independent researcher. Independent ratings showed a perfect fit.

Reliability

The Lincoln and Guba (1985) parameters used in the study's qualitative research were followed in terms of reliability standards. Reliability was accomplished using a variety of techniques, including method triangulation (Denzin, 1978), which was used to assess the consistency of the conclusions among information gathered from individual student interviews, classroom observations, and document analysis. Member controls and reference adequacy were included at different points in the analysis process (Lincoln & Guba, 1985). In the deductive coding phase, credibility was ensured through inter-interpretive reliability (Using Miles and Huberman formula (Reliability = consensus /(consensus disagreement)= 98%).

Findings and Discussions

Interviews with students were analyzed with thematic analysis protocol and themes, and sub-themes and codes were obtained. These themes were identified as associating with familiar problems, well-defined activities, scaffolding, authentic assessment, and reflection.

The views under the theme of associating with familiar problems briefly explained the experience of that real life to teach a knowledge that can be used in real life. It has been determined that there is a need for activities in the context of the real world and based on real problems.

Some excerpts from student opinions under this theme:

> *"If I see a problem with a situation I live in, I start to find solutions more quickly, and maybe I can produce more solutions. Cause I know that problem and maybe I know the solution too."(S.3)*

The opinions within the scope of the well-defined activities theme briefly explained the necessity of well-defined elements such as time, content, tasks and evaluation, and the necessity of long-term activities instead of short-term activities.

Some excerpts from student opinions under this theme:

> *"Homework is sometimes not done in ten minutes. Even so, I forget. I would like to think about it when I go home and come to class the next day."(S.7)*

The scaffolding theme briefly explained the teacher's and peer's support for the student. The teacher should be a coach in the process and manage a cooperative learning process. Instead of being an authority, the teacher should be an expert who guides the student through the process of completing the tasks. Students can seek the opinions of this expert whenever they want. The teacher should assist in processes such as information research and structuring in the task process. He should also be a model in long-term performance tasks and provide social support.

Some excerpts from student opinions under this theme:

> *"The teacher should not give the correct answer when I cannot. Alternatively, leave me alone when I ask for help. Sometimes I need to ask him something."(S.1)*

The authentic assessment and reflection theme explained the feedback that should be given to the student's sharing after structuring the knowledge. Learning is both a process and a product. Students should be allowed to explain their thinking process. Many different measurement tools need to be included.

Some excerpts from student opinions under this theme:

> *"Sometimes writing a poem about numbers or calculating the ingredients for the cake and seeing the result can be a good test."(S.2)*

As a result of the analysis of classroom observation data, it was noted that authentic activities for the content of mathematics teaching were used. However, the lack of implementation in the whole process is striking. The observed activities were analyzed and reported within the scope of the observation form. The activities were related to real-world problems rather than classroom-based activities. Moreover, most importantly, it was presented to the student in the most abstract way possible. The researcher found that clearly defined tasks were a standout quality. The teacher had already planned out the name, purpose, parameters, primary task, and subtasks for the exercise. The tasks were not finished during that lesson's allotted time. It was postponed until the following lesson or even two weeks so that it could be finished in that session. Because the student occasionally kept track of how many fruits he consumed each week and recorded his feelings as he consumed them. Such tasks can be viewed as a major time and intellectual resource investment. Not all attendees to the activities were students. Sometimes the mother and I would bake a cake, and other times we would calculate

the amount in a different way. In this way, all information related to the task could be accessed. Collaboration was always at the forefront of events.

It was determined that students' completion rate was higher when authentic tasks were done with peer-teacher-parent interaction. A total of 22 missions were completed during the observation period. Students completed 4 of these tasks individually, 4 with peers only, 6 with their peers and teachers, and 8 with their parents. The percentage of completing the tasks as a percentage reached 20% for the tasks they defined individually, 70% when they were completed only with their peers, 100% when they were completed with their peers and teachers, and 90% when they completed them with their parents.

Moreover, in general, the tasks are completed in content dominated by society's rules. The activities needed to be interdisciplinary, although not all. In this way, students had the opportunity to think about the content in different roles and complete the task. The context of the tasks evaluated the contents. Each authentic product created by the students was presented and shared, and its relationship with the task was reported. Finally, the activities did not demand products from students in a standard homework format. Instead, it offered a range that allowed for multiple solutions. Within the scope of the document analysis, 23 documents were requested from the teachers, including lesson and unit plans, in-class activities and explanations, and student works that were considered descriptive of the participant's experiences in the learning process. Moreover, the documents were reviewed with two special education teachers independent of the study process. It was written in their reports that all eight students were diagnosed with SLD and "mathematical difficulties." Although the students had no problems in reading and writing, they had difficulties learning the mathematics content. When the lesson and unit plans, in-class activities, and explanations were examined, it was remarkable that the contents were rich in authentic tasks. The association of mathematics course contents with different course contents for these students also stood out in their activity plans. When the notebooks and performance records of the students were examined, it was determined that the tasks were suitable for the activities and were completed by each student. In addition, it was seen that there was no standard product range and the results of the missions varied.

Conclusions and Suggestions

In this study, the experiences of students with mathematics learning difficulties in authentic activities were examined. The data of this study were obtained from three different data collection methods. These were determined as semi-structured interviews (before and after observation), classroom observation, and document analysis. Data were collected over five

months in 2022. To guarantee that ethical and methodological standards were upheld, a different protocol was used for each method. The interview queries centered on the ways in which the lesson's authentic context activities could be used by the students. With the help of a thematic analysis procedure, themes, sub-themes, and codes, student interviews were examined. These themes were found to be connected to well-defined tasks, scaffolding, well-known problems, reflection, and authentic evaluation. The analysis of classroom observation data revealed that authentic activities connected to actual problems were used to teach mathematics material rather than classroom-based exercises. The researcher was drawn to the clearly defined tasks as a standout quality. The tasks were' not finished during that lesson's allotted time. Not all students were the well-defined activities attracted the attention of the researcher as an outstanding feature. The activities were not completed within that lesson period. Students were not the only responders at the events. Collaboration was always at the forefront of events. Moreover, generally, the tasks are completed in content dominated by society's rules. The activities needed to be interdisciplinary, although not all. Students could think about the content in different roles and complete the task. The context of the tasks evaluated the contents. Finally, A normal homework format was not required of the students as a result of the activities. Instead, it provided a spectrum that permitted a number of options. Within the context of document analysis, it was astounding to see how many real-world duties were included in the lesson and unit plans, in-class activities, and explanations. The activity plans also stuck out because they linked activities to various course topics. The tasks were found to be appropriate for the activities and finished by every student after the notebooks and performance records of the students were reviewed. In addition, it was seen that there was no standard product range and the results of the missions varied. It has been determined that students are more successful in authentic learning processes, especially when they interact. This result was supported by many studies in the literature. Mathematics achievement increased with any scaffolding support (Cai et al., 2022; Ihechukwu, 2020; Valencia-Vallejo et al.,2018, 2019) Additionally, this finding can be supported by the increase in participation in learning content when it is supported by relevant, authentic, and fun activities (Baştürk & Alver, 2019; Gürdoğan & Aslan, 2016). It is also known that such activities support learning performance and improve the learning experience (Akça et al., 2012; Çelebi & Aydın, 2019; Gürdoğan & Aslan, 2016; Safuan & Soh, 2013). Supporting students' learning processes with real learning problems and scenarios is still important. Students taking an active role in the classroom, student participation, cooperation, and interdisciplinary activities are necessary for an effective and productive learning process (Hamurcu et al., 2016; Hockings et al., 2015; Karabulut et al., 2016; Kern et

al., 2018; Westberg & Leppien, 2018). By providing real-world experiences to students, a positive change in their intellectual capacity can be created (Church et al., 2013).

The study has several suggestions for supporting the mathematics learning processes of students with mathematics learning difficulties in authentic contexts. According to our study, students with learning disabilities in mathematics benefitted from engaging in authentic activities. Therefore, current curricula, activities, and policies must include and promote ideas, principles, and definitions in this direction in addition to supporting the learning process. In this manner, students who require this type of special education will both be supported in the short and long terms in their academic and social lives. It is essential to share concrete lists of authentic learning activities and set an example for each practitioner. In addition to supporting academic achievement, the study also showed active participation in the learning process, continuity of participation, and increased interaction. It has been revealed that authentic learning activities have an important place in the education processes of these students. Applications for integrating both authentic context and technology are also critical in the activity planning of teachers within the scope of in-service training. For this, pedagogical approaches should be in focus. The technological support of learning environments will expand the range of activities. Future studies can supplement and extend quantitative and qualitative data using qualitative and quantitative methodologies, working more longitudinally and with more students. There may be several chances to investigate real-world solutions to mathematics learning difficulties by fusing them with technology. More specifically, it is possible to assess the impact of real activities on the various skills of students who struggle with mathematics. It is possible to assess the efficacy of genuine context for kids in various special education categories.

Limitations

It is clear that the study presents important findings. However, the study has some limitations. The first of these limitations is related to the method of the study. Since the study is a case study, it is not suitable for generalization. Although the generalizability of the study is low, it is transferable. The results of the study are valid only for primary school students who have mathematical disabilities and need special education. This can also limit results, as students all live in the same country and culture. Based on these findings, future studies may try to focus on the experiences of a wider audience in different ways. Finally, the study data was obtained from observations, interviews and documents. It can also refer to different data sources in the examination of similar phenomena for future studies.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest

No conflict of interest.

Funding

None.

CRediT author statement

The study was single authored and the whole process was carried out by the corresponding author.

Research involving Human Participants and/or Animals

The study involves human participants. Ethics committee permission was obtained from Fırat University, Social and Human Sciences Research Ethics Committee.

Öğrenme Güçlüğü Olan İlkokul Öğrencilerinin Otantik Etkinliklerle Öğrenme Deneyimlerinin İncelenmesi

Özet:

Bu çalışma, matematik öğrenme güçlüğü çeken ilkokul çocuklarının otantik bağlamlarda öğrenme deneyimlerini incelemeyi amaçlamıştır. Çoklu durum çalışması olarak yürütülen araştırmaya matematik güçlüğü çeken sekiz ilkokul öğrencisi katılmıştır. Araştırma verileri üç farklı veri toplama yöntemiyle elde edilmiştir. Bunlar yarı yapılandırılmış görüşmeler (gözlem öncesi ve sonrası), sınıf içi gözlem ve doküman incelemesi olarak belirlenmiştir. Toplam beş ay süren veri toplama süreci sonunda, öğrenci görüşleri göstermiştir ki; otantik etkinliklerle desteklenen matematik öğretim, tanıdık problemler, iyi tanımlanmış görevler, bilişsel destek, otantik değerlendirme ve yansıtma gibi özellikleri beraberinde getirmiştir. Ayrıca otantik görevlerin tamamına katılan öğrenci verilerinden görülmüştür ki; otantik görevlere akran, öğretmen ya da ebeveyni ile birlikte katılan öğrenciler daha yüksek tamamlama oranına ulaşmışlardır.

Anahtar kelimeler: Matematik öğrenme güçlüğü, otantik bağlam, vaka çalışması, yapılandırmacılık, ilkokul öğrencisi.

References

Akca, H., Ata, A. Y., & Karaca, C. (2012). Inflation and corruption relationship: Evidence from panel data in developed and developing countries. *International Journal of Economics and Financial Issues, 2*(3), 281-295. Retrieved December 26, 2022 from https://dergipark.org.tr/en/pub/ijefi/issue/31954/351843

Aunola, K., Leskinen, E., Lerkkanen, M. K., & Nurmi, J. E. (2004). Developmental dynamics of math performance from preschool to grade 2. *Journal of Educational Psychology*, *96*(4), 699. https://doi.org/10.1037/0022-0663.96.4.699

Baştürk, E., & Alver, A. (2019). Modeling azo dye removal by sono-fenton processes using response surface methodology and artificial neural network approaches. *Journal of environmental management, 248*, 1-9. https://doi.org/10.1016/j.jenvman.2019.109300

Borthwick, F., Bennett, S., Lefoe, G. E. & Huber, E. (2007). Apply authentic learning to social science: A learning design for an inter- disciplinary sociology subject. *Journal of Learning design, Designing For Effective Learning, 2*(1), 14-24. Retrieved December 26, 2022 from https://eric.ed.gov/?id=EJ903900

Butterworth, B., & Laurillard, D. (2010). Low numeracy and dyscalculia: identification and intervention. *ZDM – Mathematics Education, 42*, 527-539. https://doi.org/10.1007/s11858-010

Cai, Z., Mao, P., Wang, D., He, J., Chen, X., & Fan, X. (2022). Effects of scaffolding in digital game-based learning on student's achievement: A three-level meta-analysis. *Educational Psychology Review*, *34*(2), 537-574. https://doi.org/10.1007/s10648-021-09655-0

Carnine, D., Jitendra, A., & Silbert, J. (1997). A descriptive analysis of mathematics curricular materials from a pedagogical perspective. *Remedial and Special Education, 18,* 66-81. https://doi.org/10.1177/074193259701800201

Casaley, P.M. (2004). *Toward and authentic pedagogy: An investigation of authentic learning instruction in a middle school*. Pacific Lutheran University.

Çelebi, Y. & Aydın, H. (2019). An overview on the light alcohol fuels in diesel engines. *Fuel, 236,* 890-911. https://doi.org/10.1016/j.fuel.2018.08.138

Cholewinski, M. (2009). An Introduction to constructivism and authentic activity. *Journal of The School of Contemporary Studies, 42*(2), 163-173. Retrieved December 26, 2022 from https://core.ac.uk/download/pdf/235011948.pdf

Church, J. A., Clark, P. U., Cazenave, A., Gregory, J.M., Jevrejeva, S.,Levermann,A., ..., Nunn,P. D. (2013). *Sea level change.* Cambridge University Press.

Cohen Kadosh, R. , Dowker, A., Heine, A., Kaufmann, L., & Kucian, K. (2013). Interventions for improving numerical abilities: Present and future. *Trends in neuroscience and education*, *2*(2), 85-93. https://doi.org/10.1016/j.tine.2013.04.001

Cohen Kadosh, R. C., & Walsh, V. (2007). Dyscalculia. *Current Biology*, *17*(22), 946-947. Retrieved December 26, 2022 from https://www.cell.com/current-biology/pdf/S0960-9822(07)01855-6.pdf

Courtade, G. R., Test, D. W., & Cook, B. G. (2015). Evidence-based practices for learners with severe intellectual disability. *Research and Practice for Persons with Severe Disabilities, 39*(4), 305-318. https://doi.org/10.1177/1540796914566711

De Smedt, B., Noël, M. P., Gilmore, C. & Ansari, D. (2013) The relationship between symbolic and non-symbolic numerical magnitude processing skills and the typical and atypical development of mathematics: A review of evidence from brain and behavior. *Trends in Neuroscience and Education, 2,* 48-55. https://doi.org/10.1016/j.tine.2013.06.001

Denzin, N. K. (1978). *Sociological methods: A sourcebook*. McGraw-Hill.

Dolapçıoğlu, S., & Doğanay, A. (2022). Development of critical thinking in mathematics classes via authentic learning: An action research. *International Journal of Mathematical Education in Science and Technology, 53*(6), 1363-1386. https://doi.org/10.1080/0020739X.2020.1819573

Donovan, M.S., Bransford, J.D. & Pellegrino, J.W. (1999). *How people learn: Bridging research and practice*. National Academy Press.

Fuchs, L. S., Compton, D. L., Fuchs, D., Paulsen, K., Bryant, J. D., & Hamlett, C. L. (2005). The prevention, identification, and cognitive determinants of math difficulty. *Journal of Educational Psychology, 97,* 493-513. Retrieved December 26, 2022 from . https://psycnet.apa.org/doi/10.1037/0022-0663.97.3.493

Geary, D.C. (2011). Consequences, characteristics, and causes of mathematical learning disabilities and persistent low achievement in mathematics. *Journal of Developmental & Behavioral Pediatrics, 32*, 250.

Glatthorn, A. A. (1999). *Performance standards and authentic learning*. Eye on Education.

Glynis, H. (2013). Dyscalculia: action plans for successful learning in mathematics (2nd ed.). Routledge.

Gulikers, J. T. M., Bastiaens, T. J., & Martens, R. L. (2005). The surplus value of an authentic learning environment. *Computers in Human Behavior, 21,* 509-521. https://doi.org/10.1016/j.chb.2004.10.028

Gürdoğan, M., & Aslan, A. (2016). Sınıf öğretmeni adaylarının otantik öğrenme yaklaşımı hakkındaki görüşleri [Opinions of primary school teacher candidates about authentic learning approach]. *Fen Bilimleri Öğretimi Dergisi, 4*(2), 114-140. Retrieved December 26, 2022 from https://dergipark.org.tr/en/pub/fbod/issue/71980/1157956

Hamurcu, Z., Ashour, A., Kahraman, N., & Ozpolat, B. (2016). FOXM1 regulates expression of eukaryotic elongation factor 2 kinase and promotes proliferation, invasion and

tumorgenesis of human triple negative breast cancer cells. *Oncotarget, 7(13),* 16619–16635. https://doi.org/10.18632%2Foncotarget.7672

Herrington, J., Reeves, T. C., & Oliver, R. (2006). Authentic tasks online: A synergy among learner, task, and technology. *Distance Education, 27*(2), 233-247. https://doi.org/10.1080/01587910600789639

Hockings, C., Anwari, K., Ninnis, R., Brouwer, J., O'hely, M., Evangelista, M., ..., Fairlie, W. (2015). Bid chimeras indicate that most BH3-only proteins can directly activate Bak and Bax, and show no preference for Bak versus Bax. *Cell death & disease, 6*(4), 1-9. https://doi.org/10.1038/cddis.2015.105

Hong, H. Y., & Lin-Siegler, X. (2012). How learning about scientists' struggles influences students' interest and learning in physics. *Journal of Educational Psychology, 104*(2), 469. https://doi.org/10.1037/a0026224

Hornigold, J. (2015). Dyscalculia pocketbook. Pocketbooks.

Hwang, W. Y., Utami, I. Q., & Chen, H. (2018). An Evaluation Study of Learning Behaviors and Achievements with Ubiquitous Fraction (u-Fraction) for Elementary School Student. In IEEE 18th International Conference on Advanced Learning Technologies (ICALT) (pp. 350-354). IEEE. https://doi.org/10.1109/ICALT.2018.00087

Hwang, W. Y., Utami, I. Q., Purba, S. W. D., & Chen, H. S. (2019). Effect of ubiquitous fraction app on mathematics learning achievements and learning behaviors of Taiwanese students in authentic contexts. *IEEE Transactions on Learning Technologies, 13*(3), 530-539. https://doi.org/10.1109/TLT. 2019.2930045

Ihechukwu, N. B. (2020). Impact of instructional scaffolding approach on secondary school students achievement in mathematics. *Malikussaleh Journal of Mathematics Learning, 3*(2), 46-50. Retrieved December 26, 2022 from https://eric.ed.gov/?id=EJ1283339

Jansen, B.R., Schmitz, E.A., & van der Maas, H.L. (2016). Affective and motivational factors mediate the relation between math skills and use of math in everyday life. *Frontiers in Psychology, 7*, 513. https://doi.org/10.3389/fpsyg.2016.00513

Jobling, A., & Moni, K. B. (2004). 'I never imagined I'd have to teach these children': providing authentic learning experiences for secondary pre-service teachers in teaching students with special needs. *Asia-Pacific Journal of Teacher Education, 32*(1), 5-22. https://doi.org/10.1080/1359866042000206026

Kang, J., Haughney, K., & Cheek, A. (2022). Case Studies on Students with IDD and Moderate to Extensive Support Needs: A Document Analysis. *DADD Online, 70,* 97. http://www.daddcec.com/uploads/2/5/2/0/2520220/doj_2022.pdf#page=101

Karabulut, Ş., Karakoç, H., & Çıtak, R. (2016). Influence of B4C particle reinforcement on mechanical and machining properties of Al6061/B4C composites. *Composites Part B: Engineering,101,* 87-98. https://doi.org/10.1016/j.compositesb.2016.07.006

Kaufmann, L., & von Aster, M. (2012). The diagnosis and management of dyscalculia. *Deutsches Ärzteblatt International*, *109*(45), 767. https://doi.org/10.3238%2Farztebl.2012.0767

Kern, J., Chatterjee, R., Young, I. D., Fuller, F. D., Lassalle, L., Ibrahim, M., ..., Alonso-Mori, R. (2018). Structures of the intermediates of Kok's photosynthetic water oxidation clock. *Nature, 563*, 421-425. https://doi.org/10.1038/s41586-018-0681-2

Khing, B. (2016). Dyscalculia: its types, symptoms, causal factors, and remedial programs. *Learning Community, 7*(3), 217-229. https://doi.org/10.5958 /2231-458X.2016.00022.1

Kosc, L. (1974). Developmental dyscalculia. *Journal of Learning Disabilities, 7*(3), 46-59. https://doi.org/10.1177/002221947400700309

Krajewski, K. & Schneider, W. (2009). Early development of quantity to number-word linkage as a precursor of mathematical school achievement and mathematical difficulties: Findings from a four-year longitudinal study. *Learning and Instruction*, *19,* 513-526. https://doi.org/10.1016/j.learninstruc.2008.10.002

Kucian, K., & Von Aster, M. (2015). Developmental dyscalculia. *European Journal of Pediatrics, 174*(1), 1- 13. https://doi.org/10.1007/s00431-014-2455-7

Lave, J. & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press.

Lichtinger, E., & Kaplan, A. (2015). Employing a case study approach to capture motivation and self-regulation of young students with learning disabilities in authentic educational contexts. *Metacognition and Learning*, *10*, 119-149. https://doi.org/10.1007/s11409-014-9131-1

Lincoln, Y., & Guba, E. (1985). *Naturalistic inquiry*. Sage.

Lombardi, M. M. (2007). *Authentic learning for the 21st century: An overview* (pp. 1-12). Educause Learning Initiative.

McCloskey, M. (2007). Quantitative literacy and developmental dyscalculias. In D. B. Berch & M. M. M. Mazzocco (Eds.), *Why is math so hard for some children? The nature and*

origins of mathematical learning difficulties and disabilities (pp. 415–429). Paul H. Brookes Publishing.

Meyers, N. M., & Nulty, D. D. (2009). How to use (five) curriculum design principles to align authentic learning environments, assessment, students' approaches to thinking and learning outcomes. *Assessment & Evaluation in Higher Education, 34*(5), 565-577. http://dx.doi.org/10.1080/02602930802226502

Miles, M., Huberman, M., & Saldana, J. (2014). Qualitative data analysis: A methods sourcebook (3rd ed.). Sage.

Moeller, K., Fischer, U., Cress, U., and Nuerk, H. C. (2012). Diagnostics and intervention in developmental dyscalculia: current issues and novel perspectives. In Z. Breznitz, O. Rubinsten, V. J. Molfese & D. L. Molfese (Eds.), *Reading, writing, mathematics and the developing brain: Listening to many voices* (pp. 233–294). Springer.

Ojose, B. (2011). Mathematics literacy: Are we able to put the mathematics we learn into everyday use. *Mathematics Education. 4*, 89-100. Retrieved December 26, 2022 from https://filinja.com/wp-content/uploads/2019/05/9510-1640-251f.pdf

Olafson, L., C. Grandy & Owens, M. (2015). Qualitative approaches to studying teachers' beliefs. In H. Fives & M. G. Gill (Eds.), *International handbook of research on teachers' beliefs* (pp. 128-149). Routledge.

Ozkan, T., & Kilicoglu, E. (2021). Reflections of authentic learning on students' scientific process skills and achievements in mathematics. *Acta Didactica Napocensia, 14*(1), 29-44. https://eric.ed.gov/?id=EJ1308685

Reeves, T. C., Herrington, J., & Oliver, R. (2002). *Authentic activity as a model for web- based learning.* Annual Meeting of the American Educational Research Association.

Renzulli, J. S. (1997). *How to develop an authentic enrichment cluster.* National research center on the gifted and talented.

Reyna, V.F. & Brainerd, C.J. (2007). The importance of mathematics in health and human judgment: Numeracy, risk communication, and medical decision making. *Learning and Individual Differences, 17*, 147-159. https://doi.org/10.1016/j.lindif.2007.03.010

Safuan, H. A. J., & Soh, R. (2013). The integration of authentic learning principles and Facebook in service learning. *Turkish Online Journal of Educational Technology-TOJET, 12*(4), 192-199. Retrieved December 26, 2022 from https://eric.ed.gov/?id=EJ1273286

Shadiev, R., Hwang, W.-Y., Huang, Y.-M., & Liu, T.-Y. (2016). Cognitive diffusion model: Facilitating EFL learning in an authentic environment. *IEEE Transactions on Learning Technologies, 10*(2), 168-181. https://doi.org/10.1109/TLT.2016.2574356

Shalev, R. (2004). Developmental dyscalculia. *Journal of Child Neurology, 19*(10), 765-771. https://doi.org/10.1177/08830738040190100601

Sharma, M. (2020). *Mathematics for all. Mathematics education workshop series at Framingham State University*. Mathematics Education Workshop Series.

Simms, V., Gilmore, C., Cragg, L., Marlow, N., Wolke, D. & Johnson, S. (2013). Mathematics difficulties in extremely preterm children: Evidence of a specific deficit in basic mathematics processing. *The Journal Of Pediatric Research, 73*, 236-244. https://doi.org/10.1038/pr.2012.157

Soares, N., & Patel, D. (2015). Dyscalculia. *International Journal of Child and Adolescent Health, 8*(1), 15-26. Retrieved December 26, 2022 from https://psycnet.apa.org/record/2015-46796-009

Soares, N., Evans, T., & Patel, D. R. (2018). Specific learning disability in mathematics: a comprehensive review. *Translational pediatrics, 7*(1), 48. https://doi.org/10.21037%2Ftp.2017.08.03

Stake, R. E. (2013). *Multiple case study analysis*. Guilford press.

Tobias, S., & Dufy, T. M. (2009). The success or failure of constructivist instruction: An introduction. In S. Tobias & T. M. Dufy (Eds.), *Constructivist instruction: Success or failure?* (pp. 3-10). Routledge.

Uzunboylu, H., Tezer, M., & Yildiz, E. P. (2020). The effects of the authentic learning approach with a course management system (Moodle) on students' mathematics success and online authentic learning self-efficacy. *Educational Research and Reviews, 15*(11), 679-689. https://eric.ed.gov/?id=EJ1280106

Valencia-Vallejo, N., López-Vargas, O., & Sanabria-Rodríguez, L. (2018). Effect of motivational scaffolding on e-learning environments: Self-efficacy, learning achievement, and cognitive style. *Journal of Educators Online, 15*(1), n1. Retrieved December 26, 2022 from https://eric.ed.gov/?id=EJ1168944

Valencia-Vallejo, N., López-Vargas, O., & Sanabria-Rodríguez, L. (2019). Effect of a metacognitive scaffolding on self-efficacy, metacognition, and achievement in e-learning environments. *Knowledge Management & E-Learning, 11*(1), 1-19. Retrieved December 26, 2022 from https://eric.ed.gov/?id=EJ1245649

Wadlington, E., & Wadlington, P. (2008). Helping students with mathematical disabilities to succeed. *Preventing School Failure: Alternative Education for Children and Youth, 53*(1), 2-7. https://doi.org/10.3200/PSFL.53.1.2-7

Wardani, R., Zakaria, M., Priyanto, P., Luthfi, M. I., Rochmah, I. N., Rahman, A. F., & Putra, M. T. M. (2021). An authentic learning approach to assist the computational thinking in mathematics Learning for elementary school. *Elinvo (Electronics, Informatics, and Vocational Education), 6*(2), 139-148. http://dx.doi.org/10.21831/elinvo.v6i2.47251

Westberg, K. L., & Leppien, J. H. (2018). Student independent investigations for authentic learning. *Gifted Child Today,41*(1), 13-18. https://doi.org/10.1177/1076217517735354

Woolley, N. N., & Jarvis, Y. (2007). Situated cognition and cognitive apprenticeship: A model for teaching and learning clinical skills in a technologically rich and authentic learning environment. *Nurse Education Today, 27*(1), 73-79. http://dx.doi.org/10.1016/j.nedt.2006.02.010

Yin, R. K. (2014): *Case study research, design and methods*. 5th edition, Sage.

Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi
Cilt 17, Sayı 1, Haziran 2023, sayfa 66-98. ISSN: 1307-6086
Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education
Vol. 17, Issue 1, June 2023, pp. 66-98. ISSN: 1307-6086

Research Article

Concept Images of Prospective Mathematics Teachers for Geometric Representation of the Double Integral Concept

Mustafa ÖZBEY [1], Şenol DOST [2]

[1] Hacettepe University, Institute of Educational Sciences, Beytepe, 06800, Ankara, hacettepe.mustafa.ozbey@gmail.com, http://orcid.org/0000-0002-8638-5153

[2] Hacettepe University, Mathematics and Science Education, 06800, Beytepe, Ankara, Turkey, dost@hacettepe.edu.tr, http://orcid.org/0000-0002-5762-8056

Received : 31.03.2023 Accepted : 12.05.2023

doi.org/10.17522/balikesirnef.1274911

Abstract – This study has focused on how prospective mathematics teachers understand the geometric representation of double integral. The basic qualitative research method was adopted as the research design in accordance with the research purpose. Six participants have been asked six questions. Later, semi-structured interviews were conducted with the participants. In this study, the data obtained from questionnaire form and interviews were analyzed with open and axial coding. As a result of this research, it was observed that the concept images of prospective mathematics teachers were grouped into two categories as "area" and "volume". It was determined that the participants acted with an intuitive approach without having to establish a relationship between the concept definition and the concept image, the $\iint$ in the symbol of the double integral caused the participants to think of it as a two-dimensional geometric structure and their image of the concept of the single integral was very active. The findings obtained in this research show that there are problems in understanding the concept of the double integral, which is the first step of generalizing to multiple integrals, and that educators should produce solutions for this subject.

Keywords: Double integral, concept image, concept definition, prospective mathematics teachers.

Corresponding author: Şenol DOST, dost@hacettepe.edu.tr

Introduction

Multivariate calculus helps us mathematically understand objects in the 3D world. Many of the functions that represent most objects in everyday life depend on more than one variable. For example, the volume of a right circular cylinder is equal to the product of the height with

the area of the circle. Therefore, the application fields of multivariate calculus are wider than single-variable calculus application fields. Basic concepts of calculus find applications other than mathematics such as probability, statistics, biology, physics, economics and engineering (Stewart, 2009). However, the concepts of multivariate calculus are not well understood and there are few studies for the teaching of these concepts (Dorko & Weber, 2014).

Teacher training programs vary based on the countries' educational goals and generally consist of disciplinary subjects, educational studies and teaching practices (Comiti & Ball, 1996). For instance, the mathematics education undergraduate program is shaped around the deep field knowledge of prospective mathematics teachers, pedagogical knowledge of the field and knowledge to ensure the cognitive development of students (Loewenberg Ball et al., 2008; Shulman, 1987). While teachers' thinking structures, mental schematics and beliefs affect teaching practices in the classroom environment and students' learning (Ernest, 1988; Heid et al., 1998), teacher training programs should be able to reflect the nature of mathematics well to prospective teachers (Fennema & Franke, 1992) since students' mathematical thinking can be improved (Dossey, 1992; Loucks-Horsley et al., 2009). Therefore, mathematics teachers should have advanced mathematics thinking. Although Calculus 1 and 2 where single-variable functions are located, linear algebra and the image of pre-university mathematical concepts have been researched for over 40 years exceedingly, little is known about the image of advanced mathematical concepts (Hamza, 2012). Moreover, it is also difficult to create an appropriate concept image when advanced mathematical concepts need a high level of thinking (Tall & Vinner, 1981).

Prospective mathematics teachers take multivariate calculus as a field course and stated that their learning of multivariate calculus concepts better interprets single-variable concepts (Tchoshanov et al., 2002). In addition, it was observed that mathematics teachers who took multivariate calculus courses were more successful in understanding the basic concepts of calculus (Tchoshanov et al., 2004). Teachers who do not have a deep understanding of calculus concepts will also be incapable of educating students with the ability to pursue careers in science, technology, engineering, and mathematics (STEM) (Maltas & Prescott, 2014). Thereby societies that could not be settled with their age in the 21st century, whose economy was weak and dependent on other countries would be created. For this reason, calculus education has become a necessity to be taught conceptually in both secondary education and higher education (Sofronas & DeFranco, 2010).

One of the basic concepts of calculus, which has an increasing use in this century and has an application in real life problems, is the double integral (Steward, 2009). The double integral is the integral of a two-variable and continuous function $f\ (x, y)$ over a bounded region in the plane. More clearly; we consider a function of two variables defined on a closed rectangle

$$R = [a, b]x[c, d] = \{(x, y) \in R^2 |\ a \leq x \leq b, c \leq y \leq d\}$$

and we first suppose that $f(x, y) \geq 0$. The graph of f is a surface with equation $z = f(x, y)$. Let S be the solid that lies above R and under the graph of f. We are trying to find the volume of S. First, we will divide the R region into rectangles as seen in Figure 1.

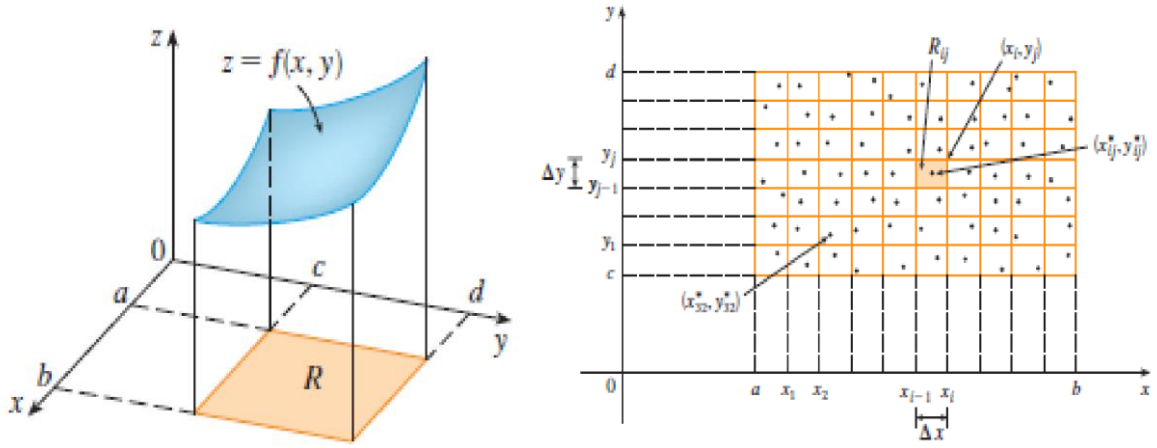


Figure 1 Dividing R into rectangles

Then the area of each rectangle ($\Delta A = \Delta x \Delta y$) and the $f(x_{ij}^*, y_{ij}^*)$ value of a point inside the rectangle is multiplied. So, the volumes of the prisms formed are found. Then, if we add all the volumes, we get the approximation $V \cong \sum_{i=1}^{m} \quad \sum_{j=1}^{n} \quad f(x_{ij}^*, y_{ij}^*)\Delta A$ for the volume of S as seen in Figure 2.

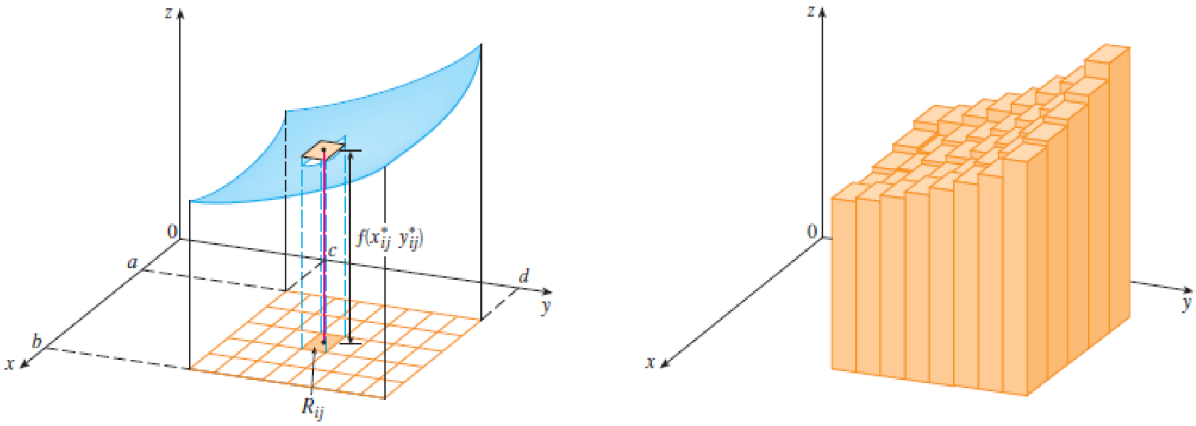


Figure 2 Volume approximations of the solid

While the width and length of each rectangle are reduced (as m and n increase) the volume sums of the prisms converge to the quantity. $V = \sum_{i=1}^{m} \quad \sum_{j=1}^{n} \quad f(x_{ij}^{*}, y_{ij}^{*})\Delta A$ is defined under the graph of f and the volume of the solid S remaining above the rectangle R. This limit also occurs when f is not positive. And the double integral of f over the rectangle R is $\iint_R f(x,y)dA = \sum_{i=1}^{m} \quad \sum_{j=1}^{n} \quad f(x_{ij}^{*}, y_{ij}^{*})\Delta A$, if this limit exists (Steward 2009). Therefore, the understanding of volume is at the heart of the double integral concept. For this reason, students are expected to see this implicit relationship in order to learn more deeply while learning the double integral concept. Otherwise, the students' understanding of the double integral concept will not be able to go beyond the operation that a calculator does. For example, students will have trouble interpreting situations where the function is negative. The curriculums expect students to see these implicit relationships by going beyond the procedural knowledge (Radzimski, 2020).

Many studies have been conducted about the single integral in the literature of mathematics education, and in some of these studies it has been discovered that since the students regard the integral calculation and area calculation the same (Rösken & Rolka 2007), they perceive the symbolic form of the integral as a special function such as $f(x) = sin\,(x)$ (Rösken & Rolka 2007; Serhan 2015), have difficulties in creating representation (Huang 2015; Serhan 2015), act with prototype examples (Jones 2018) and have difficulty in defining the relationship between image and definition (Rasslan & Tall 2002; Habineza 2013; Rösken & Rolka, 2007; Serhan 2015). There are not many studies relating to the multiple integral and it is observed that mathematics instructors have been starting to focus on multiple integral over the last five years (Martinez-Planell & Trigueros 2020). In this context; the generalization of the single-variable integral into the multiple integral (Jones & Dorko 2015), the pedagogical examination of the teaching of double and triple integral definitions by dividing them into geometric, numerical and symbolic representation layers (McGee & Martinez-Planell 2014) and how students establish the relationship between the multiple integral and the Riemann sum have been investigated (Martinez-Planell & Trigueros 2020).

There are difficulties and hardships in understanding the concept of double integral, which requires high-level cognitive competence (Dorko & Eric 2014; McGee & Martinez-Planell 2014). The concept of double integral makes it difficult for students to understand because it requires understanding function of two variables, three-dimensional geometry knowledge and visualization skills. Once students have learned the single integral, they should

be able to generalize the concept of single integral both conceptually and procedurally as the first step of inductive reasoning. Problems in a mental configuration in the concept of double integral will cause problems in the concept of multiple integral as well. For this reason, the diagnostic and treatment methods of mental structures of the students for the double integral concept will also contribute to the mental structuring studies of the multiple integral concepts.

The quality of the relationship between the concept and their geometric representation also reveals the quality of understanding (Fischbein, 1993). Rösken and Rolka (2007) mentioned the importance of the analytical and geometric definitions of the concept of integral and stated that using different images instead of single and dominant images for the concept of integral will take conceptual understanding to an advanced level. Oberg (2000), on the other hand, stated that the reason for the sign problem of function that the students experience when the results of the integral processes are negative is that they cannot identify a relationship between the integral and its geometric representation. According to APOS theory, which examines how to learn advanced mathematics concepts, the relationship between multivariable functions and its geometric representation takes place only at a high level cognitive stage (McGee & Martinez 2014; Şefik & Dost, 2019). In addition, it has been determined that students have difficulty in understanding the relationship between the double integral and its geometric representation (McGee & Martinez 2014; Martinez-Planell & Trigueros 2020; Şefik & Dost 2019). Thus, their understanding (images) of the geometric representation of the concept of the double integral is of high importance. It will be beneficial to reveal how much the students' understanding of volume is in accordance with the nature of the double integral concept and in what context it is difficult to teach the concept better. In this context, this study is aimed to determine concept images of prospective mathematics teachers for the geometric representation of a double integral concept. Accordingly, the following research problem has been answered:

What are the concept images of prospective mathematics teachers regarding the geometric structure of the concept of double integral?

Theoretical framework

The whole cognitive structure formed in the individual's memory for a concept is called "concept image" (Tall & Vinner, 1981; Vinner 1983). It consists of all cognitive structures such as mental pictures, features, and processes related to the concept (Tall & Vinner, 1981; Vinner 1983). When a function word is heard, examples can be given, such as remembering the expression y=f(x) or reviving a function graph in the mind (Vinner, 1991).

The concept definition is a set of words that accurately describe a concept (Vinner, 1983). From this point of view, the definition of concept can be expressed as a structure consisting of words and/or symbols used by textbooks or relevant experts. Definitions shape our image of the concept, and once the image is formatted, the definitions are abandoned or forgotten (Vinner, 1991). The effective status of the concept images that are generated can vary depending on time, event, or even question (Tall & Vinner 1981; Vinner, 1983). This means that an image of a concept that is effective in one question may not be effective in the other question.

Image is an element that defines knowledge and gives information about whether people's thoughts belonging to the concept are appropriate for the formal structure (Smitt & Kosaslyn, 2014). The theoretical framework for "concept definition and concept image" in mathematics education covers how students think and understand a mathematical concept, in short, all the cognitive structure of a concept. In this study, the theoretical framework of the concept definition and concept image will be used to determine how prospective mathematics teachers shape the geometric representation of the double integral in their minds. Thereby, by determining the images for the geometric representation of the concept of double integral, how they conceptualize the double integral and the problems encountered will be revealed.

Method

Since the study aims to reveal the concept images of prospective mathematics teachers about the geometric representation of double integral, the basic qualitative research method was adopted as the research design. Basic qualitative research is about how people interpret their experiences and how they make sense of their own minds (Merriam, 2009). This is to reveal how prospective mathematics teachers interpret the geometric representation of the double integral and how they formed the concept image. Besides, qualitative research designs contribute to the consistency of the research phases by providing a flexible approach to the researcher in determining data collection and analysis approaches.

Participants

Students' mathematical learning changes according to the student population of learning (Kloosterman, 2002). For example, while it is sufficient for engineering students to learn procedural information by profession, conceptual understanding is not very important to them (Khiat, 2010). However, conceptual learning is very important for prospective mathematics teachers expected to reach more abstract concepts than other professions. For this reason,

participants in the study consist of six prospective mathematics teachers (P_1, P_2, P_3, P_4, P_5, P_6) who are studying in the faculty of education in a state university in the 2017-2018 academic year and that can provide data diversity.

Calculus 4 course is offered in the spring term of the second class and focuses on the limit-derived concepts of multivariate functions and multiple integral. The teaching program is scheduled to finish the double integral concept in 12 hours. In Calculus 4 course, formal definition, algebraic operations, Fubini theorems, region transformations, area and volume calculations and improper integral subjects are taught for the double integral concept. In this context; participants were selected from the students who succeeded in lesson Calculus 4. Additionally, participants are made up of volunteers in accordance with the opinions of the relevant instructor. Examination of students' comments and exams during the course process allows the instructor to be a natural observer. Thus, it is expected that it will be possible to reach different and rich images.

Data Collection Tools

The data consists of written responses to the questionnaire form of the participants and audio recordings from semi-structured interviews with the participants about these questions. Firstly, while the concept of the double integral was offered in the Calculus 4 lesson, one of the researchers listened to the course for 3 weeks. A questionnaire form has been created taking into consideration the questions and responses students have asked in the lessons. Two expert opinions were consulted for questions prepared to ensure the content validity of the research. A pilot study has been performed with 10 students who have just learned the double integral concept. In the pilot implementation, written questionnaires have been given in their classes and during the application courses. There have been six questions (from Q1 to Q6) (Appendix 1) after the pilot study. Semi-structured interview form questions were prepared based on both the observations of Calculus 4 lectures to understand students' and lecturers' reactions to the related concept and adopted questions from previous research (e.g., Rasslan & Tall, 2002; Rösken & Rolka, 2007) according to research purposes. These questions are about concept image, interpreting symbolic and geometric representation, formal structure of double integral and calculation of Riemann Sum. After the questions of the semi-structured interview forms were formed, two expert opinions were taken to ensure the quality of both mathematics and mathematics education content of questions. Interview questions were revised and asked expert opinions until providing consensus. Some questions are revised to be provided more clearly. New questions were also added based on the research purpose. Based on expert opinions, Semi-

structured interview questions are formed from easy to hard levels. Different images of students were tried to be reached by using verbal, algebraic, and graphical representations in the questions. The questionnaire form has been applied to the participants at any time in the classroom environment. They were asked to answer the questions in writing. There has been a semi-structured interview with six participants answering questionnaire form. The interviews were held at the time the participants requested. The following questions have first asked in the semi-structured interview:

I1) What do you understand from the concept of double integral?

I2) What is the formal definition of a double integral?

I3) What do you think about the geometric representation of the double integral?

After these questions, questions such as “What did you think in this question?”, “How did you calculate this question?”, “Could you explain why you thought like that” were asked in line with their answer to the questions. In addition, they have been asked additional questions based on the expressions of their participants in a semi-structured interview.

For example, when the participant said that the two-fold integral was a two-dimensional geometric structure when the integrand function was 1, the researcher asked the participant "What does the $\int_0^1 \int_0^1 dydx$ integral mean geometrically?" Vinner (1983) noted that students may have the wrong image of a concept even if they pass the exam. In addition, the conformity or relationship of the resulting concept images to the concept definition has been examined from the perspective of capacity understanding of the double integral definition described in the introduction. For example, when the participant stated in the questionnaire form that he found volume with the integral in Q2, he was asked what the integrand function meant geometrically. Thus, it has been examined whether the concept image is related to the concept definition.

The interview has been audio recorded with the permission of the participants. No time restriction has been made. The semi-structured interview lasted 45 minutes approximately.

Data Analysis

In this study, the content analysis process proposed by Strauss and Corbin (1990) is adopted. It is desired to reveal the concepts and relationships hidden in the data by subjecting them to a deep process in content analysis. It is not easy to form the appropriate concept image in advanced calculus concepts (Tall & Vinner, 1981). In order to reveal students' concept image in depth, the data were analyzed to benefit from open and axis coding techniques of grounded

theory. These analysis methods allow the examination of the concept images in the most detailed way and to reveal the implicit mental pictures. Otherwise, for example, the concept images for the concept of integral will not go beyond the calculation of area and volume, and whether it is related to the concept definition will not be exactly determined. Researchers have not interfered with any participant's perspective. The data acquired with audio recording has been first converted into written form before proceeding with data analysis. The answers of the participants to the questionnaire form and the written data from the semi-structured conversation audio recordings have been assessed by transferring them to the Maxqda 2018 program. The data obtained from the questionnaire form and audio recordings were evaluated as holistic. In other words, the data obtained from the questions have not separated from each other. The concepts and connections included in the answers have tried to be analyzed by comparing them with each other.

Data analysis has been analyzed step by step and then comparatively by two authors; analysis supported by open and axial coding. Open coding is an analytical process in which the dimensions and features of the concepts are attempted to be discovered by carefully separating the data into the smallest piece (Strauss & Corbin, 1998). After the data has been separated into its smallest part, the labeling process has been performed by asking persistent questions such as “What is the major idea brought idea brought out this sentence?” (Strauss & Corbin 1998, p. 120) and continuously comparing the data. The two researchers have independently encoded a participant's interview deciphering. After that, unnecessary codes have been discarded by discussing among themselves and the codes have been finalized. Then, the transcripts of the other participants have been also examined in this perspective. Finally, the researchers have came together and discussed the differences. Member control is one of the most important strategies of qualitative studies to learn how accurately codes reflect what participants express (Rossman & Rallis, 2012). Two participants have been selected and confirmed that the coding made reflected their own thoughts, and the final version of open coding has been decided. As far as possible, analytical codes have been tried to be reached from descriptive codes (Urquhart 2012). For example, in the 6th question of the application, when participants have been asked to find the double integral result using the volumes below and above of the surface in both $-z$ and z, they marked the sum of volumes $V_1 + V_2$. P_3 has explained this as follows:

Because it is on the positive side of the region here is on the negative side. (….) If I say this place V, it will be found out. $-V$ negative. For example, we take this directly as the volume would not be negative.

This data has been first labeled as “non-negative status of volume calculation”. Later, when other data have been examined since the participant considers the volume finding account and the integral account to be identical, it has been seen that the result of the integral calculation will not be negative, this data piece has been coded as “The identical state of volume and integral”.

Axial coding is the process of classifying data around categories based on the characteristics and dimensions (Strauss and Corbin 1998), which we study in the most detail in open coding. After open coding, the two researchers have independently determined which categories these codes have dimensions by re-examining the written responses to the transcripts and application questions. The two researchers have finally agreed on the encodings in Table 1. Table 1 shows categories, subcategories (“concepts that pertain to a category” (Strauss and Corbin 1998, p. 101)). Open codes, and each concept will be explained in detail in the findings section.

Table 1 Concept images of prospective mathematics teachers for the geometric representation of the double integral

Category	Subcategory	Open coding
Area	As a discourse, the state of expressing the area. (Expressed as double integral discourse)	Area of non-rectangular regions (geometric shapes that cannot be calculated with a certain formula), area of the region (the area of the integral region in the double integral), area under a curve (the area under a curve within the limited interval), shadow of a curve (finding the area of the place between the curve and the plane by moving a curve to the xyz-plane), three-dimensional area (the area of that shadow by drawing a curve on the XYZ-plane, showing its shadow in two dimensions), surface area (finding the area of a surface with a double integral)
	The status of "able to calculate area" (Status in which case the area is calculated with the double integral)	If the function is 1 (the expressions of the participant who considers that integrand function is 1 as a rule), absence of function (the expressions of the participant who states that integrand function is one and there is no function), the status of area calculation by integral if the height is 1 when calculating the volume (the integrand function is geometrically high and height be).
	Connection of integral area (Relationship between integral account and area account)	Identical status of area and integral (the interpretations of the participants indicating that the result of double integral will not be negative and zero), Differentiation of area and integral (the interpretations of the participants indicating that the result of double integral may be negative and zero)
	Area calculation strategy (Interpretations made while calculating areas with double integral)	The status of non-calculation of the area if the function is not given (situations where a geometric shape is asked to express the area with a double integral; the participant states that he/she cannot solve it because no function is given)
Volume	As a discourse, the state of expressing the volume. (Expressed as double integral discourse)	The volume of the remaining space between the region and $f(x,y)$ (volume of the remaining part between the surface and the specific region while calculating the double integral), The volume of solid (volume of solid objects such as a prism, cylinder),

		the cross-section method (the cross-sectional method used when calculating the volume with the single integral), volume of irregular objects (volume of objects that cannot be directly calculated by formula such as prism, cylinder), the disk method (the disk method used when calculating the volume with the single integral)
	The status of "able to calculate volume" (Status in which cases volume is calculated with the double integral)	The status of being triple integral (the concept of volume is related to triple integral concept) status of being function inside the integral (situations where the integral function of the double integral 1 does not exist), status of setting additional conditions (the operations performed when calculating the single integral volume), the status of able to calculate volume if $f(x,y) \geq 0$ is (double integral represents volume where integrand function in double integral is positive)
	Connection of integral volume (Relationship between integral calculation and volume calculation)	Identical status of volume and integral (double integral operation and volume calculation are identical and the result of double integral cannot be negative and zero), Differentiation of volume and integral (the result of double integral operation may be negative and zero)
	Volume calculation strategy (Interpretations made while calculating volume with double integral)	The status of unable to calculate volume if height (z) is not given (volume calculation will not be made because no integrand function is given when a solid is provided and asked to be calculated with double integral)

Findings

In this part, findings related to concept images of prospective mathematics teachers for the geometric representation of the double integral concept are provided. As a result of the analysis of the data of this research, it has been that the concept images of the prospective mathematics teachers for the geometric representation of the concept of double integral are gathered in the categories of “area” and “volume”.

Area

This category refers to the concept image of the participants who see the double integral concept as an “area" from prospective teachers.

As a discourse, the state of expressing the area

This subcategory represents the answers given by the participants who see the double integral as “area”. The following codes represent the participants' comments representing their understanding of double integral while interpreting the semi-structured interview questions (I1 and I3) and explaining their answers to the questions, Q1 and Q2, in the questionnaire form.

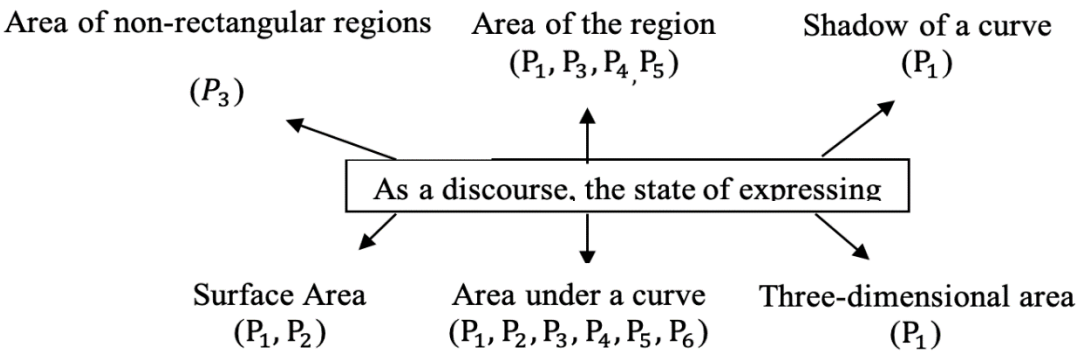


Figure 3 The classification of the expressions of the participants "what they have found" with double integral

The idea reflected by each code in Figure 3 is described below. In this way, the expressions related to the views of the participants are reflected by making direct references.

The area of non-rectangular regions refers to geometric shapes that cannot be calculated with a certain formula, such as squares, rectangles, etc., P_3 shared his thoughts on the double integral concept as follows:

"Hmm. Well. For example, there is a region, an area with no clear shape. (….) We cannot calculate them directly. So, I think the double integral has been consulted."

The area of the region represents the area of the integral region in the double integral. When the researcher asked what area we have found, P_5 said he found the area of "a closed region".

The shadow of a curve represents finding the area of the place between the curve and the plane by moving a curve to the xyz-plane. P_1 expressed how he found the area with double integral as follows and illustrated his thoughts as shown in Figure 4:

"Areaaa. I would draw a function. Like a shadow of a function, I would reduce the area down."

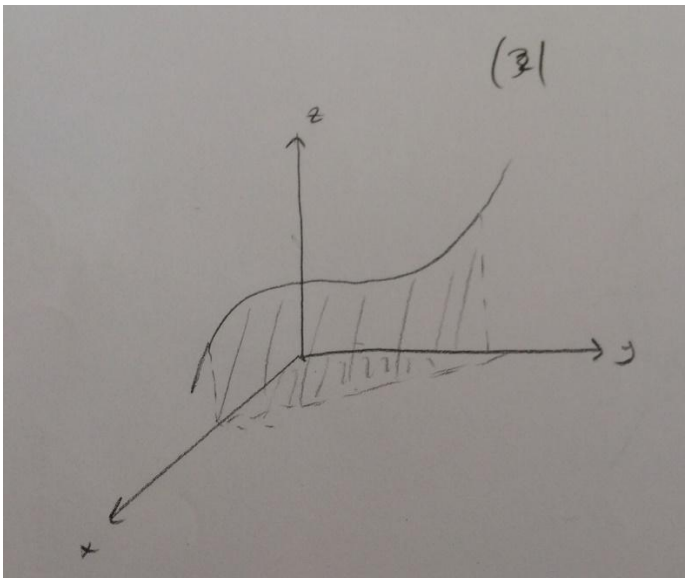


Figure 4 Interpretation of P_1 related to the double integral concept

Surface area refers to finding the area of a surface with a double integral. P_2 described the surface area as follows and illustrated its thoughts as shown in Figure 5:

"We performed it Calculus 4. This provides a region. It provides a function on it. For example, it wants the area on T region from us, by drawing them, the area or volume on *T* region of that function."

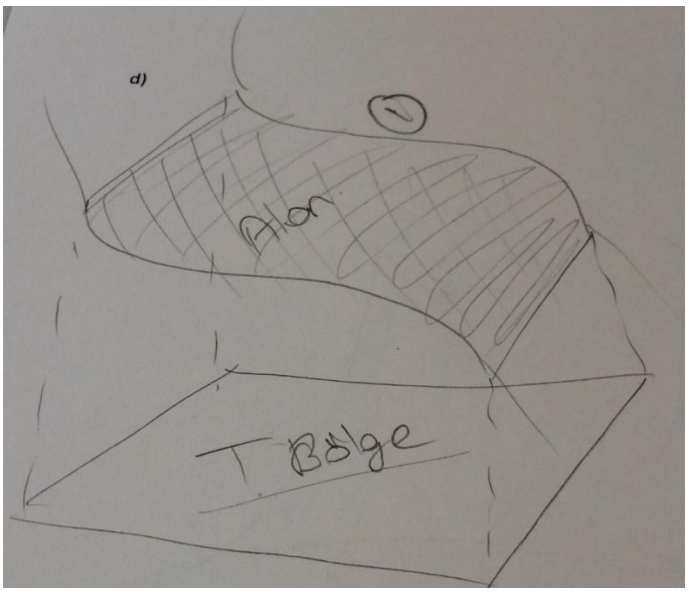


Figure 5 Interpretation of P_2 related to the double integral concept

The area under a curve represents the area under a curve within a limited interval. All participants have used this expression. P_6 has expressed the double integral as follows.

"We always found the area under this function ($y = x^2$) with the help of integral."

The three-dimensional area represents the area of that shadow by drawing a curve on the XYZ-plane, showing its shadow in two dimensions. When the researcher has asked, "What do you understand about the concept of double integral?" P_1 explained his idea as follows.

"An area on double integral. So, in the first dimension, in the single integral, I usually think of the first dimension. (….) The double integral area comes to my mind in three dimensions. "

Here, it is seen that P_1 thinks of the integral symbol in terms of dimension. The participant thinks that the single integral is one-dimensional, and the double integral is two-dimensional. For this reason, the area image is formed in the participant's mind. He illustrated the above explanations by drawing in Figure 6.

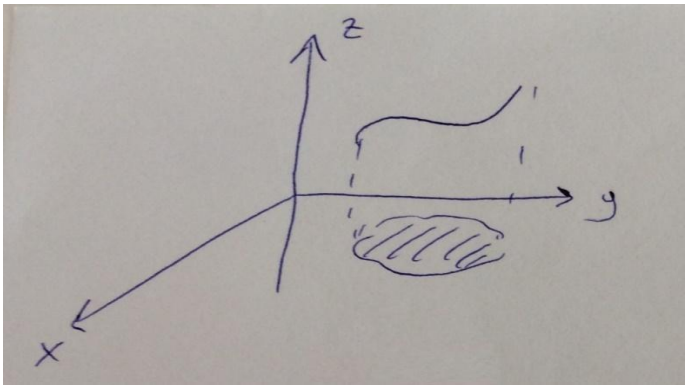


Figure 6 Interpretation of P_1 related to the double integral concept

When the above codes are examined, all codes are related to the concept of single integral rather than double integral except for the surface area code. Furthermore, the common point of these codes is that the participants consider the concept of double integral as a single variable function. Inappropriate concept images stand out in the participants. Therefore, a relationship between concept definition and concept image cannot be detected.

The status of "able to calculate area"

This subcode includes the answers given by the participants to the questions, Q2 and Q3, in the questionnaire form. In other words, it represents the concept images that explain how the

participants construct the integrand function, in which cases the area is calculated with double integral and what the integrand function means geometrically. The coding for this subcategory is shown in Figure 7, followed by the meaning expressed by each code.

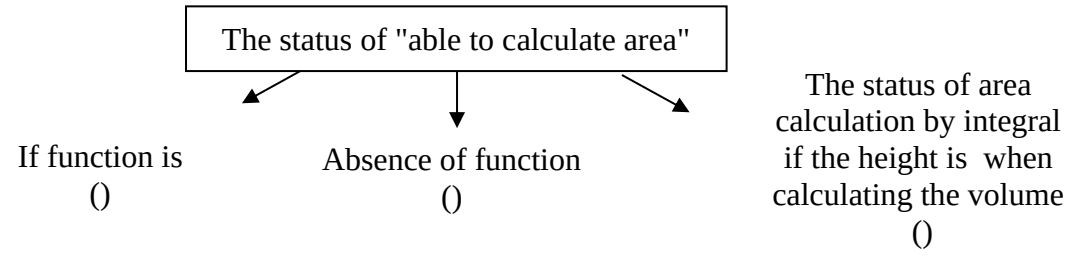


Figure 7 The classification of the interpretations of the participants on the area account with double integral

If the function is 1 represents the expressions of the participant who considers that integrand function is 1 as a rule. When the researcher asked why they wrote the integrand function 1 while calculating the area, the participants below gave the following answers.

"I'm not sure if 1 when? Hımm. If it weren't zero, we wouldn't have any area." (P_4)

The Absence of function represents the expressions of the participant who states that integrand function is one and there is no function. Some of the participants, for example:

"If there has been a function, I could interpret it as three-dimensional, but since it yields 1, it is two-dimensional." (P_6)

While P_5 explained how he solved Q3 and Q4, "stated that there should be no function. Upon this statement, the researcher asked what $\int_1^0 \int_1^0 dydx$ geometrically represented; P_5 shared his thoughts as follows.

"I call it the exact area. Because there is no function. There is no function before $dxdy$. I understand that the area is there whatever it is necessary and what it requires."

The status of area calculation by integral if the height is 1 *when calculating the volume* means that the integrand function is geometrically high and height is 1. P_3 and P_4 have been able to visualize that here and integrand function is 1 not only as a rule but also geometrically. When the researcher asked what $\int_2^3 \int_5^4 1dxdy$ geometrically meant, P_3 said:

"Here comes $z = 1$. I mean, a certain height. (….) That is the area. (….) It will be the same when we multiply it by 1. It is inferred from there. "

P_3 and P_4 were able to see the relationship between the volume perspective and the area in the concept definition of the double integral only with extra questions. They may have reached such a comment by being influenced by the questions on the questionnaire form in the semi-structured interview.

When the subcategory of "The status of "able to calculate area"" is examined, it is seen that most of the participants shared their thoughts that 1 should be written in the integral or there should be no function in order to calculate the area with double integral. Participants think that the integrand function is 1 as a rule/operation. Since the participants do not perceive the understanding of the volume in the formal structure of the double integral, they imagine the integrant function to be 1 as a rule only. Therefore, they do not realize the relationship between integrand function being 1 and height of a solid. In addition, the participants do not see "1" as a function.

Connection of integral and area

This subcategory represents the interpretations of the participants as a result of the negative result of the integral calculation when the questions, Q2 and Q3, in the questionnaire form are asked. The coding and descriptions for the subcategory are shown in Figure 8.

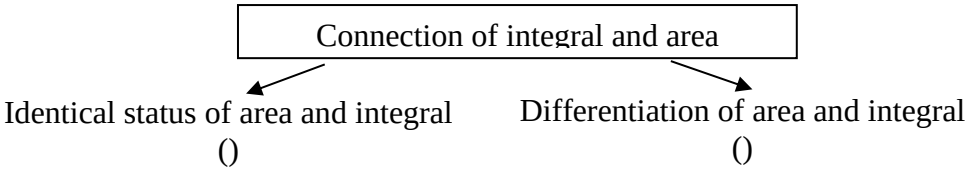


Figure 8 The classification of the interpretations of the participants on the relationship between double integral and area

The Identical status of the area and integral represents the interpretations of the participants indicating that the result of double integral will not be negative and zero. Below is a quote about P_3 interpretations of the negative result of the double integral.

"It is $-1/4$. We are supposed to never find it negative. (….) It is $-1/4$ but we are talking about area and volume."

Differentiation of area and integral represents the interpretations of the participants indicating that the result of double integral may be negative and zero. When the result of the

double integral has been negative, P_1 stated that the area could not be negative. Later, he realized that the function may be in the negative region and shared his thoughts as follows.

> "The area is not negative. I think it's wrong. (….) Maybe it can get something in a minus region, function. (….) We'll find the bottom half."

Although the participant also said that the integral result was from the negative region in the statement above, he stated that he thought he had solved it incorrectly when the result came back negative when solving Q1 and Q2 questions. In the semi-structured interview, he stated that the answer might be due to the negative region.

When Figure 8 is examined, most of the participants see the calculation of area as identical to the double integral process. This situation shows that the relationship between concept image and definition is not established and the implicit relationships underlying the concept are not noticed.

Area calculation strategy

This subcategory represents the interpretations of the participants when calculating the area with double integral. The coding for the subcategory is shown in Figure 9.

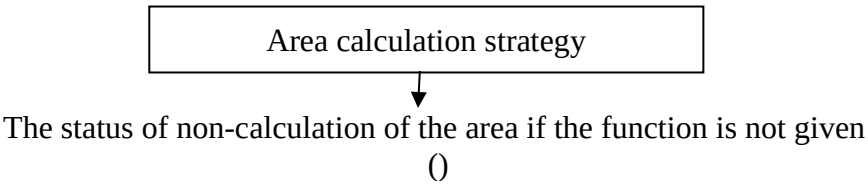


Figure 9 The classification of interpretations of the participants while calculating the area with double integral

The status of non-calculation of the area if the function is not given refers to situations in which the participant states that the participant "cannot solve because the function is not given" when a geometric shape is asked to express the area with a double integral. In the Q4, when the area of a closed rectangular region was asked to be expressed with the concept of double integral, the participants stated that they could not solve it because the integrand function was not given in the question. The expressions related to these views are given below in the form of direct references:

"He didn't define us a function. Since function has not been defined, I don't know that." (P_1)

From the above citation, it is seen that the participants have the perception that it is an obligation to give integrand function in the questions.

Volume

This category refers to the concept image of the participants who see the double integral concept as “volume" from prospective teachers.

Status of linguistically expressed volume

This subcategory represents the answers given by the participants who see the double integral as “volume”. The following codes represent the participants' comments representing their understanding of double integral while interpreting the semi-structured interview questions (I1 and I3) and explaining their answers to the questions, Q1 and Q2, in the questionnaire form.

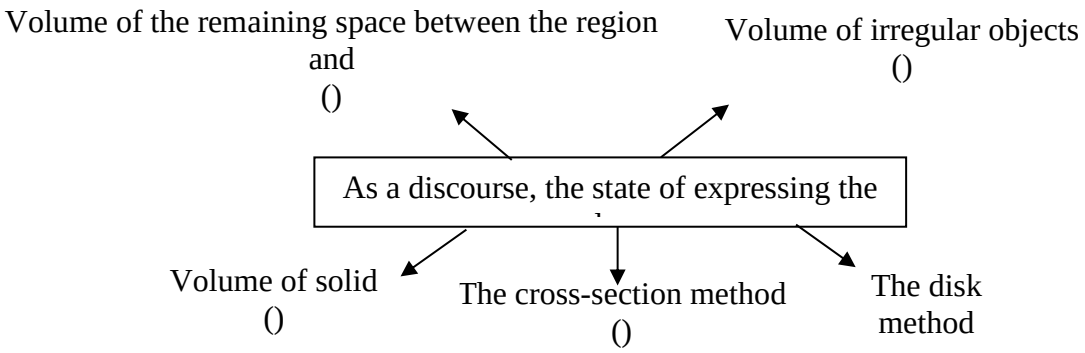


Figure 10 The classification of the expressions of the participants “what they have found” with double integral

The idea reflected by each code in Figure 10 is described below. In this way, the expressions related to the views of the participants are reflected by making direct references.

The Volume of the remaining space between the region and $f(x, y)$ indicates that there is the volume of the remaining part between the surface and the specific region while calculating the double integral. P_2 shared his thoughts on the double integral as follows:

“I might be able to find the volume between this B region and this $f(x, y)$ function."

Participants using the above attributes cannot be sure that what they are saying is true. This indicates that the participants could not make connection with the volume perspective in the concept definition. Such a concept image may have been established from the questions they solved in the lesson.

The Volume of irregular objects refers to the volume of objects that cannot be directly calculated by formulas such as a prism, cylinder. When asked by the researcher why we use the concept of double integral, P_3 reflected his opinion as follows:

"Yes. Whether it's area or volume. We use it to find the volumes and areas of objects whose picture is not exactly clear, which we cannot fully formulate."

The Volume of solid refers to the volume of solid objects such as a prism, cylinder. For example, P_5 described the concept image related to the double integral as follows:

"For example, the triangular prism can be calculated in them. It helps calculate their volumes in double integrals."

The cross-sectional method represents the cross-sectional method used when calculating the volume with a single integral. P_6 shared his thoughts on the double integral as follows:

"It is the volume of the cylinder $\pi r^2 h$. (….) If we find a double integral area, we can add something to it and find the volume. (…) you know, putting πr^2 on top of each other h time. This could lead us to a triple integral."

The disk method represents the disk method used when calculating the volume with the single integral. When P_2 was asked what the concept of double integral reminds you, he explained his thoughts as follows.

"When we turn this curve like this, it eventually forms a conical shape there. We find its volume with integral. With double integral."

When the above codes and quotations are examined, it is seen that the participants generally have concept images for the understanding of volume in the concept of single integral rather than the understanding of volume arising from the nature of the concept of double integral.

The status of "able to calculate volume"

This subcategory represents the participant responses indicating in which cases the double integral process indicates the volume. The coding for the subcategory is shown in Figure 11 followed by the meaning expressed by each code.

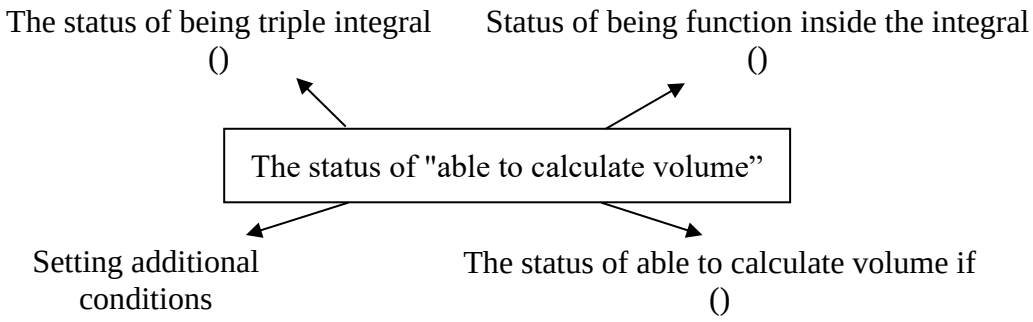


Figure 11 The classification of the interpretations of the participants on the calculation of volume in double integral

The status of being triple integral signifies that the concept of volume is related to the triple integral concept. The concept of triple integral outweighs the participants when they say "volume". Some views of the participants on volume are as follows.

"There are three different variables. I believe it's a triple integral as volume calculation. " (P_5)

"Volume to triple integral. Double integral for area. Indeed, when I hear a double word group, I think of the area that comes to mind " (P_6)

Status of being function inside the integral represents situations where the integral function of the double integral 1 does not exist. It also $f(x,y) = 1$ shows that it does not see the expression as a function. For example P_2 , when there is an expression outside the integrand function 1, he said that there is volume and that he adopts it as a rule.

"Here it is the area when we take the function 1, the volume when there is a function inside, so I …Stereotyped, in my mind." (P_2)

The status of setting additional conditions describes the operations performed when calculating the single integral volume. P_6, remembered the area of each section of the solid when calculating the volume of the cylinder in the single integral and mentioned that the integral should be multiplied by "π".

The status of able to calculate volume if $f(x,y) \geq 0$ refers that double integral represents volume where integrand function in double integral is positive. P_3 said that the integrand function must be positive for the double integral to be a volume calculation. And by writing the $\int_1^2 \int_3^4 (x^2+y)dxdy$ integral as an example, he stated that this integral must be $x^2 + y \geq 0$ to give volume calculation. Although it is considered here for P_3 because of the relation with

the concept definition, he cannot fully interpret that the image of the function is positive. He says that this is how it is expressed during the study of textbooks and lessons. Therefore, it has been observed that the negative image of the function only causes a concept image to be created by saving the graphic as a picture drawn in that region. Because the function's mission there cannot be interpreted by P_3.

The idea of the participant's "If usually there are x and y terms in the integrand function, the volume is calculated" and the understanding of "Volume is calculated with triple integral" outweighs. When the codes here are examined, the area image is more outweighs the volume image for the double integral. Therefore, it is seen that there are problems with understanding the double integral concept. The fact that procedural knowledge is at the forefront of the participants causes a limited concept image.

Connection of integral and volume

Interpretation of the results of the double integral as positive, negative, and zero represents the answers of the participants regarding the calculation of the volumes below and above the surfaces in z and $-z$ with double integral. The coding and descriptions for this subcategory are shown in Figure 12.

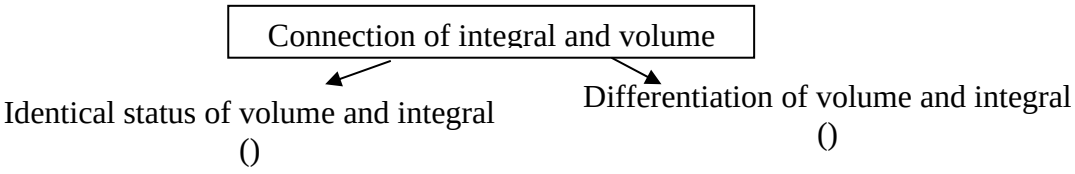


Figure 12 The classification of the interpretations of the participants relating to the relationship between double integral and volume

Identical status of volume and integral refers that double integral operation and volume calculation are identical and the result of double integral cannot be negative and zero. For example, when participants have been asked to find the double integral result using the volumes below and above the surface in both $-z$ and z in the Q6 they marked the sum of volumes $V_1 + V_2$. For example, P_3 explained marking this option as follows:

"If I say this place V, it will be found out. $-V$ negative. For example, we take this directly as the volume would not be negative"

Differentiation of volume and integral represents that the result of the double integral operation may be negative and zero. Below is a quote about P_2's interpretations of the negative result of the double integral.

Researcher: Is the integral calculation the same as the volume calculation?

P_2: It's not always the same, actually. (….) For example, if ee is at the negative and bottom area of z, we take it into absolute value.

Although P_2 above see the volume and integral calculation differently, he does not connect with the concept definition. The participant was able to comment on the absolute value of the integrand function of the volume calculation.

When Figure 12 is examined, most of the participants see the volume calculation as identical with the double integral operation. Therefore, participants think that the integral result cannot be negative or zero. Some of the participants realized that the volume could be different with double integral only later.

Volume calculation strategy

It represents the interpretations of the participants when calculating volume with double integral. The coding for this subcategory is shown in Figure 13.

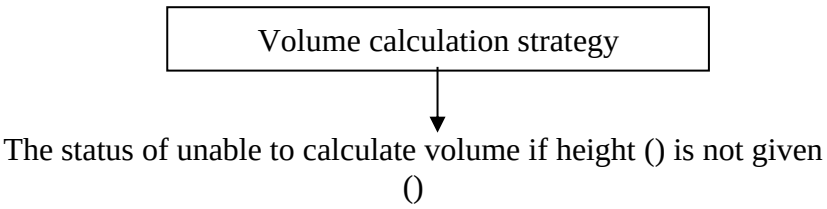


Figure 13 The classification of the interpretations of the participants when calculating volume with double integral

The status of unable to calculate volume if height (z) is not given means that volume calculation will not be made because no integrand function is given when a solid is provided and asked to be calculated with double integral. Participants explained the reasons why they could not calculate the volumes of solids given in application question 5 as follows.

"We can't find the volume. Because there's nothing. Like height." (P_1)

"I need to know what the $f(x,y)$ function is." (P_6)

From the above citations, it is seen that the participants have the perception that it is an obligation to give integrand function in the questions.

The Interplay Between Concept Definition and Concept Image for Double Integral

None of the participants could formally define the double integral (I2). In addition, there has been no finding that the participants established a relationship between the concept definition and the concept image. The interpretations of the participants in the semi-structured interview do not arise from the formal definition of double integral. When the subcategories are examined, it is seen that the interpretations of the participants result from the concept of a single integral.

Discussions

This study is aimed to reveal the concept image of prospective mathematics teachers for geometric representation of double integral.

Semi-structured interviews (I1 and I3) and answers to questions in the questionnaire form (Q1-Q4) appear to prioritize procedural skills for the concept of double integral. Due to such an approach, it is not a surprise that the participants have a limited concept image. It has been observed that the double integral is not associated with the volume understanding in accordance with the formal structure of the double integral because it takes the resulting concept images and has a volume calculation restriction. It may have been caused by the region drawings used to analyze the double integral rather than the geometry structure represented by the double integral in calculus lessons. Due to the formal structure of the double integral, the volume image is expected to be more revived in the minds of the participants, but it is seen that it is less represented. When Figure 4 and Figure 6 are examined, in fact, some of the students are aware of a concept in 3-dimensional space, but they cannot sense any further since they cannot exactly relate to the concept definition. One of the reasons why the volume image is problematic and limited in the minds of prospective mathematics teachers for a double integral can also be caused by the difficulty of visualizing 3-dimensional concepts (Seaman, 2000). In this case, symbols, rules, and prototype examples are at the forefront of memory.

Rules are at the forefront as the participants could not establish a complete relationship between concept definition and concept image in this study. For example, students have created a mental representation of the relationship of the double integral to the area as a 1 or no function in the symbolic expression rather than the height being 1 in the volume calculation. When Vinner and Drefyus (1989) examined the concept images of function in their study, it is seen

that the rules become more active in memory. In the studies of Martinez-Planell and Trigueros (2020) and Jones and Dorko (2015), it is seen that between the lines, students have confused between area and volume with double integral. The reason for this confusion among students is stated to be caused by seeing the two-variable function as a two-dimensional structure by Jones and Dorko (2015).

More detailed data were obtained with the concept image-concept definition theoretical framework and grounded theory coding techniques. For example, the expression of the concepts of area and volume as discourse is an important argument in demonstrating the inadequate images of concepts formed in the mind of people and how they relate to the definition. It is observed that there are problematic and unconnected images in discourse codes. Hall (2010) stated in his study that discourse has an effect on learning calculus concepts and shows whether there is sufficient conceptualization or not. When solving double integral questions, drawing is made to determine the boundaries, but the geometric representation expressed by the integral is not drawn. In this case, it can cause students' concept image to be shaped around the area.

When the participants have been given an image of the area of a region on the XYZ-plane and a solid on the XYZ-plane and asked to calculate area (Q4) or volume with double integral (Q5), the participants had difficulty interpreting such questions. Since the integrand function is usually defined in problems, it is seen that this leads to a perception (image) such as an obligation situation in the participants. Participants do not have a connection between the function and the height, which causes problems in solving the problem. It is believed that resolving problems with the translation of different representations will lead to the creation of different and rich image concepts.

It has been identified that participants are seeing the integral calculation and finding the area and volume accounts of geometric structures identical. Therefore, the participants have placed an image where the integral result cannot be negative. Participants are unable to recognize cases arising from the negative region because they see the area and volume and the integral calculations similar. In other words, students who see the double integral as a formula that can only calculate area and volume, like a calculator, cannot notice the state of the function arising from the negative region. Additionally, this situation shows that students cannot establish a bridge between concept definition and concept image and they do not have appropriate concept image. Students limiting the calculation of the integral to area and volume only limits their conceptual understanding (Orton 1983; Sealey 2014). Even participants who state that the result of the double integral may be negative do not realize that the appearance of

the function is negative. In textbooks and lectures, explanations of the result of integral as negative region by instructors overshadows the situation caused by the appearance of the function. Therefore, the Riemann sum should be given importance. The implicit relationships that underlie the concept image of Rieman's total activities can contribute to the understanding of the students. The Riemann sum will be both with the ability of students to develop a richer image of concept and to better solve their daily life problems (Sealey 2014; McGee & Martinez-Planell 2014; Martinez-Planell & Trigueros 2020).

Symbols have a significant effect on the representation of concepts in memory (Allen & Brooks, 1991). If people do not know the implicit nature of the concept, they act with the meanings in symbols (Smith & Kosslyn, 2007). We believe that the double integral has two symbols on its symbolic expression $\int\int$, which are effective in thinking as a two-dimensional geometric structure in the participants. In this study P_1, P_5, P_6 think that the concept of volume is related to the triple integral due to being three variables. Students can see two-variable function as a two-dimensional structure (Jones & Dorko, 2015). Both the complete lack of a two-variable function and the graphs drawn to determine the boundaries of the double integral symbol and the double integral in the lessons can cause the double integral to be two-dimensional. In this study, it is seen that participants load dimension meaning into the integral symbol because they cannot see the relationship of the symbolic expression of the double integral to the independent variable. Therefore, the meaning of the symbolic structure of the double integral should be given well. With outlier examples, this false concept image can be prevented. Outlier examples are effective in creating an adequate and accurate concept image of students (Tall & Vinner, 1981)

These results show that participants are acting with an intuitive approach, without having to correlate the concept definition with the concept image. Whereas definitions are an important building block in understanding the essence of mathematical concepts, in the development of concepts of students, in clarifying and communicating terms, in communicating with mathematical arguments. However, mathematicians see the concept definitions as the center of the issue in advanced mathematics, vice versa, it is seen that students act with images. (Tall & Vinner 1981; Edwards & Ward, 2004). In addition, it has shown that none of the participants can define the formal definition of the double integral and that no relationship is identified between the concept image and concept definition; the concept image and concept definition model created by Vinner (1983; 1991) have shown that participants act with an intuitive approach. Therefore, it shows that there are problems understanding relationships for the double

integral concept. When the data is reviewed, the concept images for the geometrical representation of the double integral of prospective mathematics teachers can be modeled in Figure 14.

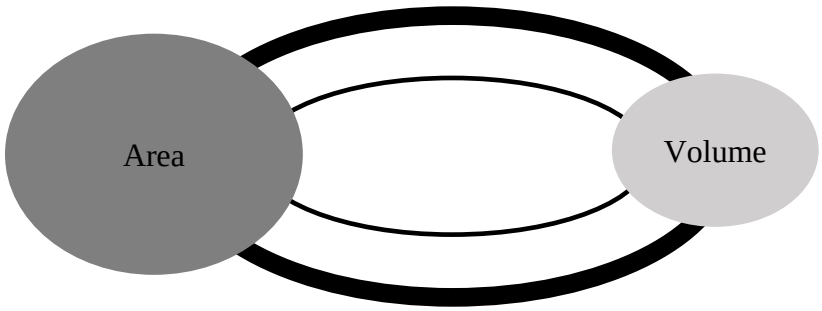


Figure 14 Views of prospective mathematics teachers for the geometric representation of the double integral

The study of Figure 14 shows that the image of the area in the minds of students is very dominant, and the concept of the integral, which is more single integral than the double integral, is seen as active.

In cognitive psychology, when the stimulus is presented quickly in sequence, the error of recognizing the stimulus is called repetition blindness (Kanwisher, 1987). The second stimulus is not seen as a separate event after the first stimulus, triggering the first stimulus and recording a single event. (Smith & Kosslyn, 2007). Repetition blindness claims that we do not create a new and separate representation of something that we have just processed as we have restricted time and we do not notice the repetition for this reason. (Smith & Kosslyn, 2007). Cognitive obstacles arise in mathematical thought processes such as reversibility, flexibility and generalization (Norman & Pichard, 1994, p.76). In the two-dimensional thinking of the double integration, the two-variable function may have some intellectual barriers, except in cases of detection problems, etc. We believe that one of the reasons why there is no appropriate concept image, especially in advanced mathematics concepts, is perception errors, such as repeat blindness. Although there are more volume questions than area questions about the double integral concept when we look at the calculus books, the area image is outweighed by the participants. This is because participants receive a single integral concept as an integral concept in a calculus course in both high school and first-class in an undergraduate degree. Therefore, it arouses the idea in which they encode the concept of integral as a single concept in general.

For this reason, it is thought that the image of the area is active in the double integral by our authors. In this regard, participants consider the multiple integral as a single integral and do not create a different image. Once students have learned the concept of a variable function, if they do not see the two-variable functions as a separate concept, they will not represent the two variances for functions separately and will act with the images of a variable function. These types of inappropriate images can be called concept blindness. The study conducted by Edwards and Ward (2004), expressed their surprise by finding that they created a new concept, images of a previously learned concept, and incorrect mental pictures. Experts who design multiple and versatile teaching should be assisted to identify perception errors of mathematical concepts and create rich and accurate image concepts. This will help strengthen the conceptual understanding of the students by designing activities that prevent perception errors.

It is not easy to create a consistent concept image in advanced calculus subjects, and it is difficult to gain deep knowledge of concepts with an inappropriate concept image (Tall and Vinner, 1981). Therefore, for a better conceptualization of the double integral concept, concrete material activities should be used. Otherwise, only the computer systems and proofs used may be weak in concept image formation. It is also effective in the formation of mental pictures in accordance with the nature of the concept of concrete materials (Fischbein, 1993). In this way, it can be explained that the area is only a feature and comes out because the height is multiplied by 1. As it seems that there is no permanent learning at the desired level in verbal expression or written proof of concept. Moreover, it will be useful to introduce the lesson with the problems that are the basis of the concept of double integral, and the features taught after that are steps towards solving these problems, and by going back to these problems again, it will be useful to reach a conceptual understanding that can solve similar problems practically. Thus, it may be possible to form appropriate concept images.

In fact, the studies to be carried out for the development of these advanced mathematical concepts have contributed to the development of mathematical thinking of mathematics teachers. It will lead to a better mathematical idea of the students they will raise indirectly. Considering the results of this study, it is recommended to carry out action studies and teaching experiments to learn the concept of better double integral.

Limitations and Recommendations

This research is limited to the concept image of six prospective mathematics teachers. Similar research may be conducted on a large group to make generalizations of the findings. Furthermore, a general model or theory would be put forward if double integral could be

searched in the departments of mathematics, mathematics education, and engineering. From this point of view, the differences and similarities of concept images of students can be deepened and understood. Concept images of prospective mathematics teachers who graduate before and after 2018 may be compared to highlight the effects of the undergraduate program which is updated in 2018.

Conclusion

The concept of revealing general concept images of a concept has an important place for teaching (Vinner & Drefyus, 1989). Thus, it will help the people who plan to teach to develop their teaching methods by knowing in advance what kind of idea structure their target audience has and the cognitive obstacles they may fall into. The aim of this study is to determine how prospective mathematics teachers understand the geometric representation of double integral and to contribute to the understanding of double integral. The answers of the participants to the six questions and the data from the semi-structured interviews have been analyzed in parallel. Considering these data, concept images under two main headings “area” and “volume" have been examined.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest

No conflict of interest.

Research involving Human Participants and/or Animals

The study involves human participants. Ethics committee permission was obtained from Hacettepe University Ethics Boards and Commissions for the study's implementation (30.11.2017, No:E-35853172-433-4017).

Matematik Öğretmeni Adaylarının Çift İntegral Kavramının Geometrik Temsiline Yönelik Kavram Görselleri

Özet:

Bu çalışmada matematik öğretmen adaylarının çift katlı integralin geometrik temsilini nasıl anladıklarına odaklanılmıştır. Araştırmanın amacı doğrultusunda bu çalışmanın araştırma deseni, temel nitel araştırma yöntemi olarak benimsenmiştir. Altı katılımcıya altı soru sorulmuştur. Daha sonra katılımcılarla yarı yapılandırılmış görüşmeler yapılmıştır. Anket formu ve görüşmelerden elde edilen veriler açık ve eksensel kodlama ile analiz edilmiştir. Araştırma sonucunda matematik öğretmen adaylarının kavram imajlarının “alan” ve “hacim” olmak üzere iki kategoride toplandığı görülmüştür. Araştırmadan elde edilen veriler doğrultusunda, katılımcıların kavram tanımı ile kavram imajı arasında ilişki kurmak zorunda kalmadan sezgisel bir yaklaşımla hareket ettikleri, çift katlı integral sembolünü $\iint$ iki boyutlu geometrik bir yapı gibi düşündükleri ve tek katlı integral kavramına ilişkin imajları etkin olduğuna ulaşılmıştır. Bu araştırmada elde edilen bulgular, çoklu integrali genellemenin ilk adımı olan çift katlı integral kavramının anlaşılmasında zorluklar olduğunu ve eğitimcilerin bu konuya yönelik çözümler üretmesi gerektiğini göstermektedir.

Anahtar kelimeler: Çift katlı integral, kavram imajı, kavram tanımı, matematik öğretmen adayları.

References

Allen, S. W., & Brooks, L. R. (1991). Specializing the operation of an explicit rule. *Journal of experimental psychology: General*, *120*(1), 3. https://doi.org/10.1037/0096-3445.120.1.3

Anderson, R. D., & Loftsgaarden, D. (1987). A special calculus survey: Preliminary report. Calculus for a new century: A pump, not a filter. *MAA Notes*, (8), 215-216. https://www.maa.org/sites/default/files/pdf/pubs/books/members/NTE8_optimized.pdf

Balimuttajjo, S. (2010). *Exploring Concept Images of College Calculus Students* (Doctoral dissertation, University of Nevada).

Corbin, J., & Strauss, A. (2014). *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Sage publications.

Dorko, A., & Weber, E. (2014). Generalising calculus ideas from two dimensions to three: How multivariable calculus students think about domain and range. *Research in Mathematics Education*, *16*(3), 269-287. https://doi.org/10.1080/14794802.2014.919873

Douglas, R. (1986). *Toward a lean and lively calculus: Report of the conference/workshop to develop curriculum and teaching methods for calculus at the college level*. Mathematical Association of America.

Edwards, B. S., & Ward, M. B. (2004). Surprises from mathematics education research: Student (mis) use of mathematical definitions. *The American Mathematical Monthly*, *111*(5), 411-424. https://doi.org/10.2307/4145268

Fischbein, E. (1993). The theory of figural concepts. *Educational studies in mathematics*, *24*(2), 139-162. https://doi.org/10.1007/BF01273689

Martínez-Planell, R., & Trigueros, M. (2020). Students' understanding of Riemann sums for integrals of functions of two variables. *The Journal of Mathematical Behavior*, *59*, 100791. https://doi.org/10.1016/j.jmathb.2020.100791

Gleason, M. A., & Hallett, H. D. (1992). The calculus consortium based at Harvard University. *Focus on Calculus*, *1*, 1-4.

Habineza, F. (2013). A case study of analyzing student teachers' concept images of the definite integral. *Rwandan Journal of Education*, *1*(2), 38-54. https://www.ajol.info/index.php/rje/article/view/111569

Hall, W. L. (2010). Language and area: Influences on student understanding of integration. *Electronic Theses and Dissertations. 1205*. https://digitalcommons.library.umaine.edu/etd/1205

Huang, C. H. (2015). Calculus students' visual thinking of definite integral. *American Journal of Educational Research*, *3*(4), 476-482. https://doi.org/10.12691/education-3-4-14

Jones, S. R. (2018). Prototype images in mathematics education: the case of the graphical representation of the definite integral. *Educational Studies in Mathematics*, *97*(3), 215-234. https://doi.org/10.1007/s10649-017-9794-z

Jones, S. R., & Dorko, A. (2015). Students' understandings of multivariate integrals and how they may be generalized from single integral conceptions. *The Journal of Mathematical Behavior*, *40*, 154-170. https://doi.org/10.1016/j.jmathb.2015.09.001

Kanwisher, N. G. (1987). Repetition blindness: Type recognition without token individuation. *Cognition*, *27*(2), 117-143. https://doi.org/10.1016/0010-0277(87)90016-3

Khiat, H. (2010). A grounded theory approach: conceptions of understanding in engineering mathematics learning. *Qualitative Report*, *15*(6), 1459-1488. https://nsuworks.nova.edu/cgi/viewcontent.cgi?article=1356&context=tqr

Kloosterman, P. (2002). Beliefs about mathematics and mathematics learning in the secondary school: Measurement and implications for motivation. In *Beliefs: A hidden variable in mathematics education?* (pp. 247-269). Springer, Dordrecht.

McGee, D. L., & Martinez-Planell, R. (2014). A study of semiotic registers in the development of the definite integral of functions of two and three variables. *International Journal of Science and Mathematics Education*, *12*(4), 883-916. https://doi.org/10.1007/s10763-013-9437-5

Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation*. JosseyBass A Wiley Imprint.

National Council of Teachers of Mathematics (Ed.). (2000). *Principles and standards for school mathematics* (Vol. 1). National Council of Teachers of Mathematics.

Oberg, T. D. (2000). An investigation of undergraduate calculus students' conceptual understanding of the definite integral. *Graduate Student Theses, Dissertations, & Professional Papers. 10615.* https://scholarworks.umt.edu/etd/10615

Orton, A. (1983). Students' understanding of integration. *Educational studies in mathematics*, *14*(1), 1-18. https://www.jstor.org/stable/3482303

Radzimski, V. E. (2020). *Tertiary mathematics and content connections in the development of mathematical knowledge for teaching* (Doctoral dissertation, University of British Columbia).

Rasslan, S., & Tall, D. (2002). Definitions and images for the definite integral concept. In *PME Conference* (Vol. 4, pp. 4-089).

Rösken, B., & Rolka, K. (2007). Integrating intuition: The role of concept image and concept definition for students' learning of integral calculus. *The Montana Mathematics Enthusiast*, *3*, 181-204.

Sealey, V. (2014). A framework for characterizing student understanding of Riemann sums and definite integrals. *The Journal of Mathematical Behavior*, *33*, 230-245.

Seaman, C. E. (2000). *Students' use of spatial visualization with the aid of technology in the learning of three-dimensional calculus concepts* (pp. 1-313). Central Michigan University.

Serhan, D. (2015). Students' understanding of the definite integral concept. *International Journal of Research in Education and Science*, *1*(1), 84-88. https://www.ijres.net/index.php/ijres/article/view/20

Şefik, Ö., & Dost, Ş. (2019). The analysis of the understanding of the three-dimensional (Euclidian) space and the two-variable function concept by university students. *The Journal of Mathematical Behavior*, *57*, 100697. https://doi.org/10.1016/j.jmathb.2019.03.004

Smith, E. E., Kosslyn, S. M., & Barsalou, L. W. (2007). *Cognitive psychology: Mind and brain* (Vol. 6). Pearson/Prentice Hall.

Stewart, J. (2009). *Calculus: Concepts and contexts*. Cengage Learning.

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research techniques*. Sage publications.

Tall, D. (1993). Students' difficulties in calculus. In *proceedings of working group* (Vol. 3, pp. 13-28).

Tall, D. (2006). A theory of mathematical growth through embodiment, symbolism and proof. In *Annales de didactique et de sciences cognitives* (Vol. 11, pp. 195-215).

Tall, D., & Vinner, S. (1981). Concept image and concept definition in mathematics with particular reference to limits and continuity. *Educational studies in mathematics*, *12*(2), 151-169. https://doi.org/10.1007/BF00305619

Urquhart, C. (2012). *Grounded theory for qualitative research: A practical guide*. Sage publications.

Vinner, S. (1983). Concept definition, concept image and the notion of function. *International Journal of Mathematical Education in Science and Technology*, *14*(3), 293-305. https://doi.org/10.1080/0020739830140305

Vinner, S. (2002). The role of definitions in the teaching and learning of mathematics. In *Advanced mathematical thinking* (pp. 65-81). Springer, Dordrecht.

Weber, E., & Thompson, P. W. (2014). Students' images of two-variable functions and their graphs. *Educational Studies in Mathematics*, *87*(1), 67-85. https://doi.org/10.1007/s10649-014-9548-0

Appendix 1
Questions

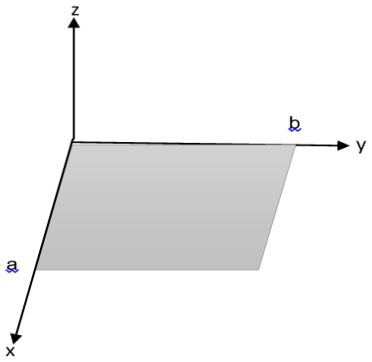
(1) Evaluate the double integral of the function $f(x,y) = xy$ over the $R = \{(x,y) \in [-1,0]x[0,1]\}$?

(2) Evalute the iterated integral.

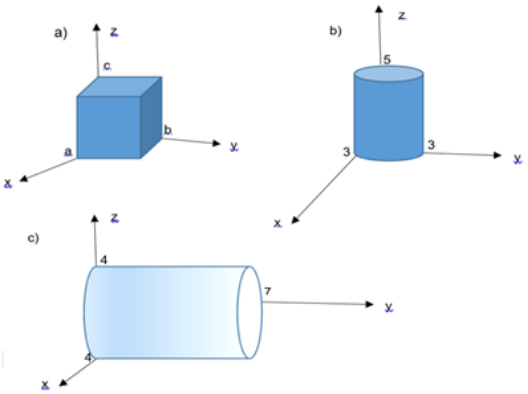
$\int_{-1}^{0} \int_{0}^{1} xy\, dydx$

(3) Use a double integral to find the area of the region bounded between the curves $y = x^2$ and $y = x$.

(4) Express the area of shaded rectangular region in the following figure by using the double integral.

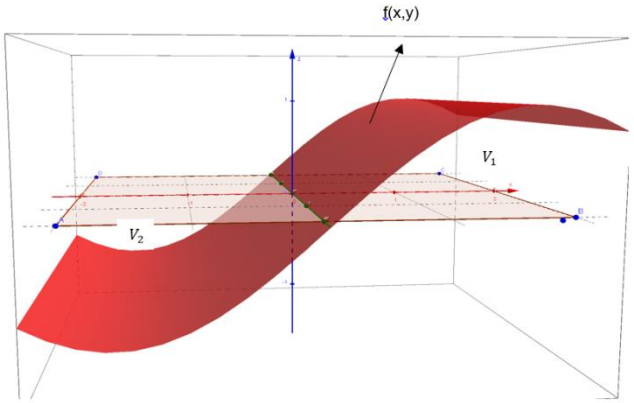


(5)



The points at which the solids listed above cut the xyz-planes are marked in the plane. Express the volume of these solids using the double integral.

(6)



The above figure shows the function $f(x,y)$ defined where $R = \{(x,y) \in [-2,2]x[-2,2]\}$. V_1 is the volume above R and below the graph of $f(x,y)$ and V_2 is the volume below R and above the graph. Accordingly, which statement provides the result of the integral given below?

$$\iint_B f(x,y)dA = ?$$

A) $V_1 + V_2$ B) $V_2 - V_1$ C) $V_1 - V_2$

D)$|V_1 - V_2|$ E) $\frac{1}{2}(V_1 + V_2)$

Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi
Cilt 17, Sayı 1, Haziran 2023, sayfa 99-119. ISSN: 1307-6086
Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education
Vol. 17, Issue 1, June 2023, pp. 99-119. ISSN: 1307-6086

Research Article

Is Drama a Magic Wand or a Waste of Time?

Ayşe Gül ÇİRKİNOĞLU ŞEKERCİOĞLU[1]

[1] Balıkesir University, Necatibey Faculty of Education, Balıkesir/Türkiye,
acirkin@balikesir.edu.tr, http://orcid.org/0000-0001-9474-2977

Received : 11.12.2022 Accepted : 29.06.2023

doi.org/10.17522/balikesirnef.1217596

Abstract – Several studies revealing that students who receive traditional instruction indicate more interest in lessons in which active learning methods are employed have been conducted. This research aimed to determine the effect of drama-assisted teaching activities on university students' achievements in Electrostatics concepts in Physics-2 class. For this purpose, instruction supported with the drama method was employed in addition to traditional teaching. The study followed a quasi-experimental research design with a control group, and the participants of the study were 83 second year students who studied at an Education Faculty, in the west of Turkey. To collect data, an Electrostatics Concept Test and a Drama Method Attitude Scale were used. As a result of the research, regarding the concept test, scores of the experimental group supported with drama-assisted instruction were significantly higher than the control group. It was found that the experimental group drama attitude mean score was 78.9% positive. According to the results of the research, drama alone is not a magic wand like Harry Potter's wand, but it is a more successful method than traditional methods.

Key words: Conceptual understanding, drama-assisted teaching, drama attitude, electrostatics, university students.

Corresponding author: AyşeGül ÇİRKİNOĞLU ŞEKERCİOĞLU, acirkin@balikesir.edu.tr, Balikesir University

Introduction

In learning physics, lessons which foster characteristics of a traditional teaching setting lack effectiveness. Due to such teaching contexts, it is observed that students' misconceptions remain unchanged after physics lessons, or only a few can be eliminated. Even though they easily solve numeric problems, students have difficulties with conceptual questions. It is

argued that the discrepancy between success at traditional context and failure in conceptual questions stems from the ineffectiveness of traditional instruction methods in terms of contribution to conceptual learning. Additionally, it is evidenced that lessons prompting students to actively participate in the activities help unsuccessful students elevate their achievement levels. Active learning methods are regarded as more effective ways for students to learn physics and chemistry concepts, and compared to traditional instruction; these methods encourage them to be more active during lesson activities (Demirci & Çirkinoğlu Şekercioğlu, 2009; Kaya Eker, 2023; Yıldırır, 2020). According to Açıkgöz (2006), active learning can be described as the process in which the learner bears responsibility for learning, is given opportunities for making decisions concerning various learning dimensions and for self-regulation, and is prompted to use cognitive faculties through complex instructional steps. There are a number of modern teaching methodologies based on active learning (Akbaş, 2011; Çirkinoğlu Şekercioğlu, 2011; Durusoy, 2012; Maharaj-Sharma, 2017; Sedef, 2012; Türkkuşu, 2008; Yağmur, 2010). And drama method in which active student participation is facilitated is one of them. Akar-Vural and Somers (2011) define drama in education as a form that stands for teaching a content item through drama elements, thus regarding drama as a fundamental teaching method. Furthermore, besides using art forms and techniques in education, the main motivation behind drama in education is creating learning situations for learners in which they can experience real occurrences through role playing in a fictional setting. To role-play, one requires knowledge. Knowledge contributes to playing the role appropriately, making learning possible at the same time. Drama in science education has been developed to enable students to understand the topics better, and it includes various activities they might need. Besides, it helps students learn by living, making the classroom enjoyable. Drama applications provide students with opportunities to make use of a language they cannot normally use in their daily lives (İçelli et al., 2008). Although there is a perception that the use of drama is limited to lessons related to social and non-math studies, it generates positive results with math and science lessons when used effectively (Oğuz-Namdar, 2017). There are certain steps to make the use of the drama method effective in classrooms as follows: preparatory/warm up stage, enacting stage, and evaluation/discussion stage. In the preparation phase, participants are facilitated to be prepared for the process of enacting both physically and mentally through introduction, interaction, free walking, plays, rapport, and trust activities. The enactment stage includes all the phases in which a topic is formed with a common effort as the product and presented to an audience. In short, it is the stage during which teaching a topic is put into action. Lastly, the evaluation stage is the final

process in which participants make judgments about activities and topics used in the enactment and a determination is sought after concerning the matching of teaching the topic and learning outcomes (Adıgüzel, 2018; Oğuz-Namdar, 2017). The drama method consists of several techniques such as improvisation, role playing, role exchange, acting teacher, flashback, hot seat, interview, conscience alley, still image (freeze frame), gossip circle, writing in role, internal voice, holding a meeting, pantomime, rituals and ceremonies, family photo, iceberg, thought tracking, etc. (Adıgüzel, 2018; Akar-Vural & Somers, 2011; Karadağ & Çalışkan, 2008). Drama techniques that were used in this study are as follows: role playing, improvisation, hot seat, and writing in a role. Role playing technique is the enactment of some roles assigned to each student. Acting out the character's all thoughts and feelings, students get out of their own personas, which reduces their fear of making mistakes and increases their calmness (Genç, 2003; Güney, 2009; Karadağ & Çalışkan, 2008; Karadağ et al., 2008). Improvisation technique is enacting an unprecedented situation or role assigned to a student without any preparation for the role. However, some basic information must be provided prior to enactment since students must have an understanding of the essence of the topic to improvise (Güney, 2009; Karadağ & Çalışkan, 2008; Okvuran, 1994). Hot seat technique requires one student to sit down to a chair and others to surround him/her to ask various questions related to a topic. In this technique, other students must avoid asking off-topic questions and making comments. Writing in role technique includes writing products such as letters, journals, etc. to generate knowledge, insights, thoughts, and feelings related to a topic by assuming the role of a character, possibly an important figure. It is possible to discuss about the products and make comments (Adıgüzel, 2018).

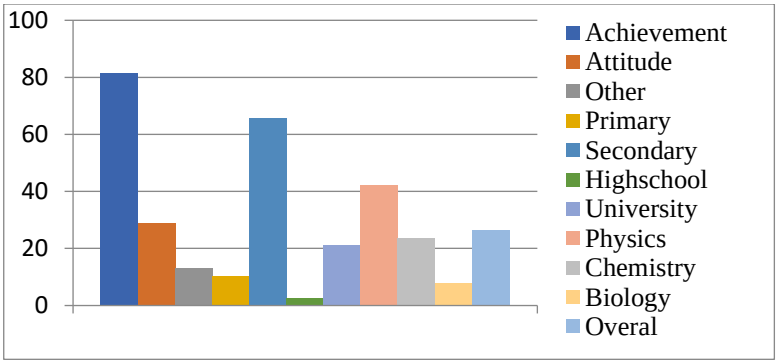


Figure 1 Distribution of research reviewed (2000-2018)

Regarding the studies focusing on the use of drama in science education, the most frequent levels appearing are the research on primary and secondary levels. Among the

research reviewed for the study, 38 experimental studies related to science education were examined in terms of education level, distribution of science fields, and dependent variables. Figure 1 and Table 1 below present the distribution of contents of reviewed research in percentages.

The reviews of the literature revealed that the majority of studies were on the effect of drama on student achievement (81.58%). It was followed by attitude studies focusing on the effect of drama-oriented education on the attitudes of students towards the lesson and subjects (28.95%). In addition, the rest of the studies with regard to drama are as follows: the effect of drama on scientific process skills, drama's effect on scientific creativity, and the nature of science (13.16%). It was observed that the majority of research studies (65.79%) were on the level of secondary school. Drama-oriented studies conducted on university level science teaching indicated an increase in recent times (21%).

Table 1 Characteristics of the studies examined in the literature review (2000-2018)

Properties	**%**
Effect of drama on student achievement	**81.58**
Effect of drama on students' attitudes towards lesson	28.95
Effect of drama on scientific process skills, nature of science, self-regulation	13.16
Research on primary school level	10.52
Research on secondary school level	**65.79**
Research on high school level	2.63
Research on university level	21.05
Research related to drama's effect on teaching on physics subjects	**42.11**
Research related to drama's effect on teaching on chemistry subjects	7.90
Research related to drama's effect on teaching on biology subjects	23.68
Research on drama in relation to general science subjects	26.32

Additionally, when Figure 1 and Table 1 regarding the amount of drama-oriented experimental studies conducted on science fields were observed, it can be seen that the highest number of studies were led in the field of physics (42.11%). Biology field follows physics in terms of number of research papers with a percentage of 23.68%. Rate of drama studies conducted through general science topics which contain physics, chemistry, and biology is 26.32%. It is noticeable that in experimental drama research with regards to physics, the most prominent studies were on the topic "Force and Motion" (Akbaş, 2011; Durusoy, 2012; Maharaj-Sharma, 2017; Sedef, 2012; Yağmur, 2010). Concerning the experimental drama studies on other physics subjects included topics as the following; heat and temperature, electricity, mirrors, sound, light, let's know our planet, and energy (Cihan-

Yılmaz, 2006; Çirkinoğlu Şekercioğlu & Yılmaz Akkuş, 2016; Kahyaoğlu et al., 2010; Sağırlı & Gürdal, 2002; Taşkın Can, 2013; Taşkın & Moğol, 2016b; Tımbıl, 2008; Timothy & Abata, 2014). Considering the research reviewed, it was revealed that the drama method led to a significant increase in both student achievement levels and their attitudes towards the lesson compared to traditional instruction techniques. Even in the cases where there was no significant difference to the control group, student achievement levels were measured to be in higher rates in groups that received drama-oriented instruction. However, in addition to the results indicating that drama instruction increased student achievement, some studies reported issues related to time constraints (Yılmaz Akkuş & Çirkinoğlu Şekercioğlu, 2019). To overcome time-related obstacles, it is vital to consider that teachers should have ready-to-use drama activities prior to instruction and the number of drama studies in science subjects should be boosted to facilitate teachers' practicality with the issue by encouraging them to make drama use more widespread. Therefore, this research makes a valuable contribution to the literature on the grounds that it designs drama activities in electrostatics topic and that these activities are used as a way to determine the effect of drama on student achievement levels of electrostatic concepts.

The main purpose of this research is to determine in what ways and how drama-assisted teaching affects education faculty students' electrostatics concept test levels and their attitudes towards drama method. For this purpose, the sub-problems of the research are shown below;

i. Is there a significant difference between Electrostatics Concept Test pre-test scores of experimental and control groups in terms of group variable?
ii. Is there a significant difference between experimental group's Electrostatics Concept Test pre-test and post-test scores in favour of the post-test?
iii. Is there a significant difference between control group's Electrostatics Concept Test pre-test and post-test scores in favour of the post-test?
iv. Is there a significant difference between Electrostatics Concept Test post-test scores of experimental and control groups in terms of group variable?
v. What are the attitudes of experimental group towards drama method?
vi. Is there any correlation between Electrostatics Concept Test and Drama Method Attitude Survey regarding the experimental group's post-test scores?

Method

Research Design

This study follows a quasi-experimental research design, making use of pre-test post-test control group model. Considering the use of data collection tools, both quantitative and qualitative interpretations are benefitted from.

Participants

The participants of the study were 83 second year students who studied at an Education Faculty, in the west of Turkey.

Table 2 Demographics of Groups

	Experimental Group	Control Group
Female	36	35
Male	8	6
Total	42	41

In forming the sample, the principal of accessibility was followed. This type of the sample requires participants and setting formed taking finances, time, and economy of the environment into consideration (Balcı, 2004).

Data Collection

As data collection tools, the research made use of an Electrostatics Concept Test (ECT) and a Drama Method Attitude Scale (DMAS).

Electrostatics Concept Test (ECT)

To determine the impact of drama-assisted teaching on students' achievement levels regarding electrostatics concepts, an ECT consisting of 20 multiple-choice questions was used. The original test developed by Maloney et al. (2001) included 32 questions and covered topics of electrics and magnetism, and was translated and adapted into Turkish by Demirci and Çirkinoğlu (2004). Validity and reliability tests related to 20-item electrostatics version which is the same test used in this study were run by Çirkinoğlu Şekercioğlu (2011). Table 3 below presents the distribution of topics and concepts regarding the question items in Electrostatics Concept Test.

Table 3 Concepts /Topics Covered by ECT

Items Concepts/Topics	Items
Distribution of charge in conductive and non-conductive	1, 2, 11
Coulomb's law of force	3, 4, 5
Electrical force and electrical field superposition	6, 7

Force caused by electrical field	8, 9, 10, 15
Work, electrical potential, field, and force	9, 13, 14, 15
Getting charged by impact and electrical field	11, 12
Gauss Law	16, 17, 18
Capacity, potential difference, electrical field, electrostatic field	19
Capacity, potential difference, electrostatic energy	20

KR 20 reliability coefficients obtained from various study data related to ECT are presented in Table 4.

Table 4 ECT data KR-20 reliability coefficient Works

	Number of Items	KR 20
Maloney et al. (2001)	32	0.75
Demirci and Çirkinoğlu (2004)	32	0.71
Çirkinoğlu Şekercioğlu (2011)	20	0.67
This study	20	0.66

The reliability coefficient obtained from the data of ECT was calculated as 0.66. Table 5 indicates item difficulty indices and item discrimination indices.

Table 5 ECT item analysis values

Item	Difficulty (p_j)	Discrimination (r_{jx})	Item	Difficulty (p_j)	Discrimination (r_{jx})
1	0.83	0.44	11	0.48	0.52
2	0.36	0.60	12	0.28	0.44
3	0.90	0.30	13	0.60	0.44
4	0.86	0.30	14	0.66	0.30
5	0.84	0.35	15	0.34	0.52
6	0.84	0.35	16	0.69	0.44
7	0.66	0.35	17	0.14	0.30
8	0.69	0.48	18	0.62	0.30
9	0.42	0.30	19	0.55	0.39
10	0.78	0.48	20	0.35	0.30
-	-	-	Mean:	0.59	0.39

ECT average difficulty value was calculated as 0.59 while the average discrimination value was 0.39. The obtained values are in the acceptable range (Tezci & Yıldırım, 2007).

Drama Method Attitude Survey (DMAS)

For the purpose of determining the attitudes of students towards drama method, a DMAS was developed. Influenced by Peer Teaching Attitude Survey developed by Authors

(2011), the scale has four dimensions as follows: “Drama in Physics Lesson (FD)”, “Drama in Electrostatics (ESD)”, “Drama and Problem Solving, Abstract-Concrete Thinking Skills (PCD)”, and “Choosing Drama (DTE)”. After a factor analysis was run, 26 items with 5-point Likert scale was diminished into 18 items. After a pilot study on 152 students who were exposed to drama method and a confirmatory factor analysis via LISREL8.8 software, the survey was applied to 42 students and students and the questionnaire was finalized.

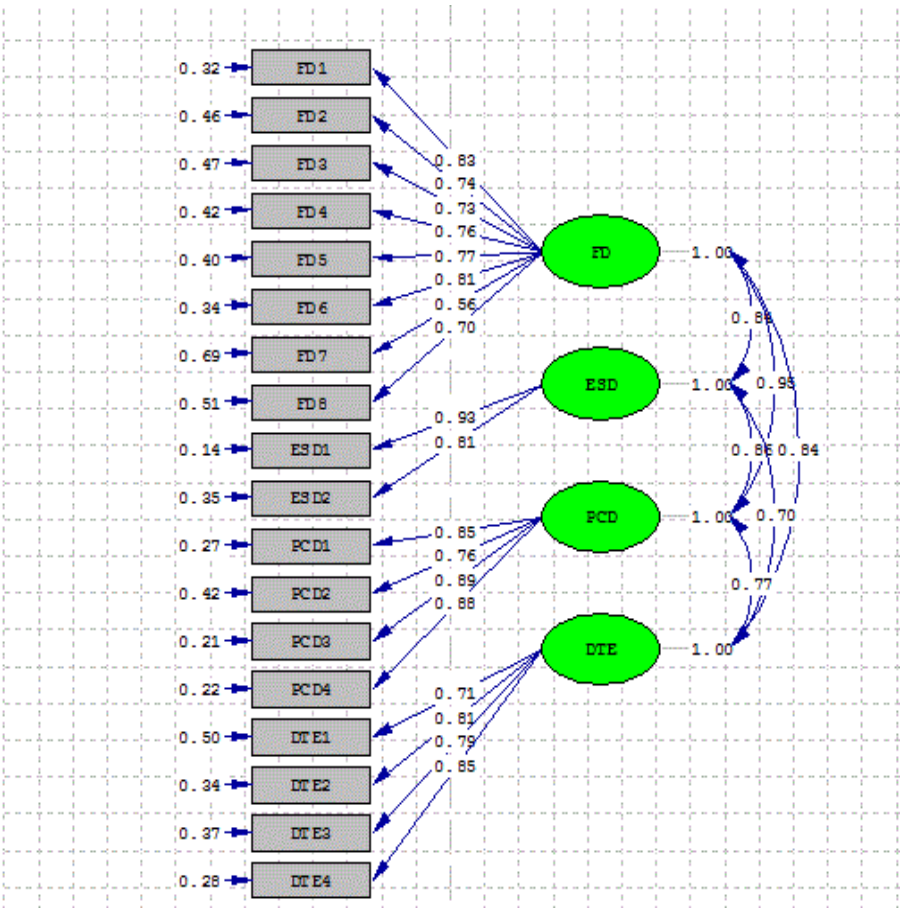


Figure 2 Confirmatory Factor Analysis Values

As shown in Figure 2, considering the distribution of 18 items in accordance with factors and factor loadings, NFI, CFI, and CRMR values were calculated as 0.87, 0.88, and 0.08 respectively. In addition, generated RMS value of 0.19 was outside the desired range. It was assumed that it was due to the small number of items and the participants. Finally, Cronbach’s Alpha reliability co-efficient was calculated as 0.95.

Instruction Process

Both unassigned groups were administered an ECT as pre-test prior to the instruction. It was determined that there was no significant difference between two groups, and the group with the most appropriate timetable was assigned as the experimental group. In the experimental group, drama activities were performed following the regular lesson activities as presented to traditional classroom. For the control group, traditional instruction activities used such as lecturing and question-answer. After the 4-week-long instruction period, both groups were administered the same concept test as post-test. Moreover, the experimental group was administered the DMAS.

Drama Activities Related to Electrostatics

Initially, drama activities concerning electrostatics topic in university were designed by the researcher. After the confirmation of a scholar in the field, these activities were piloted in a group with similar characteristics to the experimental group. After the pilot activities, necessary revisions and developments were made to be implemented to the ultimate context. Activities are listed as follows: electrification by friction, touching, and force; grounding; electrical force and Coulomb Law, electrical field lines, movement of a charged particle in a laminar and a turbulent electrical field and Gauss Law; electrical potential; energy and capacitors.

Table 6 Drama Activities Related to Electrostatics

No	Topic	Drama Techniques	Duration
1	Conductive and insulative	Role playing, improvisation, and still image	45 min
2	Types of electrification and grounding	Role playing, improvisation	45 min
3	Electrical force and Coulomb Law	Role playing, improvisation	45 min
4	Electrical field and lines	Role playing, improvisation	45 min
5	Particle movement in uniform electrical field	Role playing, improvisation	45 min
6	Gauss Law	Acrostics, hot seat	45 min
7	Electrical potential and energy	Role playing, improvisation	45 min
8	Capacity	Role playing, improvisation	45 min

Below is the an example from the drama activities used in teaching:

ACTIVITY 1
Topic: Gauss's Law
Objective: Students discover the features of Gauss's Law and solve the problems presented by using Gauss's Law.
Grade: University 2nd grade
Materials: Pen and paper

Duration: Two lesson hours
Drama Techniques: Writing in a role, acrostics, and hot seats.

1st phase:
In this phase, the lesson knowledge about the basic principles of Gauss's Law is presented to students through direct instruction technique.

2nd phase: Drama Activities

2.1. Preparation - Warm-up:
Since drama activities are to be performed in the classroom environment, the game of stand-up/sit-down is played.

2.2. Enactment:

1st step: Pens and papers are handed out to students. Then, students are asked to write GAUSS'S LAW from top to bottom to create a poem involving the features of Gauss's Law starting with the corresponding letter on each line. Following the completion of the poems, each student reads aloud the product in turn.

2nd step: Features of Gauss's Law are repeated by using hot seats techniques. To do this, four volunteers from the student group are each seated in a chair in turn. The student who is seated is addressed as Gauss's Law. Other students ask questions about the features of Gauss's Law and the circumstances under which it is used. The student in the seat who enacts Gauss's Law answers these questions. Then, other students in turn start enacting Gauss's Law.

2.3. Evaluation:
During this phase, students are asked questions concerning the basic principles of Gauss's Law. Following this, they are asked to write down the general formulae of Gauss's Law, and they are asked to explain how they would solve a problem regarding electrostatics by using Gauss's Law. Finally, sample problems about Gauss's Law are solved to revise what has been learned.

Findings

To determine if the variables were distributed normally, Skewness and Kurtosis normality test was run, and values calculated by dividing Skewness and Kurtosis values were divided by Skewness and Kurtosis error values. As a result, the values were calculated in the range of -1.96 and +1.96; thus, it indicated a normal distribution (Can, 2014).

Table 7 Normal Distribution Values of Data

	Pre Test Scores		Post Test Score		Drama Attitude Score
	Exp.	Control	Exp.	Control	Exp.
N	42	41	42	41	42
Mean	6.21	6.32	13.64	10.07	78.94
Median	6.00	6.00	13.50	10.00	75.77

Mode	6	6	12	9	93
Std.Dev.	2.066	2.055	2.748	2.696	11.972
Skewness	.203	.094	.008	.393	.171
Std. Skewness Error	.365	.369	.365	.369	.365
Kurtosis	-.915	-.880	-1.110	-.394	-.408
Std. Kurtosis Error	.717	.724	.717	.724	.717

Following the determination of data distributed normally, it was decided that parametric test should be used in data analysis.

Findings Concerning First Research Question

Regarding the first research question, an independent sample t-test and Levene test were run to determine a significant difference between two groups' ECT pre-test scores in terms of group variables.

Table 8 Levene and Independent Samples t-test Findings of Pre-test Mean Scores of Groups

						Levene Test		T test	
	Group	N	M	%	S	F	p	t	p
Pre-test	Experimental	42	6.21	31.05	2.066	0.004	0.951	-0.227	.821
	Control	41	6.32	31.60	2.055				

When the experimental and control groups' ECT pre-test scores were examined, it was deduced that both groups mean scores were close in the sense of values, yet no significant difference between them was detected [t81=-0.227, p>0.05].

Findings Concerning Second Research Question

Regarding the research question, a significant difference between ECT pre-test and post-test scores of the experimental group was sought and a paired samples t-test was run.

Table 9 Paired Samples t-test Results of Experimental Group Pre-test Post-test Scores

	N	M	S	sd	t	p
Pre-test	42	6.21	2.066	41	-16.151	.000
Post-test	42	13.64	2.748			

According to t-test findings, a significant difference between the experimental group's pre-test and post-test scores [t41=-16.151, p>0.05]. It was indicated that drama-assisted instruction positively affected student conceptual understanding.

Findings Concerning Third Research Question

For the research question, the control group's ECT pre-test and post-test scores were compared to detect a significant difference, and a paired samples t-test was run.

Table 10 Paired Samples t-test Findings for Control Group Pre-test Post-test Scores

	N	M	S	sd	t	p
Pre-test	41	6.32	2.055	40	-9.334	.000
Post-test	41	10.07	2.696			

Findings of the t-test revealed that there was a significant difference between control group's pre-test and post-test scores [t40=-9.334, p>0.05]. It was found that traditional instruction had a positive impact on students' conceptual understandings.

Findings Concerning Fourth Research Question

An independent samples t-test and Levene test were run to determine if there was a significant difference between ECT post-test scores of control and experimental groups in terms of group variables.

Table 11 Control and Experimental Groups' Post-test Mean Scores and Findings of Levene and Independent Samples t-test

						Levene Test		T test	
	Group	N	M	%	S	F	p	t	P
Post-test	Experimental	42	13.64	68.20	2.748	0.307	.581	5.972	.000
	Control	41	10.07	50.35	2.696				

Considering ECT post-test scores of both group students, mean scores of the experimental group participants were observed to be higher than the control group, and there was a significant difference between them [t81=5.972, p<0.05]. In the study, it was revealed that drama-assisted instruction was more effective than traditional instruction to teach electrostatics in terms of student conceptual understanding.

Findings Concerning Fifth Research Question

Data analysis with regard to the fifth research question was performed to determine if the attitudes of the experimental group towards drama method were positive or negative. It

was revealed that the experimental group mean scores were 78.9% positive based on DMAS administered after the instruction.

Table 12 Means and Percentages of DMAS Items

Item Number	Item	M	%	Std. Dev.
1 (FD1)	Drama is a suitable method for physics class.	4.07	81.4	.712
3 (FD2)	I prefer learning physics through drama more than other methods.	3.90	78	.878
5 (FD3)	Drama simplifies physics subjects.	4.05	81	.764
6 (FD4)	Drama makes physics class more tedious.	4.24	84.8	.576
7 (FD5)	Using drama in physics class is hard and complicated.	3.81	76.2	.943
9 (FD6)	Drama helped me prepare for physics exams.	3.67	73.4	1.028
11 (FD7)	Using drama in physics class is unnecessary.	3.90	78	.692
14 (FD8)	Drama improved my observation and explanation skills in physics class.	3.93	78.6	.778
2 (ESD1)	Drama is a suitable method for electrostatics topic.	3.95	79	.731
15 (ESD2)	Learning electrostatics through drama is enjoyable.	4.07	81.4	.712
8 (PCD1)	Drama improved my logical thinking skill.	3.98	79.6	.715
10 (PCD2)	Drama improved my ability of tangible thinking.	3.98	79.6	.563
12 (PCD3)	Drama improved my ability of abstract thinking.	3.76	75.2	.850
13 (PCD4)	Drama helped me solve problems and devise new approaches.	3.79	75.8	.898
4 (DTE1)	I want to use drama in other classes, as well.	3.93	78.6	.997
16 (DTE2)	Drama is a more modern method compared to traditional instruction.	4.10	82	.726
17 (DTE3)	Teaching through drama should be more widespread.	4.07	81.4	.867
18 (DTE4)	I prefer traditional instruction to learning through drama.	3.86	77.2	.952
	Total	3.95	78.9	11.972

Note. "Drama in Physics Lesson (FD)", "Drama in Electrostatics (ESD)", "Drama and Problem Solving, Abstract-Concrete Thinking Skills (PCD)", and "Choosing Drama (DTE)".

In Table 12 where each item and corresponding values are presented, the data were entered in a way that negative items were coded reversely. When Table 12 is examined, 84.8% of the students thought the drama method eliminated the dull nature of physics lesson while 82% regarded drama method as more modern compared to traditional instruction. Similarly, 81.4% of the participants responded that it is a suitable method for physics lessons, and electrostatics with the help of drama is so fun that it should be made more common. Finally, 81% thought that the drama method simplifies physics subjects.

In addition, when Table 12 is examined, the lowest attitude score of 73.4% is related to the issue of whether drama helps prepare for physics exams. In general, it is evident that each item has a score above 70%, which indicates positive attitudes.

Findings Concerning Sixth Research Question

The data regarding the results of a Pearson Correlation test run to determine if there was a correlation between ECT post-test scores and DMAS post-test scores of the experimental group are presented in Table 13.

Table 13 Experimental Group Post-test DMAS Scores Pearson Correlation Test

		Drama Percentage	Pre-test Score
Drama Percentage	Pearson Correlation	1	.718**
	Sig. (2-tailed)	-	.000
	N	42	42

In accordance with the values in Table 13, there was a significant correlation between ECT and DMAS post-test scores of the experimental group participants. Therefore, it was indicated that students with high attitude scores towards drama method had high concept test levels related to the topic.

Conclusions, Discussion and Suggestions

In the research in which pre-test post-test control group quasi-experimental research model was used, the way drama-assisted instruction as a supplement to traditional setting affected achievement in electrostatics concepts and attitudes towards the drama method was investigated. Both groups were compared to determine if there was a significant difference between their pre-test scores of ECT, and it was revealed that there was no significant difference between the two groups. However, both groups' pre-test scores were quite close in terms of mean scores. On a related note, for the experimental group, a drama-assisted instruction was employed whereas the control group merely followed a traditional instruction. Following the instruction, both groups were compared in terms of their scores based on ECT administered as a post-test, and some conclusions were reached as discussed below:

The experimental group was examined in terms of significant differences regarding the comparison of their ECT pre-test and post-test scores. According to findings of the t-test, there was a significant difference between the pre-test and post-test scores of the experimental group. Therefore, it can be deduced that drama-assisted instruction raises student concept test

levels in teaching electrostatics. This result is aligned with the findings reached in the majority of drama related studies in the literature. For instance, Sağırlı and Gürdal (2002) detected a difference between pre-test and post-test scores in their research in which electrostatics subject was taught through drama. Similarly, Başkan (2006) emphasized the difference between test scores (Başkan, 2006; Sağırlı & Gürdal, 2002).

A comparison of ECT pre-test and post-test scores of the control group was made to determine if there was a significant difference. The findings based on the t-test suggested a significant difference between pre-test and post-test scores of the group [$t40=-9.334$, $p>0.05$]. In accordance with this result, it can be concluded that traditional instruction, similar to the drama-assisted, helps increase the student conceptual understanding levels in the sense of electrostatics. Although teaching methods that harbour active learning techniques have a bigger impact on student concept test levels, it can be thought that traditional instruction methods also affect concept test levels to a considerable extent.

Even though success rates were observed to have increased in both experimental and control groups, ECT post-test scores of the groups were compared and interpreted to decide which group was more successful. Accordingly, when ECT post-test scores of both groups were examined, the comparison revealed that students in the experimental group had higher mean scores than the ones in the control group, thus generating a significant difference [$t81=5.972$, $p<0.05$]. It was revealed that in teaching electrostatics, drama-assisted instruction was more effective in terms of student conceptual understanding levels compared to traditional instruction. Even though the literature did not provide similar research that focused on teaching electrostatics through drama instruction, results of studies including teaching both electricity and other physics subjects indicated that the use of drama increases student achievement levels significantly. For instance, in their research on teaching electricity units to secondary school students through drama, Sağırlı and Gürdal (2002) observed that drama instruction raised student achievement. Moreover, studies that focused on the effect of drama instruction on university level students generated similar findings. Özdemir and Üstündağ (2007) explored in their research conducted on scientists at the university level that drama instruction escalated student achievement levels. In addition, Şahin and Yağbasan (2011) revealed that the use of drama instruction increased student success in physics lab lessons.

Furthermore, whether the experimental group students had positive or negative attitudes towards the drama method were investigated, and DMAS administered following the instruction revealed a percentage of 78.9 in total mean scores. 84.8% of students who received

a drama-assisted instruction stated that the drama method eliminates boring elements in physics class. In addition, 82% thought drama method is more modern than traditional methods whereas 81.4% regarded drama as a suitable tool for physics, suggesting it is so enjoyable that it must be more widespread. Finally, 81% of the participants stated that drama method simplifies physics subjects. As a final note, the research investigated if there was a significant correlation between ECT post-test scores and DMAS scores of the experimental group. Related to this, results indicated that experimental group's ECT and DMAS scores were significantly correlated. Additionally, students with the higher scores for attitudes towards drama method were also more successful with regards to the topic. Among the research in university level, it was pinpointed that students' attitudes towards the drama was generally positive. Taşkın and Moğol (2016a) collected student responses related to drama before and after the instruction, and it was reported that students' attitudes towards drama-oriented instruction improved a great deal after the instruction. Majority of students that participated in the studies stated that drama method can be used in physics lessons and that they would want to use it in their future professional lives. Furthermore, they responded that the most crucial benefit of drama method is that it simplifies the process of establishing a connection between physics subjects and daily life. Oğuz and Altun (2013) obtained similar results in their research focusing on university students, and they revealed that students' attitudes towards drama increased, and drama reduced students' shyness levels.

Regarding all the studies on the field, it was indicated that drama increased student achievement levels and it was favored by majority of students on all levels ranging from primary school to university (Bertiz, 2005). However, it should be taken into consideration that drama might have problematic dimensions. As an example, in the study conducted by Arieli (2007), it was stated that drama instruction activities required more time compared to traditional teaching. Additionally, Türkkuşu (2008) asserted that drama is not suitable for all science subjects, requiring careful consideration for choosing subjects, and drama should not be used as the only instructional tool. Moreover, Taşkın and Moğol (2016a) proclaimed in their study that students might face difficulties with preparing a lesson plan and managing the classroom. In the light of all the insight, it is assumed that drama use should be employed in teaching appropriate subjects if not all, and it is important to make it more widespread in control of the proficient teachers that can efficiently use it. Furthermore, to prevent time constraints in lessons, drama activities pre-designed by scholars in the field should be used and their availability levels for teachers should be increased. Therefore, more drama activities related to physics and science subjects should be designed and added to the literature. Such a

favored method with which active involvement of students can be encouraged should be promoted for a more frequent use to eliminate the tedious atmosphere of traditional teaching environments.

As the last word, drama is not a magic wand like Harry Potter's wand by itself, but it is a more successful method than traditional methods. Because the majority of students have positive attitudes toward this method. The biggest problem with this method is the shortage of time. However, this problem can be overcome by pre-prepared activities, the professionalism of the teacher, and the use of the drama method in appropriate subjects. It can be used in the teaching process from primary school to university.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest

No conflict of interest.

Funding

None.

CRediT author statement

The study was single authored and the whole process was carried out by the corresponding author.

Research involving Human Participants and/or Animals

The study involves human participants. Ethics committee permission was obtained from Balıkesir University, Science and Engineering Sciences Ethics Committee.

Drama Sihirli Bir Değnek mi Yoksa Zaman Kaybı mı?

Özet:

Aktif öğrenme yöntemlerinin kullanıldığı derslere katılan öğrencilerin geleneksel öğretim yöntemlerinin kullanıldığı derslere katılan öğrencilere göre konulara daha fazla ilgi gösterdiğini ortaya koyan birçok araştırma yapılmıştır. Bu araştırmada, drama destekli öğretim etkinliklerinin üniversite öğrencilerinin Fizik-2 dersindeki Elektrostatik kavramlarına ilişkin başarılarına etkisini belirlemeyi amaçlanmıştır. Bu amaçla geleneksel öğretime ek olarak drama yöntemiyle desteklenmiş öğretim gerçekleştirilmiştir. Kontrol gruplu yarı deneysel araştırma deseninde yürütülen çalışmanın katılımcılarını Türkiye'nin batısındaki bir Eğitim Fakültesinde öğrenim gören 83 ikinci sınıf öğrencisi oluşturmuştur. Veri toplama araçları olarak Elektrostatik Kavram Testi (EKT) ve Drama Yöntemi Tutum Ölçeği kullanılmıştır. Araştırma sonucunda drama destekli öğretimle desteklenmiş deney grubunun kavram testine ilişkin puanları kontrol grubuna göre anlamlı düzeyde yüksek bulunmuştur. Ayrıca drama yöntemi ile desteklenmiş öğretim yapılan deney grubunun drama tutum puan ortalamasının %78.9 olumlu olduğu bulunmuştur. Araştırma sonuçlarına göre drama tek başına Harry Potter'ın asası gibi sihirli bir değnek olmasa da geleneksel yöntemlere göre daha başarılı bir yöntem olduğu görülmüştür.

Anahtar kelimeler: Kavramsal anlama, drama destekli öğretim, drama tutumu, elektrostatik, üniversite öğrencileri

References

Açıkgöz, K. (2006). *Aktif öğrenme [Active learning]*. Kanyılmaz Press.

Adıgüzel, Ö. (2018). *Eğitimde yaratıcı drama [Creative drama in education]*. Yapı Kredi Publications.

Akar Vural, R., & Somers, W. J. (2011). *Hümanist ilköğretim programları için ilköğretimde drama: Kuram ve uygulama [Drama in primary education for humanist elementary programs: Theory and practice]*. Pegem Publishing.

Akbaş, H. Ş. (2011). *The Effect of drama practices as problem solving strategy in science education on success, attitude, conceptual understanding and recall* [Unpublished master's thesis]. Marmara University.

Arieli, B. (2007). *The integration of creative drama into science teaching* [Unpublished doctoral dissertation]. Kansas State University.

Balcı, A. (2004). *Sosyal bilimlerde araştırma: Yöntem, teknik ve ilkeler [Research in social sciences: Method, technique and principles]*. Pegem Publishing.

Başkan, H. (2006). *The effect of drama method on science and technology teaching on misconceptions and student motivation* [Unpublished master's thesis]. Karadeniz Technical University.

Bertiz, H. (2005). *The Attitudes of prospective science teachers' towards creative drama and their views about story work* [Unpublished master's thesis]. Abant İzzet Baysal University.

Can, A. (2014). *SPSS ile bilimsel araştırma süresince nicel veri analizi [Quantitative data analysis in scientific research process with SPSS]*. Pegem Publishing.

Cihan-Yılmaz, G. (2006). *Using method of drama in science education* [Unpublished master's thesis]. Pamukkale University.

Çirkinoğlu Şekercioğlu A. G. (2011). *The effect of peer instruction method on prospective teachers' conceptual understanding and their attitude toward electrostatics* [Unpublished doctoral dissertation]. Balıkesir University.

Çirkinoğlu Şekercioğlu A. G., & Yılmaz Akkuş, G. (2016, May 19-22). *The use of drama method in 7th grade science and technology course solar system and beyond: space puzzle unit.* International Conference on Education in Mathematics, Science & Technology, Bodrum, Turkey.

Çirkinoğlu Şekercioğlu, A. G., & Yılmaz Akkuş, G. (2019). The effect of drama method to the 7th grade students' success in solar system and beyond: space puzzle unit. *Bolu*

Abant İzzet Baysal University Journal of Faculty of Education, *19*(1), 125-146. https://dx.doi.org/10.17240/aibuefd.2019.19.43815-538314

Demirci, N., & Çirkinoğlu, A. (2004), Determining students' preconceptions/misconceptions in electricity and magnetism. *Journal of Turkish Science Education*, *1*(2), 116-138. https://www.tused.org/index.php/tused/article/view/46/19

Demirci, N., & Çirkinoğlu Şekercioğlu, A. G. (2009). The effect of peer instruction method on students' conceptual understanding and their attitude toward electrostatics. *e-Journal of New World Sciences Academy, Education Sciences, 4*(1), 240-256. https://dergipark.org.tr/tr/download/article-file/185980

Durusoy, H. (2012). *The Effects of curriculum layered and creative drama methods on 6th grade "force and movement" unit on student achievement and retention of knowledge*, [Unpublished master's thesis]. Hacettepe University.

Genç, N. H. (2003). The reception of creative drama in education. *Journal of Hacettepe University Faculty of Education, 24*(1), 196-205. http://www.efdergi.hacettepe.edu.tr/shw_artcl-921.html

Güney, S. (2009). *Use of drama techniques in primary 4th and 5th grades (The Case of Dede Korkut Stories)* [Unpublished master's thesis]. Atatürk University.

İçelli, O. Polat, R., & Sülün, A. (2008). *Fen eğitiminde yaratıcı drama desenleri [Creative drama patterns in science education]*. Maya Academy Publishing.

Kahyaoğlu, H., Yavuzer, Y., & Aydede, M. (2010). The effect of creative drama method on achievement in science teaching. *Turkish Journal of Educational Sciences*, *8*(3), 741-758. https://dergipark.org.tr/tr/download/article-file/256245

Karadağ, E., & Çalışkan, N. (2008). *Kuramdan-uygulamaya ilköğretimde drama "Oyun ve işleniş örnekleriyle" [Drama in primary education from theory to practice "Play and practice examples"]*. Anı Publishing.

Karadağ, E., Korkmaz, T., Çalışkan, N., & Yüksel, S. (2008). Teacher as the leader of drama and scale of sufficiency of educational drama application validity and reliability analysis. *Gazi University Journal of Gazi Education Faculty, 28*(2), 169-196. https://dergipark.org.tr/tr/download/article-file/77123

Kaya Eker, S. (2023). *The effect of creative drama method on students' conceptual understanding, motivation and attitudes in teaching the subject of impulse and momentum* [Unpublished master's thesis]. Balıkesir University.

Maharaj-Sharma, R. (2017). Drama in science teaching – An example from Trinidad and Tobago. *Electronic Journal of Science Education*, *22*(4), 19-34. https://ejrsme.icrsme.com/article/view/18517

Maloney, D. P., O'kuma, T. L., Hieggelke, C. J., & Heuvelen, A. V. (2001). Surveying students' conceptual knowledge of electricity and magnetism. *American Journal Physics, 69*(7), 12-23. https://doi.org/10.1119/1.1371296

Oğuz, A., & Altun, E. (2013). Yaratıcı drama uygulamalarının öğretmen adaylarının yaratıcı dramaya yönelik tutumlarına ve utangaçlık düzeylerine etkisi [The Effect of creative drama practices on teachers' attitudes towards creative drama and shyness levels]. *International Journal of Social Science* *6*(1), 37-52. http://dx.doi.org/10.9761/JASSS1679

Oğuz-Namdar, A. (2017). *Creative drama in science teaching*. *New Approaches in Science Teaching* (pp:264-290) (M. Ergun, Ed.). Nobel Publishing.

Okvuran, A. (1994). The importance of creative drama in creating contemporary human effects on empathic skills and empathic tendency levels. *Ankara University Journal of Faculty of Educational Sciences*, *27*(1), 185-194. https://doi.org/10.1501/Egifak_0000000424

Özdemir, P., & Üstündağ, T. (2007). Creative drama education program for famous scientists in science and technology. *Elementary Online,6*(2), 226-233. https://www.ilkogretim-online.org/fulltext/218-1596624306.pdf?1688029276

Sağırlı, H., & Gürdal, A (2002). The Effect of drama technique on the student success in science lesson. *M.Ü. Journal of Atatürk Education Faculty Educational Sciences, 15*(1), 213-224. https://dergipark.org.tr/tr/download/article-file/2145

Sedef, A. (2012). The Effect of creative drama activities on 7th year students' scientific process skills, scientific creativity and self-regulation [Unpublished master's thesis]. *Pamukkale* University.

Şahin, E., & Yağbasan, R. (2011). Implementation of creative drama based activities ın introductory physics laboratory course. *Western Anatolia Journal of Educational Sciences,* Special Issue, 247-254. http://acikerisim.deu.edu.tr:8080/xmlui/bitstream/handle/20.500.12397/5178/247-254.pdf?sequence=1&isAllowed=y

Taşkın, T., & Moğol, S. (2016a). The Effect of creative drama method on pre-service teachers' attitude towards mechanics. *Journal of Ahi Evran University Kırşehir*

Education Faculty, 17(3), 17-37. https://dergipark.org.tr/en/download/article-file/1487408

Taşkın, T., & Moğol, S. (2016b). Teacher candidates' opinions related to using creative drama as a teaching method in teaching of physics. *Gazi Journal of Education Sciences, 2*(3), 193-210. https://dergipark.org.tr/en/pub/gebd/issue/35206/390662

Taşkın Can, B. (2013). The Effects of using creative drama in science teaching on students' academic achievement and scientific process Skills. *Elementary Online, 12*(1), 120-131. https://dergipark.org.tr/tr/download/article-file/90514

Tezci, E., & Yıldırım, B. (2007). *Öğretimde planlama ve değerlendirme [Planning and evaluation in teaching]*. Onur Kırtasiye.

Timothy, J., & Apata, F. S. (2014). Effects of creative drama-based instruction on basic science achievement and scientific attitudes in Lagos state. *Journal of Science, Technology & Education, 2*(2), 59-65. http://www.atbuftejoste.com/index.php/joste/article/view/14

Tımbıl, N. (2008). *Elementary education II. comparison of the effects of active learning approach and drama techniques on student achievement* [Unpublished master's thesis]. Muğla University.

Türkkuşu, B. (2008*). The effect of drama method application on student success in cell divisions* [Unpublished master's thesis]. Kafkas University.

Yağmur, E.(2010). *Critical thinking ability and effect of creative drama-supported processing of 7th grade science and technology course on success* [Unpublished master's thesis]. Sakarya University.

Yıldırır, H. E. (2020). Secondary school students‟ initial and changes in cognitive structures of argument and related concepts. *International Journal of Research in Education and Science (IJRES), 6*(2), 231-249. https://www.ijres.net/index.php/ijres/article/view/859

Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi
Cilt 17, Sayı 1, Haziran 2023, sayfa 120-173. ISSN: 1307-6086
Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education
Vol. 17, Issue 1, June 2023, pp. 120-173. ISSN: 1307-6086

Research Article

An Investigation of Theses and Dissertations About the Statistics and Probability Learning Area in Turkey*

Ayşe YALDIZ [1], Nadide YILMAZ [2]

[1] Başarı College, Karaman/Turkey, ayse.gokcayir@hotmail.com, http://orcid.org/0000-0003-4580-2691

[2] Karamanoğlu Mehmetbey University, Faculty of Education, Department of Mathematics Education, Karaman/Turkey, nadideylmz70@gmail.com, http://orcid.org/0000-0003-1624-5902

Received : 25.01.2023 Accepted : 02.06.2023

https://doi.org/10.17522/balikesirnef.1242577

Abstract – A document analysis was used in this study to examine Turkish theses/dissertations on probability and statistics.126 graduate theses/dissertations were analyzed by subjecting them to both content and descriptive analysis. According to the findings, theses/dissertations were not distributed evenly by publication year. The majority of theses/dissertations were written in the learning area of statistics. There was a great deal of interest in the keyword "probability". Most of the theses/dissertations examined how teaching practices affected the development of components. A large amount of research was conducted using quantitative methods. Most of the students in the study were middle schoolers, with the sample group ranging from 0 to 100 people at most. There was greater use of technology-supported teaching environments than other teaching environments. Both students and teachers exhibited misconceptions and a lack of knowledge regarding statistics and probability. Because of the teaching practices that were fulfilled, students' performance increased significantly.

Key words: thesis, dissertation, document analysis, statistics and probability.

Corresponding author: Nadide YILMAZ, Karamanoğlu Mehmetbey University.

Introduction

In today's world, rapid changes in information have paved the way for new needs to emerge. It is imperative that research be conducted to train the manpower necessary to meet these needs (Kayhan & Özgün-Koca, 2004). Therefore, questioning educational research is

* This study was created from the master thesis by the first author under the supervision of the second author

crucial (Özkaral & Mentiş-Taş, 2017). As an example of these research areas, math education is one that we use every day in all aspects of our lives, and whose importance is becoming increasingly apparent as time goes on. Various fields (such as industry, art, and technology) have evolved through mathematics, and mathematics plays a vital role in making sense of life (Hardy, 2004) because in this changing world, individuals who are competent in mathematics, will have more opportunities in the future (National Council of Teachers of Mathematics [NCTM], 2000). Mathematics education has incorporated all this awareness into the curriculum, and students are learning the knowledge and skills they need. Probability and statistics are two areas of knowledge and skills that should be acquired by students (NCTM, 2000). Despite the ease of accessing information, it has become more difficult to accurately describe and interpret information, and reading and interpreting data has become even more important (Shaughnessy, 2007). Both statistics and probability are based on randomness and deal with events that cannot be predicted with certainty in daily life (Ader, 2018), which explains the connection between them. In today's data-rich world, individuals must be able to evaluate concepts and results related to statistics and probability to correctly interpret situations and make accurate decisions (Bargagliotti et al., 2020; Franklin et al., 2005; 2007; Gal, 2002; Garfield & Ben-Zvi, 2008; NCTM, 2000; Watson, 2006; Wild et al., 2018). Statistics and probability knowledge and skills are required to acquire this evaluation skill during the educational process (Watson, 2006). It is therefore necessary to emphasize statistics and probability education at all levels of education (Garfield & Ben-Zvi, 2008; NCTM, 2000).

Turkey has prioritized the acquisition of knowledge and skills in the learning area of statistics and probability with increasing importance since 1926. As part of the 2005 curriculum, greater emphasis was given to this learning area to achieve objectives similar to those in other countries' curricula (Ader, 2016; 2018). Aside from all these changes, it has also become a matter of interest what work has been done in this field. Consequently, graduate studies, which serve an important purpose in this regard, must be examined because the field of graduate studies contains information researched by researchers and educators (Jin, 2004). Thus, the examination of theses/dissertations is of importance in this context. Furthermore, graduate studies play an important role in constructing the country's education system (Sevinç, 2001).

There are some studies that examine the trend of studies focusing on probability and statistics aiming to reveal trends in general statistics and probability research (e.g., Bakker et

al., 2018; Kayaly, 2013; Tishkovskaya & Lancaster, 2010; Zamora Araya et al., 2021). A number of studies have examined how students perform in the field of statistics and probability (Aziz & Rosli, 2021; Judi & Sahari, 2013; Sotos et al., 2007). Several studies (e.g., Zieffler et al., 2008) have attempted to reveal trends in studies on how statistics is taught and learned at universities. Becker (1996) revealed that less than 30% of the literature reviewed is constituted by experimental studies, contrary to Garfield and Ahlgren (1988) who stated there are limited studies that help students understand statistics and probability. Inference is a concept that students have profound and common misconceptions about, as shown by Sotos et al. (2007). Probability studies go beyond statistical studies, according to Garfield and Ben-Zvi (2007). Furthermore, the studies conducted with primary and secondary school students mainly covered concepts related to data, distribution, centre, variability, and probability. According to Zieffler et al. (2008), university students displayed inconsistencies in reasoning about sampling distributions, measures of central tendency, and dispersion. Studies exploring the development of students' statistical reasoning are more common than studies focusing on other statistical concepts, according to van der Merwe and Wilkinson (2011). Among the studies examined, only 15% focused on information and communication technologies. The fact that there have been very few studies that examine noncognitive factors and course design is also remarkable. According to Zieffler et al. (2011), variability is the most frequently used keyword. The Statistics Education Research Journal also published research studies on teachers and textbooks, although students are the most frequently studied participants. As listed by Judi and Sahari (2013), computer-assisted cooperative learning, problem-based learning, and active learning are the methods used in student-centered statistics education. Furthermore, the experimental method was the most commonly used, followed by the questionnaire and case study. According to Aziz and Rosli (2021), who analyzed 36 articles examining statistical literacy skills among students, four dominant factors influence statistical literacy development. They listed these factors as learning environment, students' attitudes, teaching method, and students' knowledge. Zamora Araya et al. (2021), on the other hand, bibliometrically analyzed the studies on teaching statistics indexed in the Scopus and Ebsco database between 2010 and 2019. The data were analyzed in five main categories: statistical sense, use of technology, attitude towards statistics, teacher knowledge, and active learning. The results showed that there is a need to improve statistical literacy, reasoning, and thinking in the classroom through activities using technology, active learning, and the teacher's statistical knowledge. In addition, attention was drawn to the importance of

discipline and pedagogical insight in helping students develop positive attitudes towards statistics.

According to the studies examining the trend in mathematics education research in our country, statistics and probability are the least studied subject areas (Çiltaş et al., 2012; İncikabı et al., 2017; Ulutaş & Ubuz, 2008; Yücedağ & Erdoğan, 2011). The number of studies analyzing the trends in the area of statistics and probability (Dinç, 2021; Tosun & Özen-Ünal, 2019) is quite limited. The word "graph" was used most frequently in statistics and probability articles and theses, according to Tosun and Ünal (2019). Studies with experimental designs were more prevalent than those with qualitative methods. Most of the studies were conducted with 50-100 participants and most of the data were collected using achievement tests, knowledge tests, and development tests. Studies focused primarily on the effectiveness of teaching methods and analyzed the obtained data with quantitative methods. In addition, middle school students have the most difficulty with line graphs. From 2005 to 2020, Dinç (2021) examined master's theses and doctoral dissertations carried out with middle school students in Turkey in the learning area of statistics and probability. According to the results obtained, Middle East Technical University produced most of the theses/dissertations. Additionally, more theses/dissertations were prepared in 2019 than in previous years. Additionally, the number of 8th graders participating in the probability theses/dissertations was more and the number of participants was concentrated between 31 and 100. As a result, data collection methods such as scales were used extensively, and quantitative methods were preferred. Another remarkable finding was the large number of achievement measurement studies conducted.

The worldwide importance of statistics and probability has increased considerably due to the widespread use of quantitative information in all fields (Wild et al., 2018). Being able to read this information accurately, present reliable and convincing evidence-based arguments and critically evaluate data-based inferences are important skills that all citizens of the 21st century must possess (Leavy et al, 2018). This situation has made the teaching of statistics and probability even more important in the teaching process (Bargagliotti et al., 2020; Franklin et al., 2005; 2007; Gal, 2002; Watson, 2006). Parallel to this importance, it has been observed that the research on the related subject area has significantly increased (Zieffler et al., 2011). It can be said that postgraduate studies are of great importance at this point because postgraduate studies contain information researched by researchers and educators working in this field (Jin, 2004). In this sense, it can be said that the examination of theses is important

because postgraduate theses have a very important task in terms of revealing the developments in the field and showing the direction of future research. Moreover, graduate studies are factors decisive in shaping the education system of the country (Sevinç,2001; Tarman et al., 2010). All these show the necessity of analyzing the studies to determine how the importance of probability and statistics has increased in Turkey as in the world and what kind of trends are adopted in these studies. The purpose of this paper is to present an overview of the studies done in our country on statistics and probability education. This study, in an attempt to contribute to the literature, examines theses/dissertations created in the learning area of statistics and probability holistically, handles them in different dimensions, and evaluates them to reveal their current status in our country. Educators, teachers, and researchers who work in this field may find useful clues by revealing the trend of theses/dissertations conducted during the process. In addition to guiding future studies and practices, it can also influence future research policies (Ulutaş & Ubuz, 2008; Sevencan, 2019; Suri & Clarke, 2009). This study is especially important given the very limited number of studies showing trends in the teaching and learning of statistics and probability in our country (e.g., Dinç, 2021; Tosun & Özen-Ünal, 2019). This study may also have a potential effect on increasing awareness about statistics and probability as a learning area and contribute to the field. This study can also support researchers specializing in the subject by providing a perspective to those who will do research on this subject, determining which areas need to be further researched and guiding the applications to be made. Thus, researchers can contribute to the literature by choosing an original research topic and concentrating on the points that need to be studied (Rhoades, 2011). Furthermore, curriculum experts can revise curricula based on the results. This study aimed to examine trends displayed in master's theses and doctoral dissertations in the learning areas of statistics and probability and seek answers to the following questions:

What is the distribution of the,

1. types (master’s or doctoral) of the theses/dissertations?
2. years of publication of the theses/dissertations?
3. universities where the theses/dissertations created?
4. genders of the authors of the theses/dissertations?
5. languages used in the theses/dissertations?
6. subjects of the theses/dissertations?
7. keywords used in the theses/dissertations?

8. purposes of the theses/dissertations?
9. research methods used in the theses/dissertations?
10. participants/samples of the theses/dissertations?
11. sample sizes of the theses/dissertations?
12. data collection tools used in the theses/dissertations?
13. data analysis methods of the theses/dissertations?
14. teaching practices used in the theses/dissertations?
15. results obtained in the theses/dissertations?

Methodology

Research Design

A qualitative research method was used in the current study to examine the master's theses and doctoral dissertations in the field of statistics and probability in detail and to understand the results. Document analysis was employed as one of the qualitative research methods. Document analysis allows examining documents obtained in various ways for a systematic purpose and interpreting the results obtained (Corbin & Strauss, 2008; Wach, 2013). The current study conducted a document search in consideration of the study's purpose, analyzed the obtained documents in accordance with the established criteria, and interpreted the results (Figure 1).

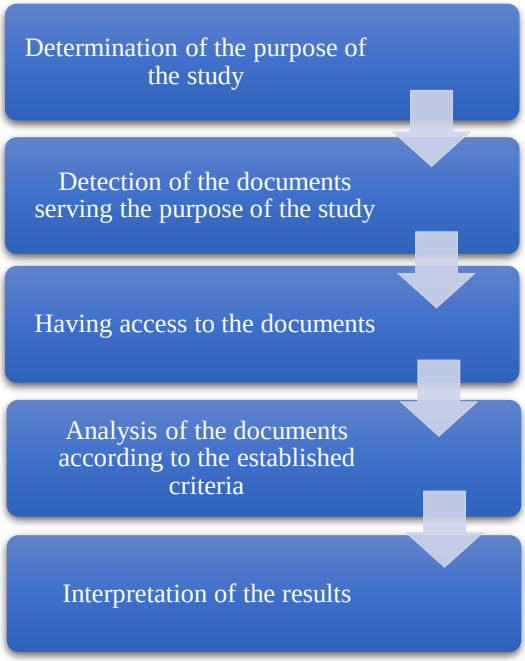


Figure 1 Research process

Data Sources and Data Collection Tools

The purposive sampling method was employed while determining the data sources of the study. This method allows the researcher to choose a rich source of data about the problem focused on (Fraenkel & Wallen, 2006). In accordance with the research problem, criterion sampling was used, which is one type of purposive sampling. Since the purpose of the current study was to examine the theses/dissertations prepared in the learning area of statistics and probability in Turkey, the theses/dissertations open to access in the National Thesis Centre [NTC] were searched. The following are the criteria that guided the selection of theses/dissertations:

- being written in the field of mathematics education,
- being related to the learning areas of statistics and/or probability,
- being completed in the period between 2000 and 2021,
- having open access.

In this context, it was determined that there were theses/dissertations in the NTC that did not use these words as keywords, although they were written in the learning areas of statistics and/or probability. Accordingly, the keywords were further customized and the search was conducted by using the keywords such as “graphs”, “measures of central tendency”, “measures of dispersion”, “variability”, “probabilistic thinking” related to these learning areas. Our search resulted in 126 graduate theses/dissertations (108 master's theses, and 18 doctoral dissertations) carried out between 2000 and 2021.

Through documents, which are an important source of data in qualitative research, written materials that contain information about the phenomena being researched by the study are analyzed (Yıldırım & Şimşek, 2011). In the current study, since it was aimed to analyze the theses/dissertations carried out in the learning area of statistics and probability, documents were used and a thesis review form was created for the criteria to be examined (App-1). These criteria included the name of the thesis/dissertation, the author and the advisor, the type of the thesis/dissertation and the year of publication, the university where the study was conducted, the language of the thesis/dissertation, the gender of the authors, the subject of the study, the list of the keywords, the purpose of the theses/dissertations, the research method, the sample (participants), the sample size, the measurement tools, the data analysis techniques, the results of the theses/dissertations, and the teaching practices used in the theses/dissertations. As a result, an Excel file was created for each thesis/dissertation after being analyzed according to these criteria.

Data Analysis

In order to analyze the data, the qualitative data analysis method was employed, and the data were subjected to both content analysis and descriptive analysis (Yıldırım & Şimşek, 2011). The first step was to create a file for each thesis/dissertation. As a result, each thesis/dissertation was evaluated using the questions outlined in App-1. Identifiers were assigned to each thesis/dissertation, such as T1, T2,... Descriptive analyses were performed on thesis/dissertation type, year, keywords, subject, method, sample (participants), sample size, measurement tools, and analysis techniques used. Codes were used to calculate the frequencies and percentages within the categories previously created. The findings were interpreted based on the tables and graphs created based on the data obtained. A content analysis was conducted on the theses/dissertations to determine their purposes, results, and teaching practices. Data from each research problem was analyzed to create codes. Similar codes were then used to create themes. In light of these themes and codes, the results and comments were presented.

Reliability and Validity of the Study

In order to establish the validity and reliability in qualitative research, credibility, transferability, internal reliability or dependability, and confirmability criteria should be met (Lincoln & Guba, 1985). For these criteria to be met, it was first explained why the purposive sampling method had been selected. Furthermore, the criteria for selecting which studies to include were explained. A detailed explanation of the research method, data collection tool, data collection processes, and data analysis was provided. Moreover, after the thesis review form was developed to analyze the theses/dissertations, it was sent to the expert reviewers for their feedback, before being finalized. The process of determining categories in data analysis is another crucial issue. Reliability is also ensured by this factor. The data were coded by both researchers and their compatibility was examined. The compatibility between these evaluations; that is, the reliability of the study, was calculated using the following formula proposed by Miles and Huberman; Reliability = Agreement / (Agreement + Disagreement) (Miles & Huberman, 1994). The current study was found to have an 85% reliability based on this formula. It indicates that a study is reliable when it exceeds 70% (Miles & Huberman, 1994). Additionally, controversial issues were discussed until a consensus was reached.

Researcher Role

Researchers who use a qualitative research approach play an important role from beginning to end in their research. The role of the researchers is extremely important for the healthy conduct of the whole process, starting with the determination of the research problem to the collection, analysis, and interpretation of the data (Fraenkel & Wallen, 2006; Gall et al., 2007). Researchers conducted the current study to be as objective as possible. By keeping their assumptions and prejudices separate, the researchers kept the information objective. They only included their own views during the interpretation stage after analyzing the collected data. Controlled inquiries were conducted on the subject being studied during the data collection stage. The collected data were checked again after they had been processed. By digitizing the data with frequency and percentage values, the data were interpreted. Furthermore, expert opinions contributed to objectivity.

Findings and Interpretation

This section provides information on the type of theses/dissertations analyzed, the year of publication, the university where they were written, the gender of their authors, the subjects, keywords used in the theses/dissertations, as well as their purposes, research methods, participants (samples), sample sizes, data collection tools, data analysis methods, teaching practices, and results. Figure 2 shows the distribution of theses by type of thesis/dissertation.

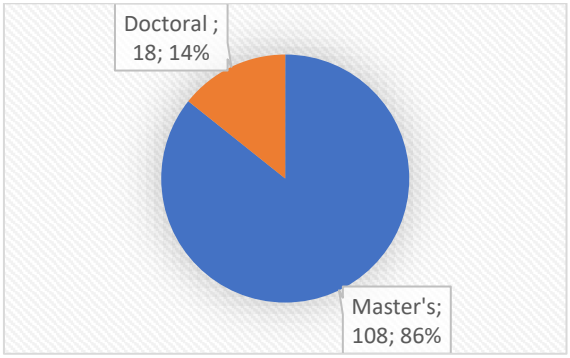


Figure 2 Distribution of the theses/dissertations by type

As seen from the distribution of 126 theses, 108 master's theses and 18 doctoral dissertations were prepared. Most of these theses were master's theses, while 14% were doctoral dissertations. Accordingly, master's theses account for the majority of theses/dissertations prepared. Figure 3 shows the results of the examination of theses based on their publication years.

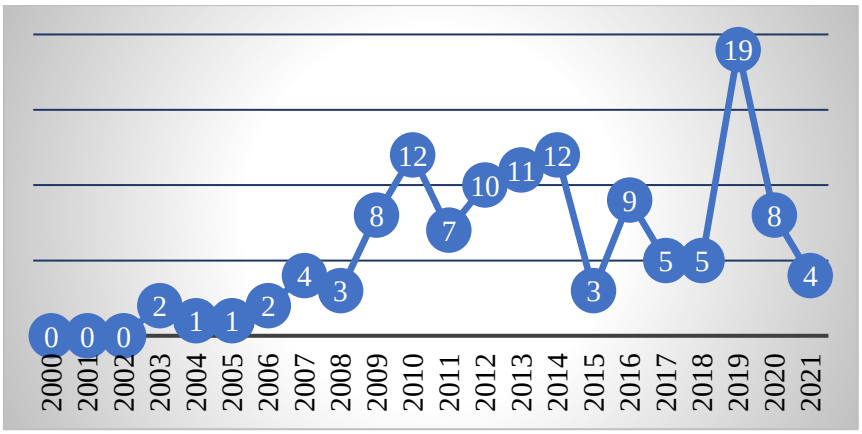


Figure 3 Distribution of theses/dissertations by year of publication

According to Figure 3, no theses/dissertations were prepared in this field between 2000 and 2002 based on the distribution of theses/dissertations across the years. Since the first studies in this field began in 2003, there has been an increase until 2010. Even though the number of theses/dissertations written in this field decreased in 2011, a significant increase was observed until 2014. In contrast, a significant decrease was observed in 2015, and a significant increase was noticed in the following years, especially in 2019. Despite the fact that this field had theses/dissertations in 2020 and 2021, they were fewer than in 2019. 2019 was the year with the highest number of theses/dissertations written. Furthermore, Figure 4 shows the distribution of master's theses and doctoral dissertations over the years.

Figure 4 Distribution of the theses/dissertations by year and type

According to Figure 4, master's theses show fluctuations over time. Doctoral dissertation fluctuation levels are lower than those of master's theses. A study of which universities the theses/dissertations were written led to the creation of Figure 5.

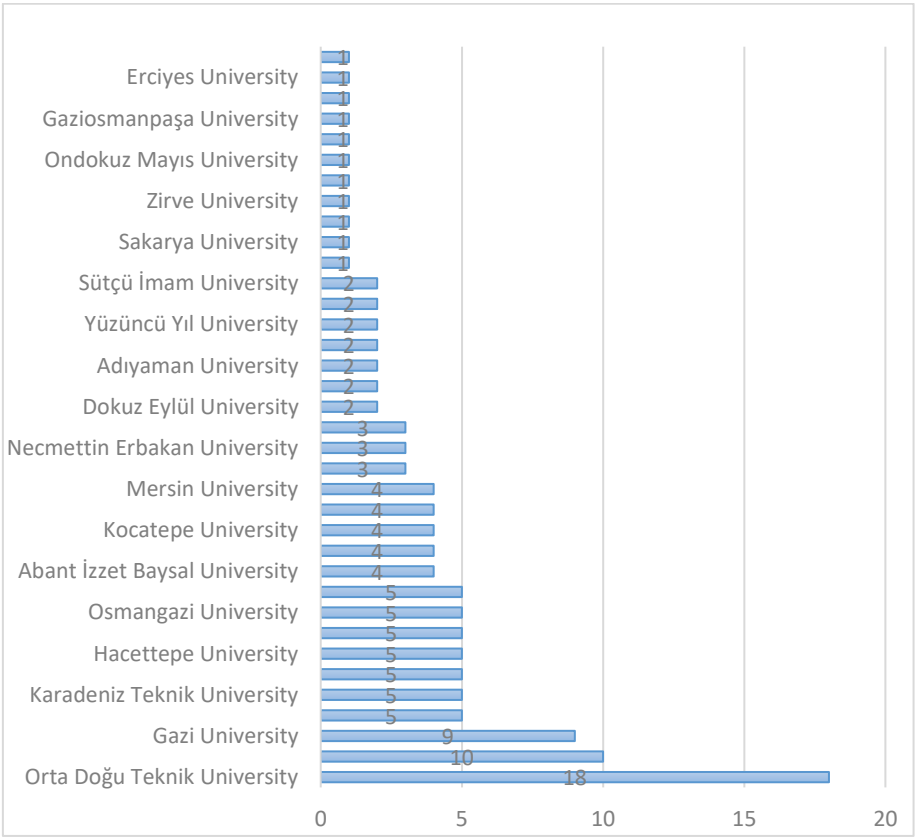


Figure 5 Distribution of the theses/dissertations by university

Middle East Technical University published the most theses/dissertations on statistics and probability, with 18 theses/dissertations, followed by Marmara University with 10 theses/dissertations, and Gazi University with 9 theses/dissertations. A total of five theses were published by seven universities, and four theses were written by five universities. Based on the genders of the authors of the theses/dissertations, it was found that approximately six out of ten theses/dissertations prepared in the learning area of probability and statistics were written by females (Figure 6).

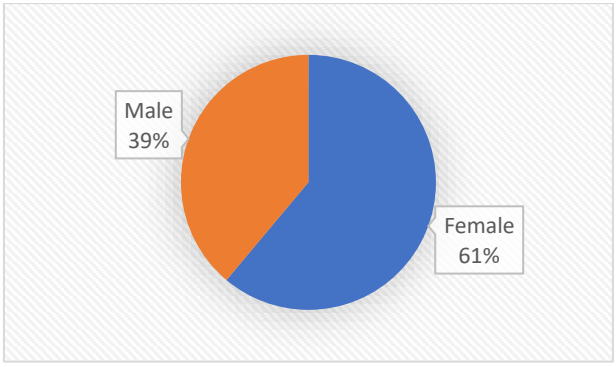


Figure 6 Distribution of the theses/dissertations by gender

When the language used in the theses/dissertations was examined, it was revealed that 80% of the theses/dissertations were written in Turkish and 20% were written in English (Figure 7).

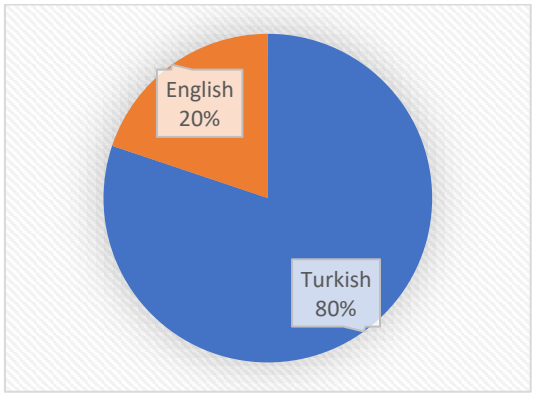


Figure 7 Distribution of the theses/dissertations by language

The distribution of the examined theses/dissertations according to their subjects is shown in Figure 8.

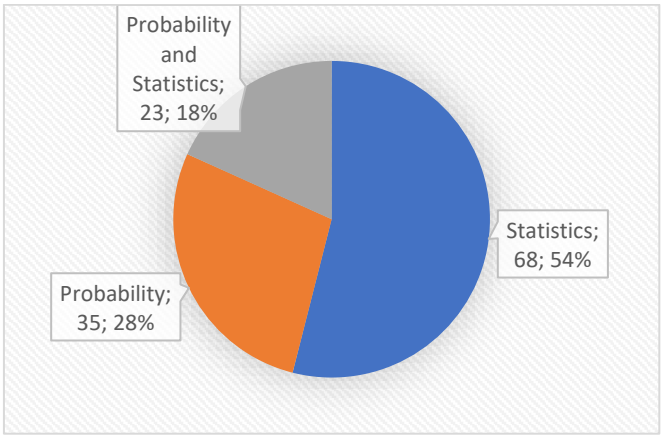


Figure 8 Distribution of the theses/dissertations by subject

Based on Figure 8, approximately half (54%) of the theses/dissertations were written in the field of statistics, followed by theses/dissertations on probability (28%). The theses/dissertations written in both statistical and probability fields account for about one-fifth (18%) of the theses/dissertations. Table 1 summarizes the keyword distribution in theses/dissertations. There are three or fewer keywords that are less frequently used, and these are listed in Table 1.

Table 1 Distribution of the Theses/Dissertations by Keyword

Keywords	Frequency (n)	Percentage (%)
Probability	28	6%
Teacher	18	4%
Attitude	18	4%
Statistics education	18	4%
Mathematics education	14	3%
Achievement	14	3%
Misconception	13	2.8%
Statistical literacy	11	2.4%
Mathematics teaching	10	2.2%
Graph	8	1.7%
Academic achievement	7	1.5%
Statistics	7	1.5%
Computer-assisted teaching	7	1.5%
Pre-service mathematics teachers	7	1.5%
Realistic mathematics education	6	1.3%
Primary school	5	1.1%
Probability and statistics	5	1.1%
Grade level	5	1.1%
Cooperative learning	5	1.1%
Constructivist learning	5	1.1%
Gender	4	0.9%
Tinkerplots	4	0.9%
Anxiety	4	0.9%
Middle school mathematics teachers	4	0.9%
Traditional teaching method	4	0.9%
Other	221	49.6%

According to an evaluation of the keywords used in the dissertations, the word "probability" was the most frequently used. Despite the fact that most of the theses/dissertations were written in the field of statistics, it is noteworthy that the most common keyword used in theses is “probability”, followed by “teacher”, “attitude”, “statistics education”, “mathematics education” and “achievement”. A total of 49.6% of the keywords were used three or fewer times.

Table 2 shows the distribution of the examined theses/dissertations by their purposes. In some theses/dissertations, there was more than one purpose, so this was taken into account in the coding process. Table 2 indicates that a significant number of theses/dissertations have been written with the purpose of investigating “the effect of teaching practices prepared to

make students gain knowledge and skills related to statistics and probability on the development of different components". Almost one-third of the theses/dissertations were prepared for this purpose (37%). Approximately one-fourth of all theses (25%) examined students' knowledge and misconceptions of statistics and probability. 16 percent of theses/dissertations examined the knowledge of statistics and probability of teachers/pre-service teachers. There were 6% of theses/dissertations that examined the relationships between statistical and probability concepts and other variables (e.g., gender). A total of 4% of the theses/dissertations were conducted to improve pre-service teachers' understanding of statistical and probability concepts. 3 percent of theses/dissertations were devoted to "developing a scale for measuring knowledge and skills related to statistics and probability (e.g., statistical literacy)" or "modelling the relationships between concepts and situations associated with statistics and probability (e.g., statistical anxiety)". Only 2% of all theses/dissertations examined curriculum/textbook/theses and revealed teachers' and students' views on statistics and probability-related situations (portfolio, dynamic geometry software). One percent of the theses/dissertations aimed at revealing teachers'/pre-service teachers' statistical awareness. According to the evaluation of the purposes of the theses/dissertations, most of the theses/dissertations were aimed at making students gain knowledge and skills related to statistics through teaching practice. There are then theses/dissertations designed to explore teachers' and students' knowledge of statistics and probability, as well as their misconceptions about them. Three out of every four theses/dissertations (79%) were structured around these three purposes. In general, the dissertations' purposes can be interpreted as consistent with the keywords. Among the components listed for the purpose of "investigating the effects of teaching practices designed to teach students statistics and probability on different components" are achievement and attitude. Accordingly, it is not surprising that the keywords related to this situation such as attitude, achievement, and academic achievement are used too often in theses/dissertations prepared for this purpose. Students' knowledge/misconceptions about statistics and probability are examined in theses aiming to examine students' knowledge/misconceptions. "Misconception" is used more often than many other keywords to achieve this goal. A fifth of all theses/dissertations focus on teachers or pre-service teachers, so it is not surprising that the word "teacher" is used excessively.

Table 2 Distribution of the theses/dissertations by purpose

Purpose	Thesis Identifier	Frequency	Percentage
Studies examining students' knowledge/misconceptions about the concepts of statistics and probability	T1, T5, T14, T17, T18, T24, T27, T29, T30, T33, T35, T36, T40, T42, T46, T62, T63, T64, T72, T73, T77, T80, T82, T92, T101, T103, T104, T105, T109, T113, T119, T120, T121, T122, T123, T124	36	26%
Studies examining the effects of teaching practices prepared to make students gain knowledge and skills related to the concepts of statistics and probability on the development of different components (e.g., achievement, attitude)	T2, T3, T4, T6, T9, T10, T11, T12, T15, T16, T20, T22, T23, T25, T26, T28, T32, T34, T38, T39, T41, T44, T45, T46, T48, T49, T52, T53, T54, T55, T58, T60, T65, T66, T67, T71, T75, T78, T79, T83, T85, T88, T91, T96, T97, T98, T105, T106, T107, T110, T115, T120	52	37%
Scale development studies on knowledge and skills related to statistics and probability (e.g., statistical literacy)	T7, T19, T43, T59	4	3%
Studies examining the relationships between different concepts of statistics and probability, and different variables (e.g., gender)	T8, T21, T29, T42, T69, T74, T80, T100, T104	9	6%
Studies revealing teacher and student views on statistics and probability-related situations (portfolio, dynamic geometry software)	T13, T89, T110	3	2%
Studies revealing the knowledge of teachers/pre-service teachers about the concepts of statistics and probability	T31, T51, T56, T57, T59, T70, T74, T76, T81, T84, T86, T93, T94, T95, T102, T111, T112, T114, T116, T117, T118, T126	22	16%
Studies aiming to improve teachers/pre-service teachers' knowledge of the concepts of statistics and probability	T31, T81, T90, T111, T116, T117	6	4%
Studies revealing the statistical awareness of teachers/pre-service teachers	T68, T87	2	1%
Studies that model relationships between the concepts/situations of statistics and probability (e.g., statistical anxiety)	T37, T47, T61, T99	4	3%
Studies examining curricula/textbooks/theses	T50, T108, T125	3	2%

The research methods employed by the theses/dissertations prepared in the learning area of statistics and probability were examined and are presented in Figure 9.

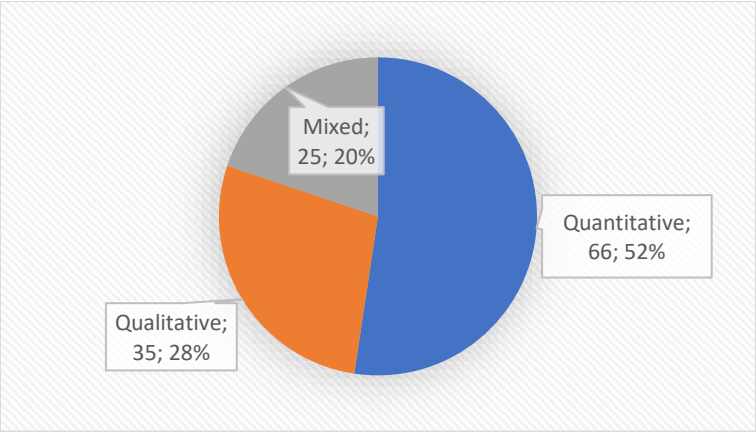


Figure 9 Distribution of the theses/dissertations by research method

Approximately half (52%) of the theses/dissertations used the quantitative research method. A qualitative research method was used in 28% of the dissertations. Twenty percent of theses/dissertations used a mixed research method. Hence, quantitative research is more commonly used to prepare dissertations. Figure 10 illustrates the distribution of quantitative research methods in dissertations.

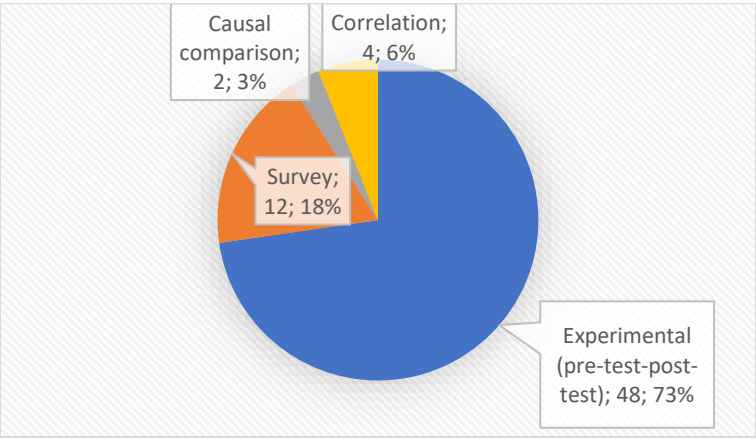


Figure 10 Distribution of the theses/dissertations by quantitative research method

According to Figure 10, the most commonly used quantitative method is the experimental method (48-73%), followed by the survey method (12-18%). A correlation method was used in four theses (4-6%), and a causal comparative method was used in two theses (2-3%). There is a higher number of experimental studies in dissertations, which is consistent with their objectives. It is not surprising that the majority of theses/dissertations (37%) prefer the experimental method since four out of ten theses/dissertations (37%) are about teaching practices designed to help students develop knowledge and skills in statistics

and probability concepts. Figure 11 displays the distribution of qualitative research methods used by the dissertations.

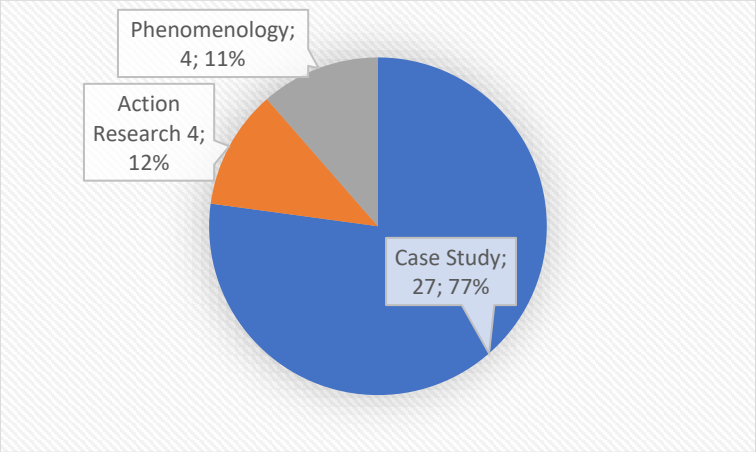


Figure 11 Distribution of the theses/dissertations by qualitative research method

Figure 11 shows that the majority of qualitative theses/dissertations used the case study design (27-77%), followed by the phenomenological design (4-12%). Additionally, no thesis employs grounded theory. Among the qualitative studies, the high number of case studies is also expected. Upon reviewing the dissertation purposes, it was noted that many studies examined both students and teachers/pre-service teachers (e.g., awareness, misconceptions) in a variety of ways. The use of case studies in these theses/dissertations is not surprising, since they allow a deeper look into the development and reveal the situation. Figure 12 shows the distribution of the sample groups of the theses/dissertations analyzed.

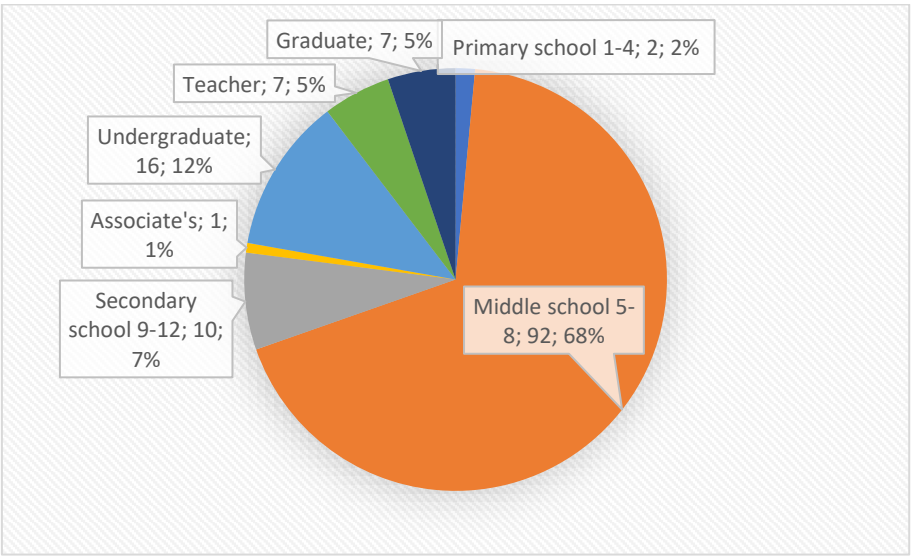


Figure 12 Distribution of the theses/dissertations by sample group

The theses/dissertations evaluated in this study are classified into groups such as primary school (1-4), middle school (5-8), secondary school (9-12), associate's, undergraduate, teacher, and graduate. According to Figure 12, the theses/dissertations analyzed in the current study most commonly interviewed middle schoolers in the 5th, 6th, 7th, and 8th grades (68%). As a result, the majority of the theses/dissertations prepared in the learning area of statistics and probability were prepared by middle school students, followed by undergraduate students (12%) and secondary school students (7%). Additionally, there are very few studies conducted with associate's degree students (1%) and primary school students (2%). A greater number of studies are conducted with teachers and graduate students than with students in primary schools and with associate's degrees. It appears, however, that studies using these sample groups are uncommon when viewed holistically. It is important to note one point. Due to the introduction of the 4+4+4 system in the 2012-2013 school year, 5th-grade students previously attending primary school started receiving education as middle school students. This study examined 5th-grade students as middle schoolers. Figure 13 shows the sample sizes of the theses/dissertations grouped in 100ths.

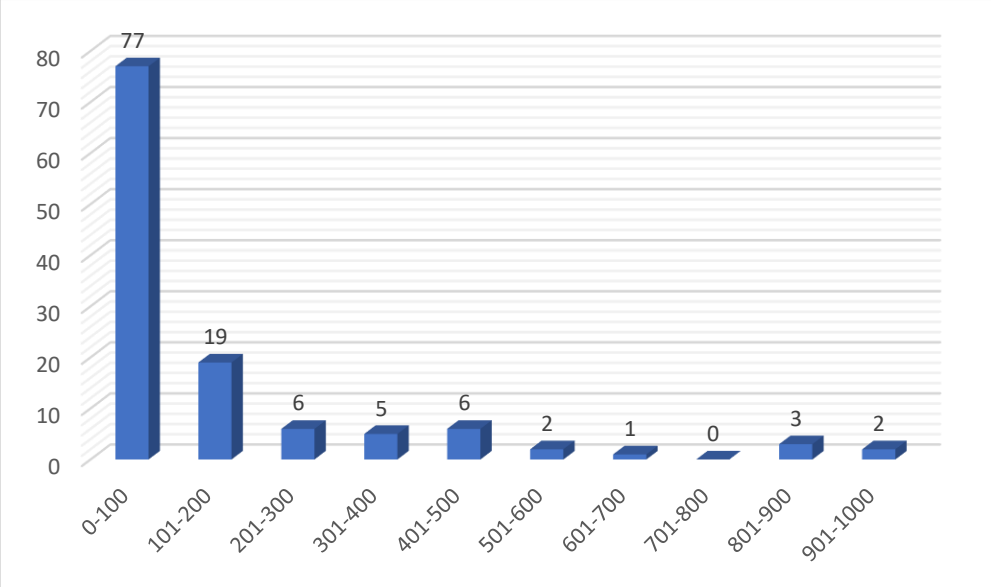


Figure 13 Distribution of the theses/dissertations by sample size

Based on the distribution of sample sizes used in dissertations, it was found that 77 theses/dissertations used a sample size ranging from 0 to 100 people (63%). The samples in 19 theses/dissertations consisted of 101-200 people (16%). There is no dissertation whose sample size ranges from 701 to 800 people. It's not much of a surprise to see such a result. According to the distribution of dissertation purposes, case studies and experimental studies

tend to involve 0 to 100 participants. Figure 14 shows the distribution of the data collection tools used in the dissertations.

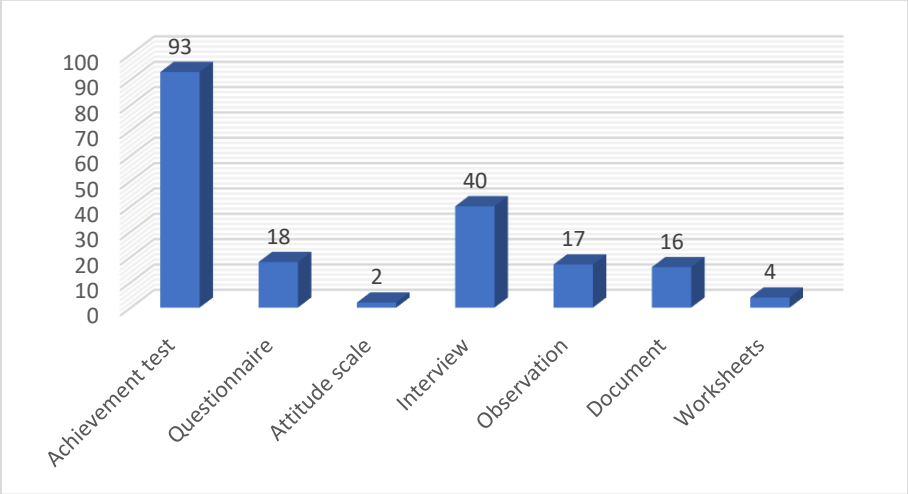


Figure 14 Distribution of the theses/dissertations by data collection tools

Figure 14 shows that theses/dissertations tend to use achievement tests to collect data (93-49%), followed by interviews (40-21%). Data collection tools such as questionnaires (11%), observations (9%), and documents (%8) are less popular. Data collection tools such as attitude scales (1%) and worksheets (2%) are the least preferred. Accordingly, it is compatible for achievement tests to be used more in data collection along with teaching practices being the subject of more dissertations. Figure 15 shows the results of dissertations' data analysis methods.

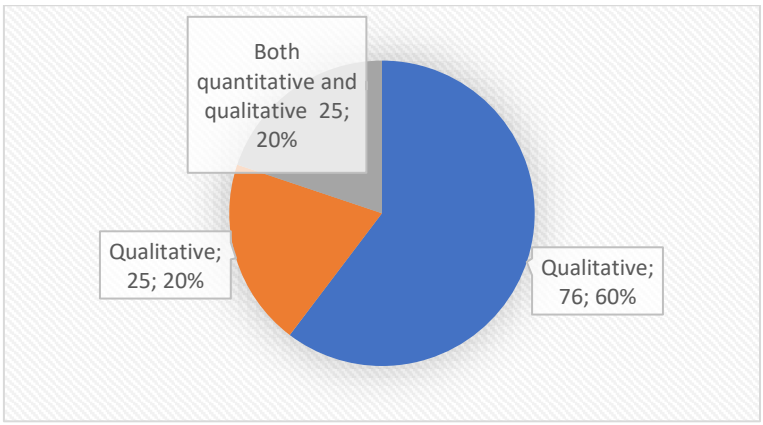


Figure 15 Distribution of the theses/dissertations by data analysis method

A review of the data analysis methods used by the theses/dissertations revealed that more than half (76-60%) were quantitative in nature. Among the theses/dissertations reviewed, the proportions of those utilizing qualitative analysis methods and those employing

both qualitative and quantitative analysis methods were the same (25-20%). According to this study, the high use of quantitative methods as data analysis methods is consistent with the data collection methods used in the theses/dissertations since achievement tests, which are more likely to be analyzed with quantitative methods, are used more frequently. As a result of classifying quantitative analysis methods within themselves, Figure 16 was created.

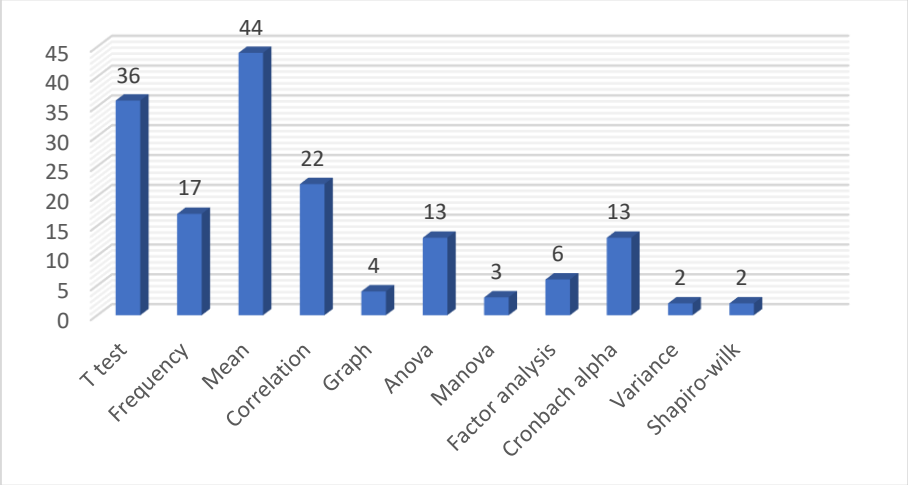


Figure 16 Distribution of the theses/dissertations by quantitative data analysis method

Figure 16 shows that in the learning area of statistics and probability, theses/dissertations using the quantitative analysis method tend to use descriptive quantitative data analysis methods (e.g., mean, graph). There is a tendency to prefer descriptive analysis methods over predictive techniques. Based on the classification of qualitative data analysis methods within themselves, Figure 17 was created.

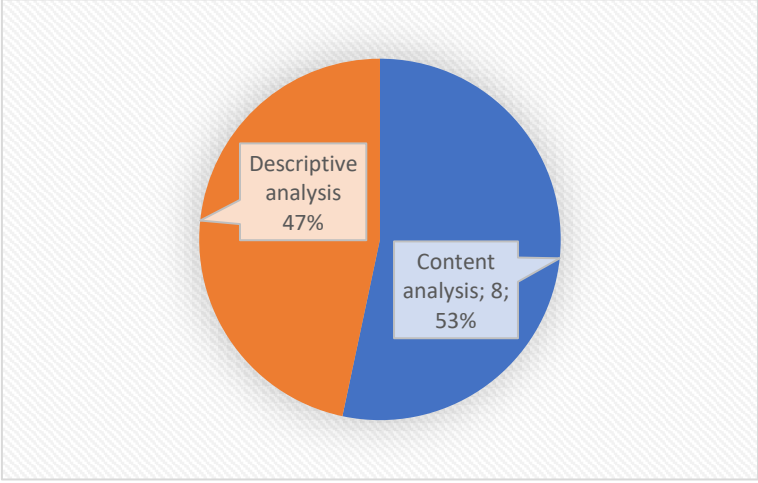


Figure 17 Distribution of the theses/dissertations by qualitative data analysis method

According to the findings in Figure 17, the percentages of the content analysis method (8-53%) and descriptive analysis method (7-47%) used in the theses/dissertations as qualitative data analysis methods are close to each other. Table 3 was created by analyzing the teaching practices used in the dissertations.

Table 3 Teaching practices used in the dissertations

Teaching Practices	Thesis Identifier	Frequency	Percentage
Technology-assisted	T3, T4, T9, T16, T28, T45, T46, T49, T53, T55, T65, T78, T83, T85, T96, T117, T120	17	28%
Realistic mathematics teaching-based	T52, T88, T97, T110	4	7%
Cooperation-based	T11, T34, T38, T71	4	7%
Multiple intelligence-based	T12, T26, T60	3	5%
Constructivist approach-based	T15, T44	2	3%
Game-assisted	T22, T115	2	3%
Metacognitive strategies-based	T39, T116	2	3%
Problem solution-assisted	T58, T91	2	3%
Professional development program	T81, T111	2	3%
Drama-based	T2	1	2%
Data driven (supported with the calculator)	T6	1	2%
Graf theory-based	T10	1	2%
Portfolio-based	T13	1	2%
Internet-assisted	T20	1	2%
Interdisciplinary teaching-based	T23	1	2%
Concrete models-based	T25	1	2%
Realistic mathematics and constructivist approach-based	T31	1	2%
Game programming-based	T32	1	2%
Creative drama-based	T41	1	2%
Concept map and Vee diagram-assisted	T66	1	2%
Exam-based teaching-assisted	T67	1	2%
Writing activities-based	T75	1	2%
Information exchange technique-based	T79	1	2%
Problem posing-assisted	T93	1	2%
Flipped learning-based	T98	1	2%
Statistical problem solving-based	T105	1	2%
Erroneous solution method-based	T106	1	2%
Digital competence-based	T107	1	2%
Game-assisted	T115	1	2%
Project-based	T48	1	2%

In examining the teaching practices used in the dissertations, it was found that more than a quarter used "technology-assisted teaching practices" (17-28%). This is followed by "realistic mathematics education-based teaching practices" and "cooperation-based teaching

practices" (4-7%). There were three theses/dissertations using "multiple intelligence-based teaching practices" out of all the dissertations. Even though many other teaching practices were used in the dissertations, their percentage was quite low (see Table 3).

Analyzing the dissertation results led to the creation of Table 4. It was observed that many different results emerged from the theses/dissertations when they were evaluated. According to 25% of the dissertations, the teaching practice carried out led to significant improvements in student achievement. It is followed by the finding that both pre-service teachers/teachers and students have difficulties/misconceptions regarding statistics and probability concepts. Furthermore, studies examining the effects of teaching practices on the development of different components (e.g., achievement, attitude) have generally found positive results. Students were more likely to be involved in scale development and correlation studies than teachers. According to the results, some variables (e.g., probabilistic reasoning-mathematical reasoning) were significantly related, while some variables (e.g., knowledge level-learning styles) were not significantly related. According to an evaluation of theses based on scale development studies, theses/dissertations were conducted to develop scales for attitudes toward statistics and literacy. Additionally, the professional development programs designed for mathematics teachers/pre-service teachers provided support in numerous areas. It was determined in studies examining textbooks that they were insufficient in a variety of ways. According to the results of the study, master's theses were more numerous than doctoral dissertations, and most of theses were conducted with the participation of 8^{th}-graders in the learning area of probability of occurrence. The quantitative research model and quasi-experimental design were both extensively used, and achievement and attitude scales were preferred. The main objective of the theses was to reveal the effectiveness of a particular method. The most important feature measured in the theses was achievement.

Table 4 Distribution of the theses/dissertations by finding

	Results			Thesis Identifier	Frequency	Percentage
Studies on students	Students have difficulties / misconceptions / lack of knowledge about the concepts of statistics and probability.			T1, T14, T18, T24, T27, T30, T35, T40, T42, T50, T62, T63, T64, T72, T73, T77, T82, T83, T92, T101, T10, T104, T109, T113, T119, T121, T122, T123, T124	29	16%
	Students are more successful in describing the data than in other thinking processes.			T17	1	0.5%
	The use of portfolio studies in statistics and probability teaching supports the teaching process.			T13	1	0.5%
	The teaching practice carried out	caused a significant increase in students' achievement		T3, T4, T9, T10, T11, T12, T15, T2, T22, T23, T26, T28, T31, T32, T33, T34, T38, T39, T41, T44, T45, T46, T48, T49, T52, T53, T54, T58, T60, T65, T66, T67, T75, T78, T85, T88, T90, T96, T98, T105, T106, T107, T110, T115, T117, T120	46	25%
		caused a significant increase in students' permanent learning		T2, T11, T23, T28, T34, T39, T52, T58, T 88, T97	10	5%
		caused a significant increase in students' attitudes		T3, T10, T25, T39, T52, T65, T67, T75	8	4.4%
		caused a significant increase in students' motivation		T22, T344, T88	3	2%
		caused a significant increase in students' intuitional thinking		T28, T54	2	1.5%
		caused a significant increase in students' metacognitive skills		T39, T75, T91, T110	4	2.2%
		caused a significant increase in students' perception of the usefulness of mathematics		T2	1	0.5%
		caused a significant increase in students' responsibility in mathematics lessons		T12	1	0.5%
		did not cause a significant increase in students' achievement		T2, T6, T16, T58, T71, T79, T97	7	4%
		did not cause a significant increase in students' permanent learning		T25, T67, T79	3	2%
		did not cause a significant increase in students' attitudes		T2, T6, T41, T49, T53, T66, T71, T85	8	4.4%
	Within the context of the teaching practice carried out	other variables (e.g., gender, family, education level, school type, peer collaboration)	have an effect on achievement	T5, T12, T80, T104	4	2.2%
			do not have an effect on achievement.	T3, T5, T8, T12, T15, T45, T80, T104	8	4.4%

	Correlation studies	There is no correlation between students' knowledge about the concepts of statistics and probability and their learning styles.	T54	1	0.5%
		There is a moderate and positive correlation between the mathematical reasoning skills and probabilistic reasoning skills of most students.	T36	1	0.5%
		There is a positive and significant correlation between students' statistical literacy and attitudes towards statistics.	T42	1	0.5%
		There is a positive and significant correlation between students' self-efficacy perceptions and general test achievement scores and between their attitudes towards mathematics and their achievement.	T80	1	0.5%
		There is a positive and significant correlation between students' attitudes towards mathematics lessons and attitudes towards statistics lessons. There is no significant correlation between students' anxiety about and achievement motivation effort towards mathematics lessons and their attitudes towards statistics lessons.	T47	1	0.5%
		Students' anxieties about statistics lessons prevent them from learning. Factors such as anxiety-hatred, benefit-importance, and love-interest have a statistically significant effect on attitudes towards statistics; attitudes towards statistics and benefit-importance and love-interest are positively correlated while anxiety-hatred is negatively correlated with attitudes towards statistics. While there is a correlation between attitudes towards statistics and self-esteem, there is no correlation between attitudes towards statistics and problem solving and state anxiety.	T100	1	0.5%
		Statistics course achievement is significantly correlated with the variables of GPA, University Entrance Exam score and duration of education.	T99	1	0.5%
		There is a significant correlation between the ability to draw and understand graphs and interpret graphs.	T8	1	0.5%
	Scale development studies	Mathematical language skills of students in statistics consisted of three interrelated sub-factors: symbolic language, verbal language and visual language. In addition, mathematical reading comprehension has a high effect on mathematical language, while the effect of mathematical writing skill on mathematical language is not significant. Concept knowledge has a high effect on mathematical writing and reading comprehension skills.	T61	1	0.5%
		The scale of attitude towards statistics consists of three factors: fear and trust, occupation and importance and love, pleasure and interest.	T7	1	0.5%
		Statistical literacy scale consists of the sub-headings of randomness, dependent and independent events, probability of occurrence of events, estimation, expectation, measures of frequency, central tendency and dispersion, normal distribution, hypothesis testing, estimation intervals and correlation.	T19, T43	2	1.5%
Studies carried out on teachers / pre-	Mathematics teachers/pre-service teachers have difficulties/misconceptions/lack of knowledge regarding the concepts of statistics and probability.		T29, T51, T56, T57, T59, T68; T70, T74, T76, T84, T86, T93, T94, T95,T102, T112, T114, T118, T126	19	10.9%

service teachers	When the probability approaches (experimental, theoretical, subjective) used by the Mathematics Teachers were examined, the success levels of those using the theoretical approach were found to be higher.		T21	1	0.5%
	Mathematics teachers/pre-service teachers have a high ability to notice some points in the teaching of statistics, but they are insufficient to notice some other points.		T87	1	0.5%
	Mathematics teacher/pre-service teachers have various difficulties in using dynamic statistics software in teaching statistics.		T89	1	0.5%
	The self-efficacy beliefs of the mathematics teachers/pre-service teachers towards the course of statistics were at a high level and their attitudes towards the course of statistics were at a moderate level.		T29	1	0.5%
	Pre-service mathematics teachers' statistical self-efficacy beliefs are low and moderate.		T74	1	0.5%
	Correlation studies	There is no significant correlation between pre-service mathematics teachers' self-efficacy beliefs and achievement.	T74	1	0.5%
		While there is a positive and significant correlation between mathematics teachers/pre-service teachers' statistical concepts achievement test achievement and self-efficacy beliefs about and attitudes towards the course of statistics, there is no significant correlation with gender.	T29	1	0.5%
		There is a significant correlation between pre-service teachers' statistical literacy scores and attitudes towards statistics.	T69	1	0.5%
	Scale development studies	The total effect values of pre-service teachers' emotions, values, cognitive competences and interests on their statistical gains are high and statistically significant. The total effect values of the mathematics achievement and effort variables on statistical gains are small but statistically significant. On the other hand, students' attitudes towards the difficulty of statistics do not have a total effect on explaining their statistical gains.	T37	1	0.5%
	The development programs prepared for mathematics teachers/pre-service teachers helped them eliminate their deficiencies.		T81, T111, T116	3	2%
Studies examining textbooks / theses	The part of the textbook on data processing learning area was mostly found insufficient in the themes of learning process, mathematical skills and measurement and evaluation. When examined in terms of values education, the textbook was found to be sufficient.		T108	1	0.5%
	It was concluded that the highest number of studies on statistics was carried out in Middle East Technical University, that the number of theses published in 2019 was higher than other years, and that the number of master's theses was higher than the number of doctoral dissertations. The highest number of theses was carried out with the participation of 8th grade students in the sub-learning area of Probability of Occurrence of Simple Events and the sample size was preferred in the range of 31-100. Researchers preferred scales such as achievement and attitude more as data collection tools and they used the quantitative research model and quasi-experimental design extensively. It was also concluded that the most measured feature in the theses was achievement and the theses mainly aimed to reveal the effectiveness of a certain method.		T125	1	0.5%

Conclusion and Discussion

This study focused on master's theses and doctoral dissertations in statistics and probability. The literature emphasizes the importance of examining theses/dissertations to determine current trends and identify future research needs. Furthermore, research results can guide policy-making institutions (Baki et al., 2011; Çiltaş et al., 2012; Ulutaş & Ubuz, 2008; Yücedağ & Erdoğan, 2011). According to the existing research, there should be more research in the learning area of statistics and probability (Garfield & Ahlgren, 1988; Karakaş, 2021; Lubiensky & Bowen, 2000; Tereci, 2017). The current trends in statistics and probability can be revealed by examining theses/dissertations prepared in the learning area of statistics and probability.

The number of master's theses compared with the number of doctoral dissertations is higher when the distribution of theses/dissertations is broken down by type; 86% of these theses/dissertations are master's theses, while 14% are doctoral dissertations. In other words, the number of master's theses is about six times that of doctoral dissertations. There were similar results in studies that examined trends in dissertations, albeit in different fields (Albayrak, 2017; Atasever, 2019; Kutluca et al., 2016; Yücedağ & Erdoğan, 2011). This result can be attributed to several factors. Firstly, we have more master's programs than doctoral programs in our country. As a result, master's theses are expected to exceed doctoral dissertations in number. Due to the higher number of faculty members required for the opening of a doctoral program, the number of doctoral dissertations may have been lower than desired. The low number of doctoral dissertations may also be due to the low number of students admitted to doctoral programs compared to master's programs. Furthermore, some theses/dissertations could not be reached due to restricted access, so the most recent information on master's theses and doctoral dissertations may not be available.

Over the years, there are ups and downs in the number of dissertations, as evidenced by the distribution of dissertations. There was a remarkable increase in the number of theses in 2010, 2014 and 2019. A significant increase can be noted between 2003 and 2010. It is not surprising to see this increase. A special emphasis was placed on statistics and probability in 2005, when the constructivist approach was introduced (Ministry of National Education [MoNE], 2005). Accordingly, it is likely to be a topic of significant research in this context. However, decreases were observed in 2011, 2015, 2017 and 2020. According to the results obtained in multiple years (2007, 2011, 2019), particularly in international exams (e.g.,

TIMSS), students' scores in the learning area of data and probability were moderate (MoNE, 2020; Yıldırım et al., 2016). It is evident from these results that this area needs more research.

Moreover, the number of theses/dissertations written in the learning area of statistics and probability is higher in 2019 than in previous years. It is possible that the curriculum updated in 2018 contributed to the change and increase. There were no theses/dissertations in the learning area of statistics and probability in the early 2000s. Despite the paradigm shifts in the curriculum since 2005, the number of these theses/dissertations has not increased consistently. It was noted that master's theses fluctuated more than doctoral dissertations over time when examining how they changed over time. A correlation was found between the fluctuation in the number of master's theses and the general trend in the number of dissertations.

Upon examining the distribution of theses/dissertations across the universities, it was found that many universities have theses published in this area. As compared to other universities, Middle East Technical University published the most theses/dissertations with 18 theses/dissertations. There are 10 theses/dissertations at Marmara University and 9 at Gazi University. The fact that these universities have produced more theses/dissertations can be attributed to the fact that the mathematics education department was established earlier. Additionally, these universities may have completed more theses/dissertations due to the higher number of researchers doing graduate studies there. These finding is in line with the findings obtained from studies examining trends in graduate studies in different fields (Albayrak, 2017; Atasever, 2019; Kutluca et al., 2016; Tabuk et al., 2018; Tereci, 2017; Yücedağ & Erdoğan, 2011). Similar results were obtained by Dinç (2021) in the learning area of statistics and probability through theses/dissertations conducted with secondary school students. Researchers have found that the theses prepared at Atatürk University are more in number than those in other universities (Doğan, 2018; İnceoğlu, 2009; Özey, 2019). Compared with these studies in the literature, it is different in this regard. It is also noteworthy that state universities produce the majority of theses. Only two foundation universities have studied this field and three theses/dissertations have been completed (two in Yeditepe University and one in Zirve University).

The number of female authors of the theses/dissertations is higher than the number of male authors when the genders of the authors are examined. Female researchers completed 61% of dissertations, while male researchers completed 39%. In this regard, it can be said that female researchers are more inclined to pursue graduate studies. According to the results

obtained, the number of women continuing their education is increasing. This is also consistent with the analyses made by the General Directorate of the Status of Women. According to the report, women's participation in higher education has increased significantly (Kadın ve Eğitim, 2008). Other studies have reported similar results (Atasever, 2019). Additionally, some studies found that there was no difference in authorship rates between males and females in doctoral dissertations (e.g., Tereci, 2017), while in others, male authors were more common (Yücedağ & Erdoğan, 2011).

It was found that four out of five theses/dissertations were published in Turkish. This result is expected since Turkish is the language of instruction in most of the universities. Similar results were found in studies examining the publication languages of theses/dissertations (Atasever, 2019; Çiltaş et al., 2012; Tabuk et al., 2018; Tereci, 2017; Ulutaş & Ubuz, 2008; Yücedağ & Erdoğan, 2011).

Three main headings were used to analyze the distribution of subjects in the dissertations. These headings are statistics, probability, and statistics and probability. A majority of theses/dissertations (54%) dealt with statistics. Probability, on the other hand, accounted for 28% of the dissertations. About one in five theses/dissertations is devoted to statistics and probability (18%). There are several reasons why more studies are being conducted in the field of statistics. The first is that statistics are more intensely taught at primary, middle, and high school levels. Primary school curriculum do not include any probability objectives, but middle school curriculum includes at the 8^{th} grade level. Researchers may have focused more on statistical knowledge and skills as a result of these findings. According to Dinç (2021), there are more theses/dissertations on probability conducted with secondary school students in Turkey than on statistics. It was revealed that studies on probability were more common than those on statistics in the study of Garfield and Ben-Zvi (2007). Thus, the results of the current study contradict with these results reported in the literature.

Based on the distribution of keywords used in theses, it was found that "probability" appeared most frequently (n=28). There were 18 uses of the words "teacher", "attitude", and "statistics education". "Mathematics education" and "achievement" were both used 14 times. There was a wide range of keywords following them. While half of the theses/dissertations deal with statistics, the word "probability" is the most commonly used keyword. Because the keywords reflect the theses/dissertations done, it is necessary that the content of the prepared theses/dissertations is compatible with the keywords.

The theses/dissertations prepared in the field of statistics and probability were examined in terms of their purposes. Approximately one-third (37% of all dissertations) examined the effect of teaching practices conducted on students' knowledge and skills about statistics and probability on the development of different components. In their examination of articles and theses/dissertations prepared in the learning area of statistics and probability, Tosun and Ünal (2019) also found that the studies were primarily focused on "testing the effectiveness of teaching methods". According to Garfield and Ahlgren (1988), more research should be conducted to support students' ability to perceive statistics and probability concepts correctly. This emphasis is reflected in the theses/dissertations conducted in the field when viewed from this perspective.

In a review of the dissertations, it was found that one-fourth (25% of the dissertations) examined students' knowledge or misconceptions about the concepts of statistics and probability. The next largest group of theses/dissertations (16%) focused on examining teachers' knowledge/misconceptions about statistics and probability. In total, 41% of theses/dissertations examined student and teacher knowledge / misconceptions about the concepts of statistics and probability. It is reasonable to say that four out of ten theses/dissertations were developed with this goal in mind. The results of Garfield and Ben-Zvi's (2007) study were similar. According to Zieffler et al. (2008), the theses/dissertations on statistics and probability at the university level are shaped by similar purposes. A total of 4% of the theses/dissertations were aimed at improving pre-service teachers' knowledge of statistics and probability. Garfield and Ben-Zvi (2007) drew attention to the existence of studies carried out for similar purposes in their study. While there are theses/dissertations carried out for different purposes, it has been discovered that these are in the minority. Most of the theses/dissertations were written with the purpose of making participants gain various knowledge and skills related to statistics based on an educational practice. Following this are theses/dissertations aiming to explore teachers'/pre-service teachers' knowledge and misconceptions about probability and statistics. Over three-quarters of theses/dissertations (78% of them) were structured around these three purposes.

A quantitative research method was used in half of the theses/dissertations examined in the current study (52%). The qualitative method was used in about one out of four theses/dissertations (28%). There was one mixed method dissertation out of every five. Experimental methods were preferred by 73% of theses/dissertations employing the quantitative method. Therefore, three out of every four quantitative theses/dissertations

preferred experimental methods. Following this is the survey method. Since one of every three theses/dissertations examined the effects of teaching practices on different components, this result is not surprising. It is possible to say that researchers prefer experimental studies because they want to prove the effectiveness of the teaching method they are focusing on. A point needs to be noted here, however. For experimental methods, traditional teaching methods are applied to the control group, while targeted teaching methods are applied to the experimental group. Because the constructivist approach has been adopted since 2005, it can be assumed that the traditional method will present some difficulties in the control group. Karadağ (2009) emphasized this point, stating that comparing the effectiveness of traditional and alternative methods in experimental studies would undermine the validity of the study. According to Becker (1996), experimental studies make up less than 30% of the literature. The results obtained in this study are inconsistent with what was found in the previous study from this perspective. In their studies, Judi and Sahari (2013), Tosun and Ünal (2019) and Dinç (2021) found similar results, revealing that quantitative methods were used mainly in the studies that examined statistics and probability. They stated that experimental methods were the most preferred quantitative methods in these experiments. In terms of consistency, these results are in line with those obtained in the current study.

A majority of theses/dissertations that preferred the qualitative method used case studies (77%), followed by action research (12%) and phenomenological research (11%). No theses/dissertations employed grounded theory as a method. A possible explanation for the widespread use of case studies in qualitative theses/dissertations is their attempt to investigate smaller groups in greater detail. A number of studies have examined the trends in studies conducted in the field of mathematics education, and they have concluded similar findings (Baki et al., 2011; Çiltaş, 2012; Çiltaş et al., 2012; Ulutaş & Ubuz, 2008; Yaşar & Papatga, 2015; Yücedağ & Erdoğan, 2011).

The sample of theses/dissertations prepared in the learning area of statistics and probability mainly comprised middle school students (68%). A number of factors can be considered when evaluating the fact that more studies have been conducted on middle school students. First of all, the learning area of statistics and probability at the middle school level contains a high number of objectives and class hours. At middle school, 60 class hours are allocated to the accomplishment of 19 objectives in the learning area of statistics and probability. Primary school students have nine objectives, whereas high school students have six. Due to the high number of objectives and class hours, statistics and probability may have

become a more remarkable research area at middle school. Undergraduates (12% of the sample) accounted for the second group of students being studied extensively in theses. There may be a preference for undergraduate students due to their greater availability compared to other sample groups. The researchers may have chosen to work with this sample group due to the longer-term permission processes for working with other sample groups. Several studies examining the trends of studies in various fields have produced similar results (Karakaş, 2021; Koç, 2020; Küçüközer, 2016; Ozan & Köse, 2014; Ubuz & Ulutaş, 2008). The number of theses/dissertations involving other sample groups is relatively small (secondary school students make up 7%, teachers and graduate students make up 5%, primary school students make up 2%, and associate's degree students make up 1%). Interestingly, no study involved special education groups and mathematics educators. Due to the importance of the learning area of statistics and probability today, it is considered important to conduct studies with all sample groups, especially with those that have never been studied or have been studied less.

As a result of examining the sample sizes in the dissertations, it was found that groups between 0-100 people were most preferred, followed by 101-200 people. The number of theses/dissertations with different sample sizes is relatively small, even though there are some studies with large samples. There are two main reasons why smaller sample groups are used in the studies. Research method might be the first. Especially in qualitative research, it is expected to work with smaller sample groups to be able to answer the research question. In addition, it is possible to consider this to be an economic tendency. Usually, when reaching participants is difficult both financially and morally, it is advisable to work with fewer participants. This finding is a finding reported in studies on statistics and probability and in other studies, as well (Çiltaş, 2012; Dinç, 2021; Özey, 2019; Tabuk et al., 2018; Tatar et al., 2011; Tosun & Ünal, 2019). The study trends in the learning area of statistics and probability, for example, were examined by Tosun and Ünal (2019) and Dinç (2021). Tosun and Ünal (2019) found that the most number of studies were conducted with 50-100 participants, while Dinç (2021) found that 31-100 participants were involved in the most studies.

Nearly half of the theses/dissertations used achievement tests (49%), based on the distribution of the data collection tools used. Since achievement tests can be used both qualitatively and quantitatively in research methods, they can be used more extensively as a data collection tool. There have been studies with similar results (Dinç, 2021; Tosun & Ünal, 2019). Interviews were found to be the second most preferred data collection tool (21%).

Although other tools (e.g., attitude scales, documents) were also preferred, their rate of use was low.

Based on the data analysis methods preferred by the dissertations, quantitative methods were preferred over qualitative and mixed methods. Quantitative research methods favored the descriptive method most. Qualitative data analysis theses/dissertations used content analysis and descriptive analysis methods at about the same rates. A review of the literature shows that similar results have been reported in other studies (Albayrak & Çiltaş, 2017; Arık & Türkmen, 2009).

According to an evaluation of the teaching practices used in the dissertations, technology-assisted teaching environments were used more than others. A technology-assisted teaching environment was preferred by one in four theses/dissertations that tested a teaching practice (28%). The emergence of such a result can be attributed to several factors. The first is the growing awareness of technology's importance today. It may have been triggered by the Covid-19 pandemic to associate education with technology in an effort to improve teaching methods. Additionally, researchers might be motivated to include such teaching practices in their theses/dissertations by the positive results obtained from studies. According to many researchers, statistics education should be integrated with technology to increase the effectiveness of the instructional and educational process (Kayaly, 2013; Tishkovskaya & Lancaster, 2010). In an analysis of the statistics education studies conducted by Van der Merwe and Wilkinson (2011), only 15% were related to technology use. Accordingly, the literature results do not coincide with the current study's findings. Another study by Judi and Sahari (2013) identified computer-assisted collaborative learning environments as the most commonly used method in student-centered learning in statistics education. The results of this study support those of the current study. The theses/dissertations also highlighted "realistic mathematics education-based teaching practices" and "cooperative-based teaching environments" (7%) as preferred teaching practices. Five percent of all the theses used "multiple intelligence-based teaching environments" (n=3). Although many other teaching practices were used, their rate of use was found to be quite low (See Table 4).

A general examination of the results obtained from theses/dissertations prepared in the learning area of statistics and probability reveals several points. In the first place, students of all grade levels as well as teachers and pre-service teachers have difficulties/ misconceptions/ knowledge deficiencies regarding statistics and probability. This conclusion was reached in almost one out of four theses/dissertations (27%). Several different factors can contribute to

the difficulties experienced by students, teachers, and pre-service teachers. These causes include teaching processes, affective features, and cognitive characteristics. According to Zieffler et al. (2008), many university students attend introductory statistics courses with fear and anxiety, and these feelings last throughout the course. Several researchers have reached similar conclusions in this field (Sotos et al., 2007; Tosun & Ünal, 2019; Zamora Araya et al.; 2021; Zieffler et al., 2008). According to Sotos et al. (2007), students have deep and widespread misconceptions about the concept of inference, and even if they can compute statistics, they cannot interpret the results. According to Zieffler et al. (2008), university students do not correctly understand sampling distribution, measures of central tendency, and dispersion in statistics. According to Tosun and Ünal (2019), secondary school students have difficulty with line graphs. Students' achievement (16%) was also significantly improved by the various teaching practices applied in the dissertations. Students' achievement did not increase significantly as a result of the teaching practices employed in some dissertations, but the percentage of these theses/dissertations is very low (4%). Student achievement practices that resulted in significant gains in achievement were not able to increase student learning permanently. In 6% of dissertations, teaching practices increased the permanent learning of students in a significant way. In the case of the effects of teaching practices on student attitudes, the same results could not be obtained. Teaching practices were associated with significant changes in attitudes of students in only 4% of dissertations, but did not result in significant changes in 4% of dissertations. In addition, other variables (e.g., gender, family, education level, school type, peer collaboration) had no impact on achievement (4%). The theses/dissertations also yielded many other remarkable results (see Table-4).

Suggestions and Limitations

The current study is limited to the master's theses and doctoral dissertations prepared in the learning area of statistics and probability in Turkey. Therefore, it may be helpful to analyze other types of studies (e.g., articles, papers) related to this learning area, which will improve the content validity and reveal the situation in Turkey in a more comprehensive way.

A framework of codes was created based on the data obtained for analyzing the purposes and results sections of the studies. No analysis was conducted within the framework of the codes previously determined. The data can be analyzed using predetermined codes in future studies (e.g., Zieffler et al. 2011).

The current study also analyzed theses/dissertations that were uploaded to the Higher Education Council's website and completed between 2000 and 2021. A variety of keywords (e.g., graph, measures of central tendency) related to statistics and probability were used to locate these theses. This keyword search might not be able to reach all theses/dissertations in the database. It is possible to consider this as a limitation of the study

In general, the results obtained have important implications for researchers, teachers, the Ministry of National Education, and students involved in this field. As well as providing important insights for researchers regarding what types of studies are needed, the results obtained can reveal the trend in theses/dissertations in the field of statistics and probability. Moreover, curriculum developers can revise the curricula based on the results. In order to organize their teaching processes, teachers can take into account the results obtained. In addition, it might be worthwhile to focus on sample groups and subject areas that have received relatively less attention. Lastly, there are fewer doctoral dissertations, which allows for further research to be focused on doctoral theses.

Compliance with Ethical Standards

Research and Publication Ethics Statement

Before starting the study, this study was found ethically appropriate by the decision of Karamanoğlu Mehmetbey University Instutional Review Board dated 07.10.2021 and numbered 09-2021/170. Moreover, all the sources used both in the text and in the references section are included.

Statement of Interest

The authors declare that they have no known conflict of interest.

Türkiye'de İstatistik ve Olasılık Öğrenme Alanına İlişkin Hazırlanan Lisansüstü Tezlerin İncelenmesi

Özet:

Bu çalışma, Türkiye'de olasılık ve istatistik öğrenme alanına ilişkin lisansüstü tezlerin eğilimini incelemeyi amaçlamıştır. Çalışmada doküman analizi yöntemi kullanılmıştır. Toplanan verilerin analizinde nitel veri analizi yöntemi kullanılmıştır. Tezlerin yayın yılına göre dağılımının düzenli olmadığını ortaya çıkmıştır. Tezlerin çoğunun istatistiğin öğrenme alanında yazıldığı tespit edilmiştir. "Olasılık" kelimesi tezlerde kullanılan en popüler anahtar kelime olmuştur. Tezlerin daha çok "öğretim uygulamalarının farklı bileşenlerin gelişimi üzerindeki etkilerini incelemek" amacıyla yazıldığı görülmüştür. Tezlerde çoğunlukla nicel araştırma yöntemi tercih edilmiştir. Çalışmalara katılan katılımcı sayısının en fazla 0-100 aralığında olduğu ve çalışmalarda seçilen en fazla tercih edilen katılımcı grubunun ortaokul öğrencileri olduğu tespit edilmiştir. Teknoloji destekli öğretim ortamının diğer öğretim ortamlarına göre daha fazla kullanıldığı ortaya çıkmıştır. Sonuçlar genel olarak incelendiğinde hem öğrencilerin hem de öğretmenlerin/hizmet öncesi öğretmenlerin istatistik ve olasılık kavramları hakkında yanlış anlamalara ve bilgi eksikliğine sahip oldukları fark edilmiştir. Uygulanan öğretim uygulamaları öğrencilerin başarılarında çoğunlukla anlamlı bir artışa neden olmuştur.

Anahtar kelimeler: lisansüstü tezler, doküman incelemesi, istatistik ve olasılık.

References

Ader, E. (2016). Programlardaki veri öğrenme alanı içeriklerine bakış: Program verilerinin karşılaştırmalı incelemesi [Overview of data learning domain contents in programs: Comparative analysis of program data]. In M. F. Özmantar, A. Öztürk, & E. Bay (Eds.), *Reform ve değişim bağlamında ilkokul matematik öğretim programları* (pp. 267-292). Pegem Akademi.

Ader, E. (2018). Programlardaki veri ve olasılık öğrenme alanı içeriklerine karşılaştırmalı bir bakış [A comparative look at data and probability learning area contents in programs]. In M. F. Özmantar, H. Akkoç, B. Kuşdemir Kayıran, & M. Özyurt (Eds.), *Ortaokul matematik öğretim programları: Tarihsel bir inceleme* (pp. 275-306). Pegem Akademi.

Albayrak, E. (2017). *Descriptive content analysis of mathematical modeling research published in the field of mathematics education in Turkey* [Unpublished master thesis]. Atatürk University

Albayrak, E., & Çiltaş, A. (2017). Descriptive content analysis of mathematical modelling research published in the field of mathematics education in Turkey. *International Journal of Turkish Education Sciences*, *2017*(9), 258-283. https://dergi.org.tr/tr/pub/goputeb/issue/34356/380612

Arık, R. S., & Türkmen, M. (2009). Eğitim bilimleri alanında yayınlanan bilimsel dergilerde yer alan makalelerin incelenmesi. *International Congress of Educational Research,* Çanakkale On Sekiz Mart University, Antalya, *1*, 16.

Atasever, D. (2019). Analysis of the graduate which made between 2014-2018 years in mathematics education in Turkey [Unpublished master thesis]. Bolu Abant İzzet Baysal University.

Aziz, A. M., & Rosli, R. (2021, March). A systematic literature review on developingstudents' statistical literacy skills. *Journal of Physics: Conference Series,1806*(1), 012102. https://doi.org/10.1088/1742-6596/1806/1/012102

Baki, A., Güven, B., Karataş, İ., Akkan, Y., & Çakıroğlu, Ü. (2011). Türkiye'deki matematik eğitimi araştırmalarındaki eğilimler: 1998 ile 2007 yılları arası. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *40*(1), 57-68. http://www.efdergi.hacettepe.edu.tr/shw_artcl-394.html

Bakker, A.; Hahn, C.; Kazak, S. & Pratt, D. (2018). Research on probability and statistics education, Dreyfus, T., Artigue, M., Potari, D., Prediger, S., & Ruthven, K. (Eds.). *Developing Research in Mathematics Education: Twenty Years of Communication, Cooperation and Collaboration in Europe*, (pp. 46-59). Routledge.

Bargagliotti, A., Franklin, C., Arnold, P., Gould, R., Johnson, S., Perez, L., & Spangler, D. (2020). *Pre-K-12 Guidelines for Assessment and Instruction in Statistics Education (GAISE) report II.* American Statistical Association and National Council of Teachers of Mathematics.

Becker, B. J. (1996). A look at the literature (and other resources) on teaching statistics. *Journal of Educational and Behavioral Statistics*, *21*(1), 71-90. https://doi.org/10.2307/1165256

Corbin, J., & Strauss, A. (2008). *Basics of Qualitative Research: Techniques and procedures for developing grounded theory* (3rd ed.). SAGE. https://doi.org/10.4135/9781452230153.

Çiltaş, A. (2012). Content analysis of the graduate thesis and dissertations in mathematics educatiob in Turkey between 2005-2010. *The Journal of Academic Social Science Studies*, *5*(7), 211-228. https://doi.org/10.9761/JASSS235.

Çiltaş, A., Güler, G., & Sözbilir, M. (2012). Mathematics education research in Turkey : A content analysis study. *Educational Sciences: Theory and Practice*, *12*(1), 565-580. https://www.idealonline.com.tr/IdealOnline/pdfViewer/index.xhtml?uId=1922&ioM=Paper&preview=true&isViewer=true#pagemode=bookmarks

Dinç, S. (2021). *Analysis of postgraduate theses in data processing and probabilty learning areas* [Unpublished master thesis], Kocaeli University.

Doğan, M. (2018). *The examination of postgraduate thesis on classroom training in Turkey between 2013-2017* [Unpublished master dissertation], Gaziantep University.

Fraenkel, J. R., & Wallen, N. E. (2006). *How to design and evaluate research in education.* McGraw-Hill.

Franklin, C., Kader, G., Mewborn, D., Moreno, J., Peck, R., Perry, M., & Scheaffer, R. (2005). *Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report: A Pre-K–12 Curriculum Framework.* American Statistical Association.

Franklin, C., Kader, G., Mewborn, D., Moreno, J., Peck, R., Perry, M., & Scheaffer, R. (2007). *Guidelines for assessment and instruction in statistics education (GAISE) report: A pre-K-12 curriculum framework.* American Statistical Association.

Gal, I. (2002). Adults' statistical literacy: Meanings, components, responsibilities. *International statistical review, 70*(1), 1-25. https://doi.org/10.2307/1403713.

Gall, M., Gall, J., & Borg, R. (2007). *Educational research: An introduction* (8th ed.). Pearson Education.

Garfield, J., & Ahlgren, A. (1988). Difficulties in learning basic concepts in probability and statistics: Implications for research. *Journal for research in Mathematics Education*, *19*(1), 44-63. https://doi.org/10.2307/749110.

Garfield, J., & Ben-Zvi, D. (2007). How students learn statistics revisited: A current review of research on teaching and learning statistics. *International statistical review*, *75*(3), 372-396. https://doi.org/41509878

Garfield, J., & Ben-Zvi, D. (2008). *Developing students' statistical reasoning: Connecting research and teaching practice.* Springer Science & Business Media.

Hardy, G. H. (2004). *A mathematician defense.* Tübitak Popüler Bilim Kitapları.

İnceoglu, G. (2009). Evaluation of theses in the field of mathematics education and mathematics teaching. *Education Sciences, 4*(3), 1046-1052. https://doi.org/19827/212432.

İncikabı, L., Serin, M. K., Korkmaz, S., & İncikabı, S. (2017). A research on mathematics education studies published between 2009-2014 in Turkey. *Adıyaman University Journal of Educational Sciences, 7*(1), 1-19. https://doi.org/10.17984/adyuebd.325368.

Jin, Y. (2004). The development of the China network digital library of theses and dissertations. *Online Information Review*, *28*(5), 367-370. https://doi.org/10.1108/14684520410564299.

Judi, H. M. & Sahari, N (2013). Student centered learning in statistics: Analysis of systematic review *Procedia - Social and Behavioral Sciences, 103*, 844 – 851. https://doi.org/10.1016/j.sbspro.2013.10.406.

Kadın ve eğitim. (2008). *T.C. Başbakanlık Kadın Statüsü Genel Müdürlüğü*. Politika Dokümanı.

Karadağ, E. (2009). A Thematic Analysis on Doctoral Dissertations Made In the Area of Education Sciences, *Ahi Evran University Journal of Kırşehir Education Faculty, 10*(3), 75-87. https://doi.org/59508/855693.

Karakaş, G. (2021). *The thematic, methodological and statistical analysis of flipped learning theses and dissertations in Turkey* [Unpublished master thesis], Maltepe University.

Kayaly, D. E. (2013). *Towards more real-live teachings of business statistics: a Review of Challenges, Teaching Innovations and Strategies for Reform in Egypt,* Working Papers 2013/21, Maastricht School of Management.

Kayhan, M., & Özgün-Koca, S. A. (2004). Research subjects in mathematics education: 2000-2002. *Hacettepe University Journal of Education, 26,* 72-81. https://doi.org/8600/107083.

Koç, D. (2020). *An investigation on theses and dissertations on mathematical modeling in Turkey the last two decades* [Unpublished master thesis]. Middle East Technical University.

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

Küçüközer, A. (2016). An overview of the ocdtoral thesis in science education, *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education, 10*(1), 107-141 . https://doi.org/10.17522/nefefmed.54132.

Leavy, A., Meletiou-Mavrotheris, M., & Paparistodemou, E. (2018). Statistics in early childhood and primary education: Supporting early statistical and probabilistic htinking. Springer.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Sage.

Lubienski, S. T., & Bowen, A. (2000). Who's counting? A survey of mathematics education research 1982–1998. *Journal for Research in Mathematics Education, 31*(5), 626-633. https://doi.org/10.2307/749890.

Miles, M, B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded Sourcebook* (2nd ed). Sage.

Ministry of National Education [MoNE] (2005). *İlköğretim matematik dersi (6-8. sınıflar) öğretim programı* [Elementary mathematics (6th-8th grades) curriculum]. Devlet Kitapları Müdürlüğü Basımevi.

Ministry of National Education [MoNE] (2020). *TIMSS 2019 Türkiye Preliminary report*, Education Analysis and Evaluation Reports Series.

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

Ozan, C., & Köse, E. (2014). Research trends in curriculum and instruction. *Sakarya University Journal of Education, 4*(1), 116-136. https://dergipark.org.tr/tr/pub/suje/issue/20635/220033

Özey, K. (2019). *Examination of graduate thesis in algebra learning: Turkey sample between 2010-2018* [Unpublished master thesis]. Bursa Uludağ University.

Özkaral, T. C., & Mentiş-Taş, A. (2017). Examination of master's theses in the field of social studies and comparative education: A metasynthesis study. *Electronic Turkish Studies, 12*(25), 651-670. https://doi.org/10.7827/TurkishStudies.12143.

Rhoades, E. A. (2011). Literature reviews. *The Volta Review*, 353-368. https://Rhoades2011LiteratureReviews-PrinterProof.pdf.

Sevencan, A. (2019). *Investigation of theses and dissertations in the field of mathematics education in Turkey* [Unpublished master thesis]. Necmettin Erbakan University.

Sevinç, B. (2001). Postgraduate education practices, problems and suggestions in Turkey. *Ankara University Journal of Faculty of Educational Sciences (JFES), 34*(1), 125-137. https://doi.org/10.1501/Egifak_0000000052.

Shaughnessy, M., J. (2007). Research on Statistic learning and reasoning. In F. Lester (Ed.) Second *Handbook of Research on Mathematics Teaching and Learning* (pp.957-1002) National Council of Teachers of Mathematics.

Sotos, A. E. C., Vanhoof, S., Van den Noortgate, W., & Onghena, P. (2007). Students' mis conceptions of statistical inference: A review of the empirical evidence from research on statistics education. *Educational Research Review, 2*(2), 98-113. https://doi.org/10.1016/j.edurev.2007.04.001.

Suri, H., ve Clarke, D. (2009). Advancements in research synthe's is methods: From a methodologically inclusive perspective. *Review of Educational Research, 79*(1), 395-430. https://doi.org/10.3102/0034654308326349.

Tabuk, M., İnan, M. & Tabuk, M. (2018). Examining the mathematical skills in preschool children in terms of some variables. *Erzincan University Faculty of Education, 20*(1), 184-201 . https://doi.org/10.17556/erziefd.290963.

Tarman, B., Acun, İ. & Yüksel, Z. (2010). Sosyal bilgiler eğitimi alanındaki tezlerin değerlendirilmesi. *Gaziantep Üniversitesi Sosyal Bilimler Dergisi, 9*(3), 725-746.

Tereci, A. (2017). *Comparative analysis of post-graduate theses conducted between the years 2010-2017 in the field of mathematics education in Turkey according to certain standards* [Unpublished master thesis]. Gaziantep University.

Tereci, A., & Bindak, R. (2019). Comparative analysis of post-graduate theses conducted between the years 2010-2017 in the field of mathematics education in Turkey according to certain ctandards. *Muğla Sıtkı Koçman University Journal of Education, 6*(1), 40-55. https://doi.org/10.21666/muefd.485737.

Tatar, E., Akkaya, A., & Kağızmanlı, T. (2011). An analysis of the materials constructed with geoGebra by primary prospective mathematics teachers and their views about dynamic mathematics software. *Turkish Journal of Computer and Mathematics Education*, *2*(3), 181-197. https://doi.org/10.17762/turcomat.v2i3.31.

Tishkovskaya, S.,& Lancaster, G. (2010). Teaching strategies to promote statistical literacy: Review and implementation. In C. Reading (Ed.), *Data and context in statistics education: Towards an evidence-based society. Proceedings of the Eighth International Conference on Teaching Statistics (ICOTS8, July, 2010), Ljubljana, Slovenia*. Voorburg: International Statistical Institute, *20*(2). www.stat.auckland.ac.nz/~iase/publications.php

Tosun, T., & Ünal, D. Ö. (2019). A content analysis of the studies about data and probability learning areas. *Ege Journal of Education*, *20*(1), 244-261. https://doi.org/10.12984/egeefd.489275.

Ulutaş, F., & Ubuz, B. (2008). Research and trends in mathematics education: 2000 to 2006. *İlköğretim Online, 7*(3), 614-626.

Van der Merwe, L., & Wilkinson, A. (2011). Mapping the field of statistics Education research in search of scholarship. *International Journal for the Scholarship of Teaching ve Learning*, *5*(1), 1-16. https://doi.org/10.20429/IJSOTL2011.050129.

Wach, E. (2013). *Learning about qualitative document analysis.* https://opendocs.ids.ac.uk/opendocs/bitstream/handle/20.500.12413/2989/P%20InBrEf%202%20QDA%20FINAL2.PDF?sequence=4.

Watson J., M. (2006). Statistical literacy at School, *Growth and Goal. Lawrence Erlbaum Associates*, Publishers. 27-53.

Wild, J. C.; Utts, M. J. & Horton, N. J. (2018). What Is Statistics? In D. Ben-Zvi, K. Makar & J. Garfield (Eds) *International Handbook of Research in Statistics Education* (pp.5-36) Springer.

Yıldırım, A., Özgürlük, B., Parlak, B., Gönen, E., & Polat, M. (2016). *TIMSS 2015 National mathematics and science preliminary report Grades 4 and 8.*

TIMSS 2015 Ulusal matematik ve fen bilimleri ön raporu 4 ve 8. Sınıflar. Ministry of National Education, General Directorate of Assessment, Evaluation and Examination Services.

Yücedağ, T, & Erdoğan, A. (2011). Investigation of mathematics education studies according to some variables studied between 2000-2009 years in Turkey. *Gaziantep University Journal of Social Sciences, 10*(2) , 825-838. https://dergipark.org.tr/tr/pub/jss/issue/24242/257013?publisher=gantep%3B.

Yaşar, Ş. & Papatğa, E. (2015). The analysis of the graduate theses related to mathematics courses. *Trakya University Journal of Education, 5*(2), 113-124. https://dergipark.org.tr/tr/pub/trkefd/issue/21482/230218.

Yıldırım, A. & Şimşek, H. (2011). *Qualitative research methods in the social sciences*. Seçkin Yayıncılık.

Zamora Araya, J. A., Aguilar Fernández, E., & Guillén Oviedo, H. S. (2021). Educación Estadística: tendencias para su enseñanza y aprendizaje en educación secundaria y terciaria. *Revista Educación*, *46*(1), 518–537. https://doi.org/10.15517/revedu.v46i1.43494

Zieffler, A., Garfield, J., Alt, S., Dupuis, D., Holleque, K., & Chang, B. (2008). What does research suggest abou the teaching and learning of introductory statistics at the college level? A review of the literature. *Journal of Statistics Education*, *16*(2). https://doi.org/10.1080/10691898.2008.11889566.

Zieffler, A., Garfield, J., Delmas, R. C., Le, L., Isaak, R., Bjornsdottir, A., & Park, J. (2011). Publishing in SERJ: An analysis of papers from 2002–2009. *Statistics Education Research Journal*, *10*(2), 5-26. https://doi.org/10.52041/serj.v10i2.345.

App.-1 Thesis Review Form

The name of the thesis/dissertation			
The author and the advisor			
The type and year of the thesis/dissertation			
The university where the thesis/dissertation was conducted			
The subject of the thesis/dissertation			
The purpose of the thesis/dissertation	.		
The language of the thesis/dissertation			
The gender of the author			
Keywords			
The results of the thesis/dissertation	☐Qualitative	☐Quantitative	☐ Mixed
	☐Action research	☐ Correlation	
	☐Phenomenology	☐ Survey	
	☐Case study	☐Causal comparison	

	☐Grounded theory	☐Experimental	
The sample of the thesis/dissertation	☐primary school (1-4)		
	☐middle school (5-8)		
	☐secondary school (9-12)		
	☐undergraduate		
	☐teacher		
	☐graduate		
	☐Other		
The sample size of the thesis/dissertation			
The data analysis techniques used in the thesis/dissertation	☐ Survey		
	☐ Achievement test		
	☐Questionnaire		
	☐Observation form		
	☐ Worksheets		
	☐Documents		
The data analysis techniques used in the thesis/dissertation	☐ Quantitative data analysis methods		☐ Qualitative data analysis methods
	☐ Descriptive	☐Predictive	☐Content analysis
	☐ Frequency	☐t test	☐Descriptive analysis
	☐Mean	☐Correlation	
	☐Graph	☐ Anova/Ancova	
	☐Standart deviation	☐ Manova/Mancova	
		☐Factor analysis	
		☐Regression	
		☐Non-parametric test	
		Cronbach Alpha	
The teaching practices used in the thesis/dissertation			

Appx.-2 Thesis/Dissertations used in the study

Abed, S. (2015). *Filistinli matematik öğretmen adaylarının istatistik dersi konularındaki kavram yanılgıları ve istatistik dersine yönelik öz yeterlilik inançları [Palestinian pre-service mathematics teachers' self-efficacy levels and performance in statistics]* [Unpublished master thesis]. Marmara Üniversitesi.

Akar, N. (2018). *İlköğretim matematik öğretmen adaylarının grafiklere ilişkin alan bilgilerinin antropolojik açıdan incelenmesi [An anthropological analysis of content knowledge of pre-service elementary mathematics teachers' on graphs]* [Unpublished master thesis]. Balıkesir Üniversitesi.

Akkaş, E. N. (2009). *6.-8.sınıf öğrencilerinin istatistiksel düşüncelerinin incelenmesi [Investigation of the middle school students' statistical thinking]* [Unpublished master thesis]. Abant İzzet Baysal Üniversitesi.

Akkaya, R. (2010). *Olasılık ve istatistik öğrenme alanındaki kavramların gerçekçi matematik eğitimi ve yapılandırmacılık kuramına göre bilgi oluşturma sürecinin incelenmesi [The investigation of knowledge construction process of concepts in probability and statistical learning field according to the realistic mathematic education and constructivism theory]* [Unpublished doctoral dissertation]. Uludağ Üniversitesi.

Alp, E. (2010). *Disiplinlerarası öğretim yaklaşımının öğrencilerin olasılık konusundaki akademik başarılarına ve öğrenmenin kalıcılığına etkisi [The effect of disciplinary teaching approach on students' academic successes and permanence of learning probability subject]* [Unpublished master thesis]. Karadeniz Teknik Üniversitesi.

Altınay, A. Ç. (2019). *8.sınıf öğrencilerinin dinamik istatistik yazılımı ile istatistiksel düşünme becerilerinin incelenmesi [Investigation of 8th grade students' statistical thinking skills with dynamic statistics software]* [Unpublished master thesis]. Mersin Üniversitesi.

Altınok, Z. (2020). *Sekizinci sınıf öğrencilerinin verilerin uygun grafikle gösterimine ilişkin tercih süreçlerinin incelenmesi [Investigation of the preference process for appropriate graphical display of data by eighth grade students]* [Unpublished master thesis]. Eskişehir Osmangazi Üniversitesi.

Andiç, T. (2012). *İlköğretim 8.sınıf matematik dersi permütasyon kombinasyon konusunun bilgisayar destekli öğretiminin öğrenci erişi düzeylerine ve tutumlarına etkisi [The effect of computer assisted education of the subject of permutation?combination of mathematics on 8th grade students? level of achievement, and attitudes]* [Unpublished master thesis]. Yeditepe Üniversitesi.

Arı, E. (2010). *İlköğretim 6.7 ve 8.sınıflarda matematik dersinin istatistik ve olasılık konusunun öğreniminde yaşanan problemler ve çözüm önerileri [The difficulties in learning the subject of probability and statistics in maths lessons of 6^{th}, 7^{th} and 8^{th} grades in primary school and suggestions on solution]* [Unpublished master thesis]. Afyon Kocatepe Üniversitesi.

Arısoy, B. (2011). *İşbirlikli öğrenme yönteminin ÖTBB ve TOT tekniklerinin 6. Sınıf öğrencilerinin matematik dersi istatistik ve olasılık konusunda akademik başarı, kalıcılık ve sosyal beceri düzeylerine etkisi [The effects of STAD and TGT techniques of cooperative learning on sixth grade students? academic achievement, retention and social skill levels in istatistic and probability subject in mathematics lesson*] [Unpublished master thesis]. Çukurova Üniversitesi.

Aslan, Ü. (2010). *Fostering students' learning of probability therough video game programming* [Unpublished master thesis]. Boğaziçi University.

Ata, A. (2013). *Öğretmen adaylarının olasılık konusuna ilişkin kavramsal ve işlemsel bilgi düzeylerinin incelenmesi [Investigation of prospective teachers' conceptual and procedural knowledge levels n probability]* [Unpublished master thesis]. Eskişehir Osmangazi Üniversitesi.

Atcıoğlu, E. (2019). *Kahramanmaraş Sütçü İmam Üniversitesi'nde istatistik dersi alan öğrencilerin profilinin ve başarılarını etkileyen etmenlerin incelenmesi [Research of the profile and the factors affecting the success of the students taking statistics course at Kahramanmaraş Sütçü İmam University*]. [Unpublished master thesis]. Kahramanmaraş Sütçü İmam Üniversitesi.

Avaroğlu, M. C. (2013). *Olasılık öğretiminde sunum biçimlerine ve yanılgı desteğine göre hazırlanmış yazılımların öğrencilerin akademik başarı, sezgisel düşünme ve öğretim süreci deneyimlerine etkisi [The effect of instructional probability software on academic success, intuitive thinking and learning Experience]*. [Unpublished master thesis]. Çukurova Üniversitesi.

Avcı, E. (2017). *Ortaokul matematik öğretmenlerinin vustat ve tinkerplots yazılımlarının veri işleme öğrenme alanında kullanılabilirliği ile ilgili görüşleri [Middle school teachers' opinions about using vustat and tinkerplots in the learning area of data processing in middle school mathematics]*. [Unpublished master thesis]. Mersin Üniversitesi.

Aydın, Ş. (2020). *Sekizinci sınıf öğrencilerinin merkezi eğilim ölçülerine yönelik istatistiksel düşünmelerinin incelenmesi [An investigation of eighth grade students' statistical thinking about measures of central tendency]*. [Unpublished master thesis]. Hacettepe Üniversitesi.

Bahar, A. (2017). *İlköğretim matematik öğretmen adaylarının olasılık kavramına yönelik bilgi oluşturma süreçlerinin incelenmesi [An investigation of prospective primary mathematics teachers' knowledge construction processes toward probability]*. [Unpublished master thesis]. Dokuz Eylül Üniversitesi.

Bakırcı, S. (2014). *İlköğretim 7.sınıf öğrencilerinin olasılıkla ilgili problem çözme süreçlerinin incelenmesi üzerine nitel bir çalışma [A qualitative study on primary school 7th grade students' probability problem solving process]*. [Unpublished master thesis]. Necmettin Erbakan Üniversitesi.

Balkan, İ. (2013). *Bilgisayar destekli öğretimin, ilköğretim 7. Sınıf öğrencilerinin matematik dersi, 'Tablo ve grafikler' alt öğrenme alanındaki akademik başarılarına ve tutumlarına etkisi [The effect of computer*

assisted instruction on academic achievements and attitudes of seventh-grade students in the field of mathematics 'Charts and Graphics'] [Unpublished master thesis]. Gazi Üniversitesi.

Balkaya, T. (2020). *Ortaokul öğrencilerinin Tinkerplots yazılımı ile istatistiksel modelleme süreçlerinin incelenmesi [The investigation of middle school students' statistical modelling processes with Tinkerplots]* [Unpublished master thesis]. Mersin Üniversitesi.

Batur, A. (2021). *Ortaokul matematik öğretmenlerinin istatistiği öğretme bilgilerinin karakterizasyonu [Characterization of middle school mathematics teachers' statistical knowledge for teaching]* [Unpublished master thesis]. Trabzon Üniversitesi.

Bayrak, S. (2012). *İstatistik dersine yönelik kaygının yapısal eşitlik modellemesi ile incelenmesi [Investigation of anxiety toward statistics course with structural equation modelling]* [Unpublished master thesis]. Uludağ Üniversitesi.

Benibil, O. (2019). *Matematik öğretmen adaylarının olasılık ve istatistik kavramlarına ilişkin bilişsel yapılarının kelime ilişkilendirme testi ile incelenmesi* [The investigation of the cognitive structures of mathematics teacher candidates about the probability and statistics concepts by word correlation test] [Unpublished master thesis]. Necmettin Erbakan Üniversitesi.

Berkün, D. N. (2016). *Permütasyon ve olasılık konusunun öğretiminde bilgi değişme tekniğinin kullanılmasının akademik başarıya ve hatırda tutma düzeyine etkisinin incelenmesi [The effect of exchange of knowledge method on the academic success and recall level in teaching permutation and probability subject]* [Unpublished master thesis]. Anadolu Üniversitesi.

Besler, B. (2009). *8.sınıf matematik dersi permütasyon ve olasılık konusunun öğretiminde yapılandırmacı yaklaşıma uygun olarak hazırlanmış çalışma yapraklarının öğrenci başarısına etkisi [To the students' success the effect of worksheets prepared suitable for the constructivist approach in 8th grade mathematics at teaching of possibility and permutation]* [Unpublished master thesis]. Gazi Üniversitesi.

Bilgin, E. A. (2014). *Temel istatistik konularındaki bir bilgisayar yazılımının öğrencileri başarı ve tutumlarına etkisinin incelenmesi [Investigation of the effects of basic statistics of student achievement and attitude of a computer program in the subject]* [Unpublished master thesis]. Yüzüncü Yıl Üniversitesi.

Boztepe, İ. (2010). *İlköğretim 6.sınıf matematik dersi olasılık konusunda çoklu zeka kuramının öğrenci başarı düzeyine etkisi [The impect of multiple intelligence theory on the student success level with respect to the probability subject on mathematic at 6th grade]* [Unpublished master thesis]. Gazi Üniversitesi.

Bursalı, G. G. (2019). *Ortaokul öğrencilerinin olasılıksal akıl yürütme seviyelerinin incelenmesi [Investigation of probabilistic reasoning levels of secondary school students]* [Unpublished master thesis]. Bartın Üniversitesi.

Cihan, E. (2017). *Gerçekçi matematik eğitiminin olasılık ve istatistik öğrenme alanına ilişkin akademik başarı, motivasyon ve kalıcılık üzerine etkisi* [The effect of realistic mathematics education on achievement, motivation and retention about probability and statistical learning field] [Unpublished master thesis]. Çukurova Üniversitesi.

Comarlı, S. K. (2018). *Ortaokul matematik öğretmenlerinin veri işleme öğrenme alanına ilişkin problem kurma becerilerinin incelenmesi [Examining the problem posing skills of secondary school mathematics teachers regarding data processing learning field]* [Unpublished master thesis]. Bartın Üniversitesi.

Çakmak, Z. (2013). *Sekizinci sınıf öğrencilerinin istatistik konusundaki matematiksel dil becerilerine ilişkin değişkenlerin yapısal eşitlik modeli ile incelenmesi [An investigation of the variables related to 8th grade students' mathematical language skills in statistics through structural equitation model]* [Unpublished master thesis]. Erzincan Üniversitesi.

Çakmak, Z. T. (2014). *İlköğretim 6-8.sınıf matematik öğrencilerinin istatistik ve olasılık öğrenme alanında zorlandıkları kavram ve konuların belirlenmesi [Determining the concepts and subjects 6-8. grade maths students have difficulty in statistics and probability learning]* [Unpublished master thesis]. Abant İzzet Baysal Üniversitesi.

Çatman Aksoy, E. (2018). *An investigation of 7th grade students' statistical literacy about the concepts of average and variation on bar and line graphs* [Unpublished master thesis]. Middle East Technical University.

Çimenci, F. (2016). *Ortaokul 8.sınıf öğrencilerinin matematik dersine yönelik kaygı, tutum ve öz yeterlilik inançlarının grafik okuma ve yorumlama başarısı düzeylerine etkisinin değerlendirilmesi [Assessment of the effects of math anxiety, attitude and self-efficacy beliefs on the 8th grade students' graph reading and interpretations]* [Unpublished master thesis]. Afyon Kocatepe Üniversitesi.

Çubuk, Ş. (2004). *Matematik öğretiminde permütasyon ve olasılık konusunun bilgisayar destekli öğretim materyalleri ile öğretilmesinin öğrenci başarısına etkisi [The effect of teaching permutation and probability in mathematics teaching with computer aided teaching materials on student success]* [Unpublished master thesis]. Marmara Üniversitesi.

Demirci, Ö. (2018). *Matematik öğretmeni adaylarının olasılık konusunda problem kurma becerilerinin gelişiminin incelenmesi [An investigation of the development of pre-service mathematics teachers' problem posing skills in probability]* [Unpublished doctoral dissertation]. Atatürk Üniversitesi.

Dereli, A. (2009). *Sekizinci sınıf öğrencilerinin olasılık konusundaki hataları ve kavram yanılgıları [The mistakes and misconceptions in probability of eighth grade students]* [Unpublished master thesis]. Eskişehir Osmangazi Üniversitesi.

Dinç, S. (2021). *Veri işleme ve olasılık öğrenme alanlarında yapılan lisansüstü tezlerin incelenmesi [Analysis of postgraduate theses in data processing and probability learning areas]* [Unpublished master thesis]. Kocaeli Üniversitesi.

Diri, F. Ü. (2007). *İstatistik dersine yönelik tutumların araştırılması meslek yüksek okul örneği [The analysis of the attitudes towards statistics case of vocational school]* [Unpublished master thesis]. Gazi Üniversitesi.

Doğucu, M. (2009). *The relationship between mathematics teachers' probability approaches and misconceptions* [Unpublished master thesis]. Boğaziçi University.

Doluzengin, B. (2019). *Gerçekçi matematik eğitiminin altıncı sınıf öğrencilerinin istatistiksel düşünme becerilerine, başarı güdülerine ve bilgilerinin kalıcılığına etkisi [The effect of realistic mathematics education on sixth grade students' statistical thinking, achievement motivation and persistence of knowledge]* [Unpublished master thesis]. Pamukkale Üniversitesi.

Dursun, H. (2019). *Meslek lisesi öğrencilerinin istatistiksel problem çözme ve okuryazarlık becerilerinin geliştirilmesi üzerine bir öğretim deneyi [A teaching experiment on the development of statistical problem solving and literacy skills of vocational high school students]* [Unpublished master thesis]. Marmara Üniversitesi.

Efe, M. (2011). *İşbirlikli öğrenme yönteminin, öğrenci takımları başarı bölümleri ve küme destekli bireyselleştirme tekniklerinin ilköğretim 7. sınıf öğrencilerinin matematik dersi istatistik ve olasılık ünitesindeki başarılarına, tutumlarına ve motivasyonlarına etkisi [The effects of cooperative learning method of students? teams- achievement divisions and team assisted individualization instructions on students' attitudes, achievement and motivation at primary 7th grade 'statistics and probability' units on mathematics course*] [Unpublished master thesis]. Mustafa Kemal Üniversitesi.

Ekinözü, İ. (2003). *İlköğretimde permütasyon ve olasılık konusunun dramatizasyon ile öğretiminin başarıya etkisinin incelenmesi [The Effect of teaching permutation and probability at secondary school on success is examine]* [Unpublished master thesis]. Marmara Üniversitesi.

Emmioğlu, E. (2011). *A structural equation model examining the relationships among mathematics achievement, attitudes toward statistics, and statistics outcomes* [Unpublished Doctoral Dissertation]. Middle East Technical University.

Emmungil, L. (2009). Effect of constructed web-supported instruction on achievement related to educational statistics [Unpublished doctoral dissertation]. Middle East Technical University.

Enisoğlu, D. (2014). Seventh grade students' possible solution strategies, errors and misinterpretations regarding the concepts of mean, median and mode given in bar graph representations [Unpublished master thesis]. Middle East Technical University.

Ercan, Ö. (2008). *Çoklu zeka kuramına dayalı öğretim etkinliklerinin 8.sınıf öğrencilerinin matematik dersi permütasyon ve olasılık üniversitesindeki akademik başarılarına etkisi [The effect of education activities based on multiple intelligence theory on the academic achievements of 8th grade students' mathematics lesson 'permutation and probability' unit*] [Unpublished master thesis]. Gazi Üniversitesi.

Erdem, E. (2011). *İlköğretim 7.sınıf öğrencilerinin matematiksel ve olasılıksal muhakeme becerilerinin incelenmesi [An investigation of the seventh grade students' mathematical and probalistic reasoning skills]* [Unpublished master thesis]. Adıyaman Üniversitesi.

Erdoğan, A. F. (2018). *İlköğretim 7.sınıf merkezi eğilim ölçüleri konusunda probleme dayalı öğrenme yaklaşımının öğrencilerin üstü düzey düşünme becerilerine etkisi [The effect of problem based learning approach on students' high level thinking skills in respect of measures of central tendency of 7th grade elementary school]* [Unpublished master thesis]. Erciyes Üniversitesi.

Egin, M. (2010). *Öğrencilerin grafik okuma ve oluşturma becerilerinin fonksiyonel anlamda incelenmesi* [The research of students' abilities about reading and creating graphs in the meaning of function] [Unpublished master thesis]. Marmara Üniversitesi.

Ergül, K. (2019). *9.sınıf öğrencilerinin dijital yetkinliklerinin istatistik dersi kapsamında geliştirilmesi [Developing 9th grade students' digital competencies as apart of statistics lesson]* [Unpublished master thesis]. Yeditepe Üniversitesi.

Eroğlu, E. (2021). *Yedinci sınıf öğrencilerinin merkezi eğilim ölçüleri konusuna ilişkin bilgiyi oluşturma süreçlerinin incelenmesi [Examination of seventh grade students knowledge construction process on the subject of central tendency measures]* [Unpublished master thesis]. Uludağ Üniversitesi.

Ersoy, E. (2013). *Gerçekçi matematik eğitimi destekli öğretim yönteminin 7.sınıf olasılık ve istatistik kazanımlarının öğretiminde öğrenci başarısına etkisi [The effect of teaching method supported with realistic mathematic education on teaching probablity and statistic goals on seventh grade]* [Unpublished master thesis]. Sakarya Üniversitesi.

Ertem, S. (2007). *Veri toplama ve değerlendirme ünitesinin ilköğretim öğrencilerinin bilimsel tutum geliştirmelerine katkı getirecek şekilde yeniden düzenlenmesi [Rearranging the 'data collection and assesment unit' in a way that will enable primary scool pupils to develop scientific attidudes]* [Unpublished doctoral dissertation]. Dokuz Eylül Üniversitesi.

Esen, B. (2009). *Matematik eğitiminde ilköğretim 6.sınıflarda olasılık konusunun öğretiminde bilgisayar destekli eğitimin rolü [The role of computer assisted instruction in the teaching of probability in sixth grade students in mathematics education*] [Unpublished master thesis]. Selçuk Üniversitesi.

Geçim, A. D. (2012). *The effect of creative drama-based instruction on seventh grade students' mathematics achievement in probability concept and their attitudes toward mathematics* [Unpublished master thesis]. Middle East Technical University.

Gökçe, R. (2019). *Ortaokul matematik öğretmenlerinin istatistiksel akıl yürütmeye ilişkin alan ve pedagojik alan bilgilerinin incelenmesi [Examining middle school mathematics teachers' content and pedagogical content knowledge of statistical reasoning]* [Unpublished doctoral dissertation]. Pamukkale Üniversitesi.

Güler, H. K. (2019). *Ortaokul 7.sınıf öğrencilerinin grafik çizme ve grafik verilerini yorumlama süreçlerinin incelenmesi [Investigating 7th grade students' processes of drawing graph and interpreting data in graphs]* [Unpublished master thesis]. Gaziosmanpaşa Üniversitesi.

Gündüz, N. (2014). *İlköğretim matematik öğretmen adaylarının istatistiksel okuryazarlık ile istatistiğe yönelik tutumları arasındaki ilişkinin incelenmesi [An investigation of the relationship between statistical literacy of primary mathematics teachers and their attitudes towards statistics]* [Unpublished master thesis]. Kocaeli Üniversitesi.

Gürakar, N. (2010). *İlköğretim 6-8.sınıf öğrencilerinin istatistik temsil biçimlerini kullanma becerilerinin belirlenmesi [The determination of using skills for statistical representation forms of garde 6-8. level students]* [Unpublished master thesis]. Abant İzzet Baysal Üniversitesi.

Gürel, R. (2016). *Ortaokul matematik öğretmenlerinin merkezi eğilim ve yayılım ölçülerine ilişkin öğretim bilgilerinin incelenmesi [An investigation of middle school mathematics teachers' knowledge for teaching measures of central tendency and variation]* [Unpublished doctoral dissertation]. Hacettepe Üniversitesi.

Hayat, F. (2009). *İlköğretim 8.sınıf öğrencilerinin olasılıkla ilgili kavramsal ve işlemsel bilgi düzeyleri ve kavram yanılgılarının belirlenmesi [The determination of conceptual and procedural knowledge lewel and misconception of elementary education 8th grades students about probability]* [Unpublished master thesis]. Atatürk Üniversitesi.

Hazer, Ö. (2013). *Çoklu zeka destekli işbirliğine dayalı öğrenme yönteminin 6.sınıf öğrencilerinin matematik dersi olasılık ve istatistik konusundaki başarılarına ve performanslarına etkisi [The effects of cooperative learning methods supported by multiple intelligence theory on sixth grade students achievement and performance toward probability and statistics of mathematics course]* [Unpublished master thesis]. Kocaeli Üniversitesi.

Hotmanoğlu, Ç. (2014). *Sekizinci sınıf öğrencilerinin grafik çizme yorumlama ve grafikleri diğer gösterimlerle ilişkilendirme becerilerinin incelenmesi [Examining of 8th grade students' skills on drawing, interpreting of graphs and connecting graphs to other representations]* [Unpublished master thesis]., Karadeniz Teknik Üniversitesi.

İlgün, M. (2013). An investigation of prospective elementary mathematics teachers' probabilistic misconceptions and reasons underlying these misconceptions [Unpublished master thesis]. Middle East Technical University.

Kanak, G. (2016). *Ortaokul 8.sınıf öğrencilerinin olasılık ile ilgili kavramsal bilgilerinin analizi* [The analysis of secondary eighth grade students' conceptual knowledge with probability] [Unpublished master thesis]. Mersin Üniversitesi.

Kapucu, T. (2017). *The effect of computer instruction on eight grade students' permutation-combination-probability achievement and attitudes towards computer assisted instruction* [Unpublished master thesis]. Middle East Technical University.

Karatoprak, R. (2014). *Assessing preservice mathematics teachers' statistical reasoning* [Unpublished master thesis]. Boğaziçi University.

Katrancı, Y. (2010). *Olasılığın temel kuralları bilgisinin yapılandırmacı kurama göre oluşturulması sürecinin incelenmesi [Constuction process analysis of knowledge of probability basic principles according to constuctivist theory]* [Unpublished master thesis]. Uludağ Üniversitesi.

Kavasoğlu, B. E. (2010). *İlköğretim 6,7 ve 8. Sınıf matematik dersinde olasılık konusunun oyuna dayalı öğretiminin öğrenci başarısına etkisi [The effects of game based teaching of probability on the achievement of mathematis lessons students of 6th, 7th, 8th grades]* [Unpublished master thesis]. Gazi Üniversitesi.

Kaya, F. (2017). *İstatistik dersi online uygulama hesaplayıcı [Statistics course online application calculator]* [Unpublished master thesis]. Kahramanmaraş Sütçü İmam Üniversitesi.

Kaynar, Y. (2012). *Yeni ilköğretim 2.kademe matematik öğretim programının istatistik boyutunun incelenmesi [The investigation of the 'statistics' dimension of the new middle school mathematics curriculum]* [Unpublished master thesis]. Afyon Kocatepe Üniversitesi.

Kılıç, M. A. (2020). *Matematik öğretmeni adaylarının olasılık alan bilgilerine yönelik tasarlanan üst bilişsel sorgulamaya dayalı öğrenme ortamı: bir öğretim deneyi [A metacognitive imquiry based learning environment designed for probability content knowledge of preservice mathematics teacher: A teaching experiment]* [Unpublished master thesis]. Bayburt Üniversitesi.

Kınalıoğlu, İ. H. (2012). *İstatistik öğretiminde kullanılan istatistiksel paket programlarının kullanım düzeyinin öğrenci başarısına etkisi [Effect of use levels of statistical software packages used in statistics education to student success]* [Unpublished master thesis]. Selçuk Üniversitesi.

Koparan, T. (2012). *Proje tabanlı öğrenme yaklaşımının öğrencilerin istatistiksel okuryazarlık seviyelerine ve istatistiğe yönelik tutumlarına etkisi [The effect of project based learning approach on the statistical literacy levels and attitude towards statistics of student]* [Unpublished doctoral dissertation] Karadeniz Teknik Üniversitesi.

Kurt, G. (2016). *Technological pedagogical content konwledge (TPACK) development of preservice middle school mathematics teachers in statistics teaching: A microteaching lesson study* [Unpublished doctoral dissertation]. Middle East Technical University.

Laçin, F. (2014). *Kavram haritası ve Vee diyagramının ilköğretim 8.sınıf istatistik ve olasılık konusunda öğrenci başarısına ve tutumuna etkisi [Effect of concept mapping and vee diagram on the achievement and attitude of students in statistics and probability for 8th grade in elementary]* [Unpublished master thesis]. Zirve Üniversitesi.

Mercimek, O. (2013). *Assessment of preservice mathematics teachers' knowledge for teaching statistic*s [Unpublished master thesis]. Middle East Technical University.

Mut, A. İ. (2003). *Investigation of students probabilistic misconceptions* [Unpublished master thesis]. Middle East Technical University.

Okuyucu, M. A. (2019). *Gerçekçi matematik eğitimi yaklaşımının 10.sınıf veri, sayma ve olasılık ünitesinin öğretiminde öğrenci başarısına etkisi ve öğrenci görüşlerinin incelenmesi* [The effect of realistic mathematics education approach on student success in teaching 10 th grade data, counting and probability unit and investigation of student opinions] [Unpublished master thesis]. Yüzüncü Yıl Üniversitesi.

Öcal, M. F. (2014). *Students' intuitively-based misconceptions in probabilty: Teachers' awarenesses and teaching practices in middle and high schools* [Unpublished doctoral dissertation]. Middle East Technical University.

Öz, Ö. (2019). *An investigation of 7th grade students' level of understanding in the statistical investigation process* [Unpublished master thesis]. Middle East Technical University.

Özbay, S. (2012). *İnformal çıkarsamalı akıl yürütme öğrencilerin örneklem hakkındaki akıl yürütme ve düşünme süreçleri [Students' thinking processes and reasoning about sample during informal inferential reasoning]* [Unpublished master thesis]. Pamukkale Üniversitesi.

Özbaykuş, P. (2008). *İlköğretim 6.sınıf matematik dersinden sayılardan olasılığa yansımalar ünitesindeki portfolyo çalışmaları hakkında öğretmen ve öğrenci görüşleri* [Teachers' and students' opinions about portfolio studies in 'reflections from numbers to probability' unit in primary school 6.class mathematics lesson] [Unpublished master thesis]. Gazi Üniversitesi.

Özdemir, G. (2012). *Yapılandırmacı öğretim yaklaşımına uygun olarak hazırlanmış çalışma yapraklarıyla 7.sınıflarda olasılık öğretimi [Teaching of probability by worksheets based on the contructivist approach at the 7th grade]* [Unpublished master thesis]., Atatürk Üniversitesi.

Özdemir, S. (2014). *İstatistik dersinde işbirlikli öğrenmenin öğrencilerin akademikr başarılarına, tutumlarına etkisi ve istatistiksel düşünme seviyelerinin incelenmesi [The effect of cooperative learning in statistics course on the academic success and attitude of the students and analyzing their level of statistical thinking]* [Unpublished master thesis]., Çukurova Üniversitesi.

Özen, M. (2013). *Investigation of pre-service mathematics teachers' critical thinking processes through statistical and probabilistic knowledge in the context of popular media texts* [Unpublished master thesis]. Middle East Technical University.

Özmen, Z. M. (2015). *Farklı lisans programlarında okuyan öğrencilerin istatistik okuryazarlığının incelenmesi* [Examination of the statistical literacy levels of students from different undergraduate programs] [Unpublished doctoral dissertation]. Karadeniz Teknik Üniversitesi.

Öztürk-Zora, L. (2019). *Sekizinci sınıf öğrencilerinin istatistiksel akıl yürütme düzeylerinin incelenmesi* [The investigation of the statistical reasoning levels of 8th grade students] [Unpublished master thesis]., Eskişehir Osmangazi Üniversitesi.

Öztürk, G. (2005). *İlköğretim 8. Sınıf düzeyinde permütasyon ve olasılık ünitesinin bilgisayar destekli öğretim tasarımı [A design of computer assisted instraction of the permutation and probability unit at 8th grade in primary school]* [Unpublished master thesis]. Balıkesir Üniversitesi.

Özyurt, H. (2013). *WEB tabanlı uyarlanabilir test sisteminin geliştirilmesi ve değerlendirilmesi: olasılık ünitesi örneği [The development and evaluation of a web based adaptive testing system: The case of probability unit]* [Unpublished doctoral dissertation]. Karadeniz Teknik Üniversitesi.

Patlar, G. (2019). *Ortaokul matematik öğretmenlerinin alan bilgisi üzerine bir çalışma: araştırma sorusu oluşturma örneği [An investigation on secondary school mathematics teachers' content knowledge: A sample of create research questions]* [Unpublished master thesis]., Necmettin Erbakan Üniversitesi.

Sarıbaş, H. M. (2019). *6,7 ve 8.sınıf öğrencilerinin olasılıksal akıl yürütme düzeylerinin cinsiyet, sınıf seviyesi ve matematiksel başarısı açısından incelenmesi* [*Investigating 6th, 7th and 8th grade students' probabilistic reasoning levels in terms of gender grade level and mathematics achievement]* [Unpublished master thesis]. Hacettepe Üniversitesi.

Selamet, C. S. (2014). *Beşinci sınıf öğrencilerinin tablo ve grafik okuma ve yorumlama başarı düzeylerinin incelenmesi [The examination of reading and interpretation achievement levels of 5th grade students about frequency table and graphs]* [Unpublished master thesis]., Afyon Kocatepe Üniversitesi.

Seyhanlı-Sümersan, S. (2007). *Graf teorisinin ilköğretim 8. Sınıf olasılık konusunun öğretiminde öğrenci başarısına etkisi [The effect on the student achievement of graph theory in teaching of the unit of 'probability' of primary school 8th class]* [Unpublished master thesis]., Balıkesir Üniversitesi.

Sev Lekesiz, E. Ç. (2011). *4.ve 5. Sınıf öğrencilerinin olasılık konusunun öğreniminde karşılaştıkları zorluklar [The difficulties in learning the subject of probability of the fourth and fifth grade students]* [Unpublished master thesis]. Eskişehir Osmangazi Üniversitesi.

Sevim, K. (2019). *Veri işleme öğrenme alanının ortaokul matematik ders kitaplarında işlenişinin öğretim programı açısından değerlendirilmesi [Evaluation of data processing learning domain in middle school mathematics textbooks in therms of curriculum]* [Unpublished master thesis]., Marmara Üniversitesi.

Sevimli, N. E. (2010). *Matematik öğretmen adaylarının istatistik dersi konularındaki kavram yanılgıları; istatistik dersine yönelik öz yeterlilik inançları ve tutumlarının incelenmesi* [Examining pre-service mathematics teachers' misconceptions; self-efficacy beliefs and attitudes towards statistics] [Unpublished master thesis]., Marmara Üniversitesi.

Sevimli, N. E. (2020). *İstatistiksel kavramların teknoloji kullanımıyla öğretimine yönelik tasarlanan bir öğretim modülünün etkililiğinin incelenmesi [Investigating the effectiveness of a teaching module designed for using technology in statistics education]* [Unpublished doctoral dissertation]., Marmara Üniversitesi.

Sezer, N. (2013). *İstatistiğin temel kavramlarının probleme dayalı öğrenme yaklaşımıyla öğretimi [Teaching of statistical basic concepts by the problem-based learning approach]* [Unpublished master thesis]., Uludağ Üniversitesi.

Şafak, C. (2016). *8.sınıf öğrencilerinin olasılık konusundaki kavram yanılgılarının incelenmesi [Examination of 8th grade students' misconceptions about probability]* [Unpublished master thesis]. Abant İzzet Baysal Üniversitesi.

Şahin, F. (2012). *A study development of statistical literacy scale for undergraduate students* (Unpublished master thesis]. Boğaziçi University.

Şan, İ. (2014). *7.sınıf matematik dersi olasılık ve istatistik öğrenme alanının öğretiminde sınav yoluyla öğrenme yönteminin öğrencilerin akademik başarı, tutum ve sınav kaygısına etkisi* [The effect of 'Learning-through-exam method' on students' academic success, attitude and test anxiety in the teaching probability

and statistics learning domain at seventh grade mathematics course] [Unpublished doctoral dissertation]. İnönü Üniversitesi.

Şen, N. (2010). *İlköğretim 6.sınıf matematik dersinde bilgisayar destekli sezgisel düşünme kontrollü olasılık öğretiminin öğrencilerin akademik başarı ve sezgisel düşünme düzeylerine etkisi [The effect of computer-based probability unit designed for the controlling of intuitive thinking on academic success, intuitive thinking and retention]* [Unpublished master thesis]., Çukurova Üniversitesi.

Topan, B. (2019). *Ters-yüz sınıf modeline göre tasarlanan öğrenme ortamının ortaokul öğrencilerinin istatistik okuryazarlık seviyelerine etkisi* [The effect of learning environment based on flipped classroom on statistical literacy levels of middle school students] [Unpublished doctoral dissertation]. Trabzon Üniversitesi.

Tortop, T. (2011). 7th-grade students' typical errors and possible misconceptions in graphs concept before and after the regular mathematics instruction [Unpublished master thesis]. Middle East Technical University.

Tosun, T. (2021). *Ortaokul öğrencilerinin grafik algılarının ve grafik oluşturma yeterliklerinin incelenmesi*[Examining of graph sense and graph construction competences of secondary school students] [Unpublished master thesis]. Adnan Menderes Üniversitesi.

Tuncer, T. (2011). *Matematik dersi yedinci sınıf permütasyon ve olasılık konusunda uygulanan üstbiliş stratejilerinin, öğrencilerin başarılarına, üstbiliş becerilerine, tutumlarına ve kalıcılığa etkisi* [The effect of metacognition strategies applied on seventh grade mathematics subject 'permutation and probability' to the students' metacognition skills, success, attitude and its lastingness] [Unpublished master thesis]. Atatürk Üniversitesi.

Tunç, E. (2006). *Özel ilköğretim okulları ile devlet okullarının 8.sınıf öğrencilerine olasılık konusundaki bilgi ve becerileri kazandırma düzeyinin değerlendirilmesi [Evaluation of acquasition levels of grade 8 students in private and public schools about knowledge and skills in the subject of probability]* [Unpublished master thesis]. Balıkesir Üniversitesi.

Türker-Biber, B. (2017). *İstatistikle ilgili modelleme etkinlikleri bağlamında öğretmen farkındalığı: bir durum çalışması* [Teacher noticing in the context of modelling activities related to statistics: A case study] [Unpublished doctoral dissertation]. Hacettepe Üniversitesi.

Türker, K. N. (2020). *Oyun destekli olasılık öğretiminin 8.sınıf öğrencilerinin olasılıklı düşünmelerine etkisi [The effect of game-based probability teaching on 8th grade students' probability thinking]* [Unpublished master thesis]., Trabzon Üniversitesi.

Uyanık, F. (2007). *Ortaöğretim 10.sınıf öğrencilerinin grafik anlama ve yorumlamaları ile kinematik başarıları arasındaki ilişki* [The correlation between tenth grade students' understanding and interpreting graphs and their kinematics achievement] [Unpublished master thesis]., Balıkesir Üniversitesi.

Ünlü, M. (2008). *İşbirlikli öğretim yönteminin 8.sınıf öğrencilerinin matematik dersi permütasyon ve olasılık konusunda akademik başarı ve kalıcılık düzeylerine etkisi [The effect of cooperative learning method on the academic success and recall levels of 8th grade students in 'permutation and probability' subject]* [Unpublished master thesis]. Gazi Üniversitesi.

Ünlü, V. (2015). *7.sınıf matematik dersi olasılık ve istatistik öğrenme alanında yazma etkinliklerinin öğrenci başarı, tutum ve üst bilişlerine etkisi [The effects of writing activities in the field of 'probability and statistics' on seventh grade math students' achievement, attitudes and metacognition]* [Unpublished master thesis]. Gazi Üniversitesi.

Vural, T. (2020). *An investigation of 8th grade students' statistical literacy through problems with and without context* [Unpublished master thesis]. Middle East Technical University.

Yağcı, F. (2010). *The effect of instruction with concrete models on eighth grade students' probability achievement and attitudes toward probability* [Unpublished master thesis]. Middle East Technical University.

Yeniçırak, Ö. (2020). *Ortaokul matematik öğretmenlerinin veri işleme öğrenme alanına ilişkin öğretme pratikleri: merkezi eğilim ölçüleri [Teaching practices of middle school mathematics teachers regarding data*

processing learning field: Central tendency measures] [Unpublished master thesis]. Trabzon Üniversitesi.

Yenilmez, İ. (2016). *İstatistiksel kavramların teknoloji ile öğretiminin matematik didaktiği perspektifinden incelenmesi [Evaluation of teaching statistical concepts using technology from perspective of didactics of mathematics]* [Unpublished master thesis]. Marmara Üniversitesi.

Yıldırım, İ. (2019). *Hatalı çözüm metodunun 7.sınıf öğrencilerinin bazı istatistik kavramlarındaki başarısı üzerindeki etkisi [The effect of erroneous solution method on the achievement of some statistical concepts of 7th grade students]* [Unpublished master thesis]. Adıyaman Üniversitesi.

Yılmaz, N. (2019). *Öğretmen adaylarının istatistiği öğretme bilgilerinin öğretmenlik uygulaması temelli ders araştırmaları bağlamında incelenmes*i [An investigation of pre-service teachers' statistical knowledge for teaching in a practicum based lesson study] [Unpublished doctoral dissertation]. Hacettepe Üniversitesi.

Yılmaz, S. (2006). *The effects of real data based and calculator supported statistics activities on 7th grade students statistics performance and attitude toward statistics* [Unpublished master thesis]. Middle East Technical University.

Yolcu, A. (2012). *An investigation of eighth grade students statistical literacy, attitudes towards statistics and their relationship* [Unpublished master thesis]. Middle East Technical University.

Yumuk, F. (2019). *Öğrencilerin istatistik dersine karşı tutumlarının psikolojik faktörlerle incelenmesi [Investigation of psychological factors of students against statistical course]* [Unpublished master thesis]., Ondokuz Mayıs Üniversitesi.

Appx.-3 Thesis/Dissertations' codes and types used in the study

Dissertation number	Author	Dissertation types
1	Mut(2003)	Master
2	Ekinözü(2003)	Master
3	Çubuk(2004)	Master
4	Öztürk(2005)	Master
5	Tunç(2006)	Master
6	Yılmaz(2006)	Master
7	Diri(2007)	Master
8	Uyanık(2007)	Master
9	Ertem(2007)	Doctoral
10	Seyhanlı(2007)	Master
11	Ünlü(2008)	Master
12	Ercan(2008)	Master
13	Özbaykuş(2008)	Master
14	Dereli(2009)	Master
15	Besler(2009)	Master
16	Esen(2009)	Master
17	Akkaş(2009)	Master
18	Hayat(2009)	Master
19	Şahin(2009)	Master
20	Emmungil(2009)	Doctoral
21	Doğucu(2009)	Master
22	Kavasoğlu(2010)	Master
23	Alp(2010)	Master
24	Arı(2010)	Master
25	Yağcı(2010)	Master
26	Boztepe(2010)	Master
27	Egin(2010)	Master
28	Şen(2010)	Master
29	Sevimli(2010)	Master
30	Gürakar(2010)	Master
31	Akkaya(2010)	Doctoral
32	Aslan(2010)	Master
33	Katrancı(2010)	Master
34	Arısoy(2011)	Master
35	Sev Lekesiz(2011)	Master
36	Erdem(2011)	Master
37	Emmioğlu(2011)	Doctoral
38	Efe(2011)	Master
39	Tuncer(2011)	Master
40	Tortop(2011)	Master
41	Geçim(2012)	Master
42	Yolcu(2012)	Master
43	Şahin(2012)	Master
44	Özdemir(2012)	Master
45	Kınalıoğlu(2012)	Master
46	Özbay(2012)	Master
47	Bayrak(2012)	Master
48	Koparan(2012)	Doctoral
49	Andiç(2012)	Master
50	Kaynar(2012)	Master
51	Ata(2013)	Master
52	Ersoy(2013)	Master

53	Balkan(2013)	Master
54	Özyurt(2013)	Doctoral
55	Avaroğlu(2013)	Master
56	Özen(2013)	Master
57	İlgün(2013)	Master
58	Sezer(2013)	Master
59	Mercimek(2013)	Master
60	Hazer(2013)	Master
61	Çakmak(2013)	Master
62	Selamet(2014)	Master
63	Hotmanoğlu(2014)	Master
64	Enisoğlu(2014)	Master
65	Bilgin(2014)	Master
66	Laçin(2014)	Master
67	Şan(2014)	Doctoral
68	Öcal(2014)	Doctoral
69	Gündüz(2014)	Master
70	Karatoprak(2014)	Master
71	Özdemir(2014)	Master
72	Bakırcı(2014)	Master
73	Çakmak(2014)	Master
74	Abed(2015)	Master
75	Ünlü(2015)	Master
76	Özmen(2015)	Doctoral
77	Şafak(2016)	Master
78	Selçuk(2016)	Master
79	Berkün(2016)	Master
80	Ateş(2016)	Master
81	Kurt(2016)	Doctoral
82	Kanak(2016)	Master
83	Yenilmez(2016)	Master
84	Gürel(2016)	Doctoral
85	Kapucu(2016)	Master
86	Bahar(2017)	Master
87	Türker Biber(2017)	Doctoral
88	Cihan(2017)	Master
89	Avcı(2017)	Master
90	Kaya(2017)	Master
91	Erdoğan(2018)	Master
92	Çatman Aksoy(2018)	Doctoral
93	Demirci(2018)	Doctoral
94	Çomarlı(2018)	Master
95	Akar(2018)	Master
96	Altınay(2019)	Master
97	Doluzengin(2019)	Master
98	Topan(2019)	Doctoral
99	Atcıoğlu(2019)	Master
100	Yumuk(2019)	Master
101	Bursalı(2019)	Master
102	Patlar(2019)	Master
103	Güler(2019)	Master
104	Sarıbaş(2019)	Master
105	Dursun(2019)	Master
106	Yıldırım(2019)	Master
107	Ergül(2019)	Master

108	Sevim(2019)	Master
109	Zora(2019)	Master
110	Okuyucu(2019)	Master
111	Yılmaz(2019)	Doctoral
112	Benibil(2019)	Master
113	Öz(2019)	Master
114	Gökçe(2019)	Doctoral
115	Türker(2020)	Master
116	Kılıç(2020)	Master
117	Sevimli(2020)	Doctoral
118	Yeniçırak(2020)	Master
119	Aydın(2020)	Master
120	Balkaya(2020)	Master
121	Vural(2020)	Master
122	Altınok(2020)	Master
123	Eroğlu(2021)	Master
124	Tosun(2021)	Master
125	Dinç(2021)	Master
126	Batur(2021)	Master

Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi
Cilt 17, Sayı 1, Haziran 2023, sayfa 174-210. ISSN: 1307-6086
Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education
Vol. 17, Issue 1, June 2023, pp. 174-210. ISSN: 1307-6086

Research Article

Enhancing Pre-Service Teachers' Technological Pedagogical Content Knowledge (TPACK) through the Learning by Design Framework: A Fink Taxonomy-based Study*

Okan DURUSOY [1], Ayşen KARAMETE [2]

[1] Balıkesir University, Balıkesir Turkey, okandurusoy@balikesir.edu.tr, http://orcid.org/0000-0002-0939-3870

[2] Balıkesir University, Balıkesir Turkey, karamete@balikesir.edu.tr, http://orcid.org/0000-0001-8442-2080

Received : 09.03.2023 Accepted : 29.06.2023

https://doi.org/10.17522/balikesirnef.1262115

Abstract – This study aimed to develop Technological Pedagogical Content Knowledge (TPACK) through the use of the Learning by Design (LBD) framework in a teaching process for pre-service teachers. During a 12-week period that included both teaching and data collection, 19 pre-service teachers produced 10 unique instructional materials. TPACK levels and self-confidence were assessed using scales and qualitative data from interviews, with the Fink Taxonomy used to analyze the interviews and determine the significance of the LBD-TPACK teaching process in terms of learning outcomes. The results showed a significant increase in pre-service teachers' TPACK scores and TPACK self-confidence scores after the teaching process (α=0.05, p=0.00). Qualitative data supported these findings, demonstrating that pre-service teachers had achieved significant learning outcomes by the end of the process. It is recommended that conducting comparable research across diverse teaching fields and larger sample sizes would lead to more robust and generalizable findings.

Key words: Teacher training, TPACK, learning by design, fink taxonomy, instructional material

---

Corresponding author: Okan DURUSOY.

* This study was produced from the data obtained within the scope of the corresponding author's doctoral dissertation under the supervision of the second author approved by Balıkesir University, Institute of Science in 2019.

Introduction

The effective delivery of quality education in modern times requires teachers to possess not only knowledge of the subject matter they teach but also teaching skills. Teachers need to be equipped with the necessary competencies to navigate and utilize various technological tools to enhance teaching and learning. There is an increasing expectation that teachers integrate educational technologies into the teaching process (Johnson et al., 2014), making the technology competency of pre-service teachers crucial (Sang et al., 2010). Research has consistently shown that teachers who receive high-quality training are critical to the educational system (Artz & Armour-Thomas, 1999). However, defining the concept of a "qualified teacher" from a single model or perspective may have limitations, such as overlooking the importance of technology competency and pedagogical skills. To address this, the Technological Pedagogical Content Knowledge (TPACK) framework has emerged as a fundamental concept in reshaping teacher training programs in many universities (Abell, 2008; Mishra & Koehler, 2008). TPACK is a teacher knowledge model created by Mishra and Koehler (2006) that integrates the Pedagogical Content Knowledge (PCK) concept developed by Shulman (1986) with technological knowledge accumulation to provide a comprehensive framework for teacher training.

The Technological Pedagogical Content Knowledge (TPACK) framework is a pioneering theory aimed at determining teachers' knowledge of how to effectively integrate technology into teaching. Within this framework, teachers articulate their requirements to become effective educational technology users. According to the TPACK model, effective use of technology in education requires a superior level of technological knowledge, pedagogical knowledge, and content knowledge. Moreover, the model emphasizes the commonalities among these knowledge types (Mishra & Koehler, 2006; Polly, 2011). The model proposes that developing the TPACK of pre-service teachers is crucial for successful teacher education, and rich educational experiences are necessary for this to occur (Mishra & Koehler, 2006). These experiences facilitate an understanding of the shared impacts of technology and pedagogy while pre-service teachers learn particular content. Learning experiences that focus solely on one or two of these knowledge components, without considering the common effects of technology, pedagogy, and content knowledge, are inadequate to support the technology integration knowledge and skills of pre-service teachers (Polly & Orrill, 2016).

Within the scope of this study, a teaching process was conducted to develop pre-service teachers' TPACK, and efforts were made to ensure they played active roles in all processes as

required by the TPACK model. This included questioning, researching, discussing, performing self-assessment, and making corrective decisions about their work. To ensure this occurred, Learning by Design (LBD) principles were used. The data obtained from the study revealed that a dynamic teaching process occurred, where pre-service teachers made their own choices, decisions, and actively carried out their roles as both teacher and learner in coordination. The variations in TPACK levels of pre-service teachers were investigated with data obtained at the end of the process, and significant learning outcomes from this learning experience were researched.

In line with this, the study sought answers to the following questions:

1. Is there a significant change in TPACK levels and TPACK self-confidence levels of pre-service teachers between the start and end of the material development process?
2. What are the opinions of pre-service teachers about the teaching process and materials developed and do these opinions include significant learning outcomes?

Development of Technological Pedagogical Content Knowledge of Pre-service Teachers

Based on research, it is recommended that teachers receive basic technological education prior to entering service and that education faculties are the most effective and cost-efficient organizations to provide this training (Hur et al., 2010). In most teacher training programs, pre-service teachers are required to take lessons in education technology or technology integration at the beginning of the program. These lessons provide opportunities for pre-service teachers to learn and develop certain content by utilizing teaching technologies. Additionally, applied lessons are often combined with these education technology courses, allowing pre-service teachers to observe the integration of education and technology in real-world environments.

Education faculties should integrate technology with teacher training programs in an effective way that is open to innovation. Within the system, a way for teachers to gain competence in terms of TPACK requires education faculties to cultivate pre-service teachers who know how to use technology (Sang et al., 2010).

Research on teacher training programs has shown that there are many obstacles to the effective integration of technology into classes by pre-service teachers. There is a significant difference between technology education in teacher education programs and technology integration in professional life (Sang et al., 2010). Additionally, differences encountered by pre-service teachers during teacher training programs can lead to the development of mistaken

beliefs about how to develop technology-based teaching and learning (Ottenbreit-Leftwich et al., 2010). These mistaken beliefs can be misleading for both the teacher themselves and their students during their professional lives. Despite pre-service teachers having adequate technological knowledge, integration efforts will fail if they do not have accurate pedagogical beliefs (Ertmer, 2005).

Pre-service teachers generally have knowledge about the basic use of technological tools; however, they often struggle to combine this technological knowledge with pedagogical implementation (Byker, 2014).

In teacher preparation programs, it is important for pre-service teachers to learn how to successfully integrate technology (Öztürk, et al., 2020). One primary way for this to occur is by involving pre-service teachers in activities that promote academic development with technology support in a planned manner throughout the duration of the program. The preparation of pre-service teachers for technology integration requires opportunities to observe models and apply knowledge in real or similar environments (Golas, 2010; Öztürk, et al., 2022; Tondeur et al., 2011).

In order to ensure the necessary development of TPACK required to manage and run teaching processes supported by information and communication technologies, pre-service teachers need to be directly included in similar situations in real learning environments and complete similar tasks (Koehler & Mishra, 2005a). According to the approach called "learning technology by design" by Koehler and Mishra (2005b), designing teaching materials and actively using them within the teaching process provides an opportunity for pre-service teachers to apply the knowledge and skills they will use during their professional lives. As teaching materials encompass all three basic knowledge types (technological knowledge, pedagogical knowledge, and content knowledge) in terms of TPACK, they offer an effective learning environment for observing relationships and integrating these knowledge types.

Learning by Design Approach in TPACK Development

It is possible to produce original content through manual activities for the development of the basic structure of TPACK. Learning technology and pedagogy is possible by designing teaching technologies and working in small cooperative groups to develop solutions in terms of technology for real pedagogical problems (Koehler et al., 2007). In the literature, learning approaches called design-based learning or learning by design (LBD) ensure the discovery of significant variables and relationships in the natural environment of the class (Koh &

Divaharan, 2013). Design activities offer important opportunities that ensure a broader understanding of the relationship between content, pedagogy, and technology by the participants. Learning-by-design work plays an effective role in removing misconceptions and completing significant learning (Koehler & Mishra, 2005a; 2005b; Kolodner et al., 2002).

The LBD approach provides significant opportunities for pre-service teachers to develop their technological knowledge. It involves a cooperative process where pre-service teachers learn through experience by making decisions and applying them. Within this systematic process, pre-service teachers need to communicate with both peers and lecturers, share ideas, and engage in cooperative work. The basic principles of LBD include the following:

- Pre-service teachers should be involved in a dynamic scientific process that involves asking questions, discussing responses, conducting research, having active discussions, and applying what is learned.
- Pre-service teachers should be guided to identify and confront misconceptions and learn new concepts.
- Pre-service teachers should be encouraged to establish connections between available knowledge, accumulation, and experiences with scientific data, theories, concepts, and laws.
- Pre-service teachers should be motivated to want to learn, and they should be provided with a thorough explanation of what learning entails and what is required for learning to occur.
- Decision-making, defending decisions, discussions, and identification of new problems should integrate real-life knowledge with scientific information (Kolodner et al., 2003).

A variety of research has been conducted on the use of LBD in higher education institutions and its effects (Alayyar, 2011; Lu et al., 2011). The common aim of these studies is to enhance technology cognition through LBD, and the results indicate that this aim has been achieved. The findings from these studies demonstrate that teaching processes completed within the scope of LBD activities enhance the TPACK levels of pre-service teachers.

Lu et al. (2011) and Kolodner et al. (2002) proposed a learning-by-design model with five stages to ensure TPACK development during the education of pre-service teachers based on the LBD model:

Determination of targets: In this process, pre-service teachers are given information about what can be included in design tasks. Generally, this task is to design an educational product with technology or shape topics in response to real-life problems with the aid of technology. Model lessons are designed, and pre-service teachers are directly included in the implementations in these lessons. These implementations include in-class discovery activities and debate sessions. Pre-service teachers research topics about how to effectively use technology for teaching purposes, and debate the results in the class environment. With the aim of recognizing problems, reading activities may be beneficial for these activities.

Making the design plan: In this step, pre-service teachers undertake special tasks related to their project. They work independently or with teammates to plan an educational product or solution design. Linked to the requirements of the project, pre-service teachers decide on their design plans by determining the target audience, topic content, making selections, and analyzing the teaching strategies and technology to be used. Project teams organize sharing and discussion activities to communicate draft ideas to teammates.

Designing and producing teaching materials: Pre-service teachers begin to design and create within the framework of the plans for projects/materials involving educational products or solutions. In this process, it is important to work in cooperation. Lecturers and other pre-service teachers share opinions and constructive feedback continuously. Mini scenarios are created about solutions to problems using integrated pedagogy, content knowledge, and technology. The main focal point in this process should be the use of technology for teaching purposes.

Trialing the material: Pre-service teachers apply their designs in a real teaching environment. Other pre-service teachers in the role of the target audience have the opportunity to use and investigate products. The trial process again ends with active feedback and recommendations. All pre-service teachers and lecturers investigate and debate the suitability of the teaching solutions in depth. The basic focus for all participants should be to ensure awareness of the relationships between content, pedagogical knowledge, and technology.

Analysis and interpretation of results: In this process, pre-service teachers are requested to express and explain their design experience with written reports, interviews, and diverse reflection forms. Within the scope of design studies, learning, strong and weak aspects are explained, new design plans are recommended based on experience, and connections are made between the experience of technology use in the lesson with use in future careers. Lecturers and other pre-service teachers provide written feedback, and it is important to reach

a common view about class applications and teaching methods by discussing these. This discussion and feedback will create a basis for pre-service teachers to be able to reflect on the common effects of pedagogy, content knowledge, and technology in teaching activities when they begin service (Lu, 2014).

As can be seen within the scope of the principles stated above, it is necessary for pre-service teachers to work in cooperation with peers and lecturers, and to determine and discuss ideas and outcomes. All processes should be repeated until final materials emerge, desired targets are reached, and all mistakes are eliminated.

LBD offers the opportunity for first-hand experience of seeing theories and ideas in practice, developing skills, sharing ideas, and seeing the outcomes of changes made. LBD, allowing the opportunity for in-depth analysis of the results of actions, ensures the creation of constructive learning environments (Han & Bhattacharya, 2001). LBD learners have the chance to have rich experiences and understand the relationships between content knowledge, pedagogy, and technology (Koehler & Mishra, 2005a; 2005b; Koehler et al., 2004). Design activities ensure the completion of concrete, understandable, and significant learning processes to resolve misconceptions and to complete inadequate information.

In a variety of studies performed with the aim of acquiring technology integration knowledge to be applied in class, pre-service teachers worked in groups to search for solutions to problems related to teaching technologies, and successful results were obtained (Alayyar, 2011; Baran & Uygun, 2016; Koehler et al., 2004; Koehler et al., 2007; Koehler & Mishra, 2005b; Jang & Chen, 2010; Johnson, 2012).

Baran and Uygun (2016) defined the steps necessary to ensure the TPACK development of pre-service teachers within the LBD framework. In line with these steps, they stated that the LBD process should be followed as listed below for TPACK development of pre-service teachers:

- Brainstorming about design
- Design of technology-supported lesson material
- Investigation of design samples
- Investigation of conceptual framework
- Research about information and communication technologies
- Reflection on design experiences
- Application of design in a real environment

• Cooperation with design teams

Fink Taxonomy

Fink Taxonomy was used as a conceptual framework for the analysis of qualitative data in the research. Fink taxonomy provides a guide to the learning content required for significant learning to occur.

Bloom's Cognitive Taxonomy is one of the references most commonly used by teachers when planning what acquirements students will learn from teaching or how to effectively instill students with acquirements. This taxonomy comprises six hierarchical steps (remembering, understanding, applying, analyzing, evaluating, and creating) (Bloom, 1956).

According to Fink (2003), this taxonomy which has been used for a long time with positive outcomes is very important. However, it was emphasized that there were a range of difficult learning types emerging with Bloom's taxonomy from the secondary education level and that it was important to access these learning types in line with changing paradigms and needs. For example, learning to learn, leadership and environmental adjustment skills, ethics, communication skills, tolerance and adaptability to change skills, etc. are learning types that are outside the cognitive field and in fact cannot be explained by cognitive learning. This situation revealed the need for a new learning taxonomy with broader meaning (Fink, 2007; Rama & Charles, 2013; Stanny, 2016).

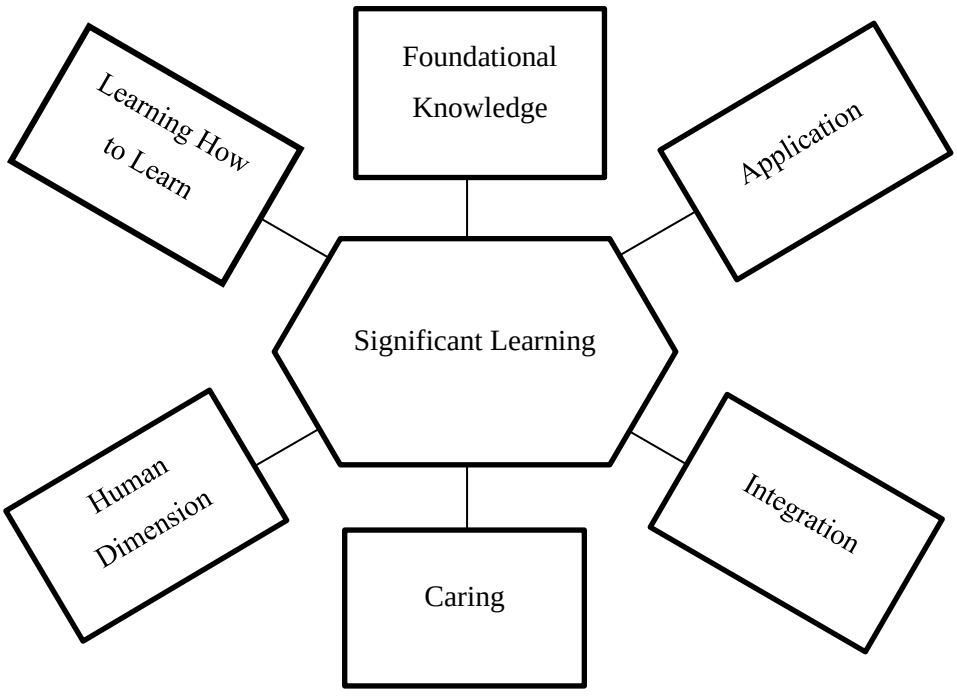


Figure 1 Learning areas and significant learning correlations (Fink, 2003, pp.10)

Fink (2003) proposed some changes were required in the learner for learning to occur and stated that these changes could be used to determine outcomes of significant learning processes. He categorizes these changes as shown in Figure 1.

Foundational Knowledge: The basis of teaching is that the student needs to know something. Knowing represents understanding and recall skills for certain knowledge and ideas by students when stated generally in accordance with the Fink Taxonomy. Currently, it is important that people have some valid basic knowledge about science, history, literature, geography, and the world they live in. Additionally, it is necessary to understand the major ideals or perspectives (e.g., what is/is not evolution, what is/is not capitalism, etc.).

Application: In addition to learning concepts, rules and ideas, students learn by being active within intellectual, physical or social activities. The application step is an important component to complete processes in a variety of forms of thinking (practical, critical, creative, etc.). Additionally, teaching of certain skills (playing piano or communication skills, etc.) and how to complete complicated projects occurs in this stage.

Integration: When students see and understand the connections between different information, it means they have obtained an important and valuable learning outcome. Sometimes, they may create connections between certain ideas, between people or different processes in life (daily life, academic life, working life, etc.).

Human Dimension: When students learn important information about themselves or others, this situation provides the opportunity for more effective communication. They discover the personal and social effects of what they have learned. Students can learn to know themselves through information learned or paths followed in learning. Additionally, this situation provides a perspective about the individual traits they wish to have in the future. Understanding others may allow understanding of the reasons for their behavior and students acquire effective communication skills as a learner.

Caring: Sometimes a new learning experience changes the degree of importance that students attach to something. These new feelings, areas of interest or values may be reflected externally. These reflections are an indicator that students care more, or differently, about something compared to before.

Learning How to Learn: During lessons, students may learn things related to their own learning process. They may learn how to learn better and more easily, how to complete research procedures, and how to manage their own learning processes. Learning all these forms the basic structure of learning.

To assist in clearer observation of learning outcomes in learning areas, the indicative verbs and behavior varieties are shown in Table 1.

Table 1 Fink Taxonomy indicative verbs

Dimension	Behaviors	Indicative verbs
Foundational Knowledge	Understanding and recall	Name, list, describe
Application	Critical, creative, and practical thinking: problem-solving	Analyze, interpret, and apply
Integration	Ability to make connections between ideas, topics, and people	Identify and associate
Caring	Ability to determine the feelings, ideas, and values of people, making changes to these	Reflect and interpret
Human Dimensions	Learning new things about the self, changing yourself; ability to understand others through interaction	Reflect and assess
Learning How to Learn	Learning to ask and answer questions; being a learning with self-direction	Criticize, analyze

There is no stage between the dimensions in the taxonomy; it is necessary to include all dimensions in the process for significant learning to occur. It may not be very easy to reveal learning areas like the learning how to learn and human dimension at all times. However, the important thing is to include learning areas at maximum levels in the teaching process (Fink, 2003; Robinson, 2009).

Method

Research Design

The research used both qualitative and quantitative data with an explanatory design from the mixed methods designs. The mixed model does not just simply combine qualitative and quantitative methods but involves comprehensive integration studies using the strong aspects of these methods to support each other. The mixed method pattern is used to answer research questions which cannot be answered with a single paradigm, especially in research based on education technologies. In explanatory mixed method research, qualitative data is collected and then used with the aim of explaining or supporting quantitative data (Creswell & Plano Clark, 2011). This pattern is used to determine the TPACK development of pre-service teachers at the end of the process and to determine whether learning outcomes were significant learning outcomes according to the Fink Taxonomy or not.

Participants

The study group for the research comprised 19 pre-service teachers attending the third year of the Secondary Mathematics Education department in a state university in the Marmara region of Turkey during the fall semester of the 2016-2017 educational year. The chosen pre-service teachers had not received any teaching material development lessons before and had no experience related to computer-supported teaching processes. With these known features of pre-service teachers, they were chosen with the targeted sampling in line with the aims of the research. Of the pre-service teachers, 4 were men and 15 were women.

Data Collection Tools

To determine the TPACK levels of pre-service teachers, at the start and end of the semester the "Technological Pedagogical Content Knowledge" scale developed by Schmidt et al. (2009) was used as the pre-test-post-test. The scale was translated to Turkish and adapted for mathematics by Dikkartın Övez and Akyüz (2013) and had Cronbach's alpha reliability coefficient of 0.91. The TPACK developed by Schmidt et al. has a 7-factor structure. These factors comprise technological knowledge, pedagogical knowledge, content knowledge, technological pedagogical knowledge, technological content knowledge, pedagogical content knowledge, and technological pedagogical content knowledge. However, basic components factor analysis by Dikkartın Övez and Akyüz (2013) gathered these factors under 4 headings of technological knowledge, mathematical knowledge, mathematic teaching knowledge, and technologic integration in mathematic teaching knowledge. These factors and relevant items were used without change as the study was completed with pre-service teachers and focused directly on mathematical knowledge. The items on the scale are answered with five-point Likert responses: completely agree (5), agree (4), undecided (3), disagree (2), and completely disagree (1). The highest points that can be obtained on the scale are 135, with the lowest points of 27.

To determine whether pre-service teachers in the research were confident in themselves in terms of TPACK competencies, the "Technologic Pedagogic Content Knowledge Self-Confidence Scale" developed by Graham et al. (2009) and adapted to Turkish by Timur and Taşar (2011) was used. The scale comprises four dimensions; technological pedagogical content knowledge (8 items), technological pedagogical knowledge (7 items), technological content knowledge (5 items), and technological knowledge (11 items). The scale contains a total of 31 items. For the scale in general, the Cronbach's alpha reliability coefficient is 0.92. The highest points that can be obtained from the scale are 186, with the lowest point of 26.

The scale uses 6-point Likert-type responses of I am fully confident (6), I am mostly confident (5), I am partly confident (4), I am somewhat confident (3), I am a little confident (2) and I am not confident (1). As an exception, five items (items 16 to 20) are rated with I don't know this type of technology (0). As pilot studies for the scale by Timur and Taşar (2011) were performed with science and technology pre-service teachers, the expressions "science topic" and "science activities" in two items (item 2 and 4) were changed in line with experts' opinions to "mathematic topic" and "mathematic activities" in this study. Apart from this, the scale was used without changes.

With the aim of identifying the thoughts of pre-service teachers about the process, semi-structured interviews were held. When preparing the interview questions, the items about observable behavior from the TPACK scale and TPACK self-confidence scale were used. With the aim of determining opinions, pre-service teachers were asked the following questions:

Q1- Do you think the material development activities you carried out during this course have contributed to your knowledge? If yes, what have you gained from it? Additionally, how has this process changed you?

Q2- What contributions did you make to the group during the working process? What were the specific tasks or projects that you completed?

Q3- Is it essential for a teacher to possess knowledge of developing instructional materials when looking at the process as a whole? Which stages of the material development process do you feel confident in? In which areas do you consider yourself particularly strong?

Q4- How would you react if you had a classroom equipped with all the necessary hardware for teaching technologies? Would this situation make you nervous or intimidated?

Q5- If you had to learn a technology that you have never encountered before, what steps would you take to be able to learn it successfully?

Q6- What considerations do you keep in mind when applying your technology and instructional material development knowledge to your classes? For what purposes do you use them? How do you determine these objectives?

Q7- What are the characteristics of a good instructional material in your opinion? What steps do you take to develop a material that possesses these characteristics?

Q8- What do you think is the connection between teaching materials and fostering mathematical thinking and instilling this mindset in students? What can you do to establish or strengthen this connection?

The questions on the interview form were shaped by receiving opinions from two different lecturers who experts in the fields of teaching technologies and mathematics education were.

Teaching and Data Collection Process

The content and activities planned according to weeks are listed below:

Introduction, Organization and Pre-Test Application: In the first week of the semester, pre-service teachers were given a brief explanation of the lesson content and information about work that would be completed during the semester. The pre-service teachers were given the printed technological pedagogical content knowledge scale and technological pedagogical content knowledge self-confidence scale and answered them in order to collect pre-test data.

Investigation and Discussion of Theoretical Topics: In the second week of the lesson, the topics of teaching technologies, teaching materials and principles of preparing teaching materials were communicated to the pre-service teachers by the researcher with the explanation method.

Theoretical topics were dealt with according to the following list:

- Communication and interaction in learning
- Teaching technologies
- Development process for teaching material
- Process components and basic principles.

In the discussion environment created in the class, pre-service teachers shared their own ideas about these topics and mentioned previous work they had performed about developing teaching material. At the end of the lesson, mathematics education material found on the Education Information Network (www.eba.gov.tr) offered by the Ministry of National Education General Directorate of Innovation and Education Technologies was investigated. Pre-service teachers shared their ideas about the material within the scope of basic principles that teaching materials should have, and a discussion was held.

In the 3rd week continuing investigation of theoretical topics, the importance of computer-supported education, varieties of implementations in computer-supported education

and technologic pedagogic content knowledge topics were investigated. In the process after this, pre-service teachers formed their own design groups and were requested to design teaching material.

Creating Design Groups and Determining Acquirements from the Materials: Pre-service teachers formed two-person working groups with friends of their own choosing. As there were 19 pre-service teachers actively continuing with the lesson, there were 9 two-person groups, and 1 pre-service teacher chose to work alone.

Pre-service teachers were fully free to choose in relation to topics like the content, form, technologies used, materials, and implementations for the material they would design. However, in the name of ensuring integration between groups during this process, the preparation stages for materials were reported. They were requested to write these reports in accordance with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) (Aldoobie, 2015) stages for general design models within teaching design models.

Creating Design Plans and Sharing Ideas: At the end of the sixth week of the lesson, all groups had completed the analysis and design stages of the material development process and shared their design plans in the class environment. Pre-service teachers criticized their colleagues about topics like how the topic will be presented, whether the aim of the material is teaching or habituation, the devices used, the basic structure of the flowchart, target audience, and readiness. Attention was drawn to basic elements that require attention in the development stage based on the criticisms and the design plans were revised. In this direction, sample flowcharts prepared by teacher candidates are presented in Figure 2 and Figure 3 below:

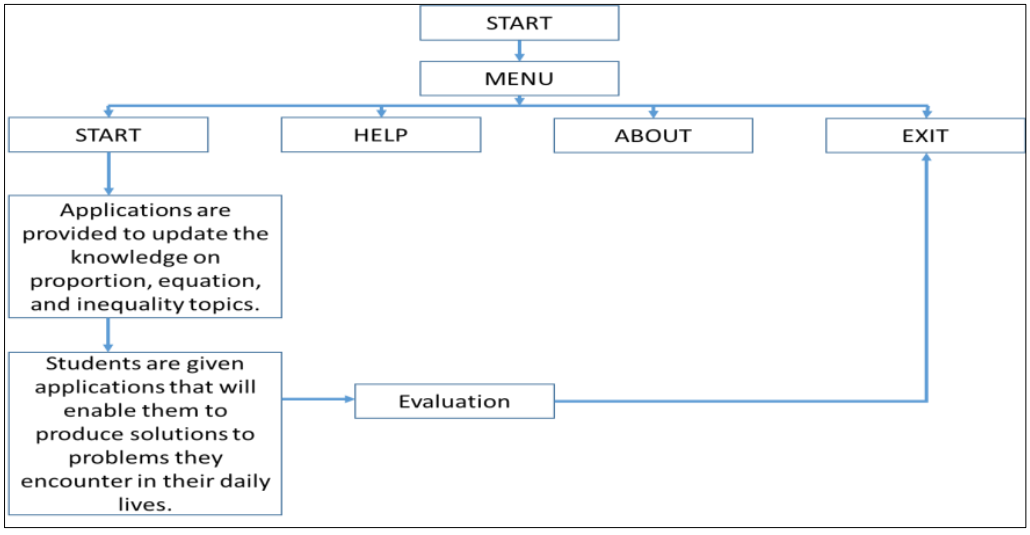


Figure 2 Flowchart of the material developed by Group 8

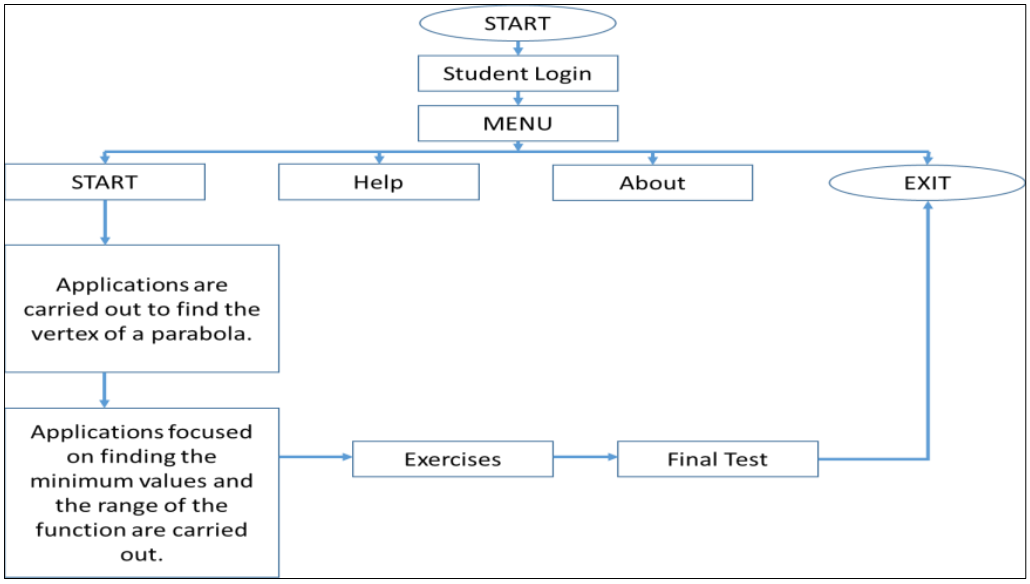


Figure 3 Flowchart of the material developed by Group 5

Development of Material, Analysis and Presentation of Results: In the second half of the semester, the presentation of material, interpretation, identification of strong and weak aspects, and redesign in line with these continued. In the name of ensuring all students were active during the process, criticism and evaluation of material continued outside of class. To ensure this situation, pre-service teachers made video recordings of material presentations and uploaded these videos to a private group on the social sharing network of Facebook. Pre-service teachers had the chance to investigate and criticize each other's materials on this platform outside of class.

Pre-service teachers have periodically presented the developmental stages of the instructional materials they have prepared to their peers during the course. These presentations continued with active feedback in a mutual discussion. After each presentation, teacher candidates evaluated their peers' designed materials using an online evaluation form. The main criteria listed below were taken into consideration in this evaluation form (Kaya, 2006):

1- Evaluations Related to the Content of the Material: Evaluations related to the achievement the material is intended to provide, the content of the subject matter, and the presentation method of the topic.

2- Evaluations Related to Inquiry Techniques: Evaluations related to the questioning and inquiry activities conducted during subject teaching in order to guide students, prevent incomplete or incorrect learning, and ensure gradual progress.

3- Ensuring Interest and Continuity: Evaluations related to the efforts made to attract students' attention and maintain their focus in order to ensure continuity of this attention state.

4- Creativity: Evaluations related to whether the material contains elements that support students' creativity or not.

5- User Control: Evaluations related to whether the material is suitable for students' use or not.

6- Feedback: Evaluations related to the effectiveness of the feedback provided by the material to the students.

7- Assessment and Record Keeping: Evaluations related to the extent to which the material has achieved the targeted learning outcomes, the assessment tools used, and the evaluation of teaching.

8- Documentation and Support Presentation: Evaluations related to support materials such as user manuals, additional resources or exercise presentations, help features, etc.

After each presentation, pre-service teachers evaluated the materials created by the presenting group using an online material evaluation form, which was shared via Google Forms and allowed for anonymous feedback. This process enabled more objective criticisms without revealing the identities of the evaluators to the evaluated group members. The researcher added the data obtained from the form as comments under the relevant posts on Facebook, and the materials were redesigned based on the revisions made in line with these comments.

Completion of Designs, Post-Test Application and Interviews: At the end of the semester, all groups revealed their final designs with weak aspects strengthened in line with the periodically continuing evaluations. The material evaluation form used during the development process was applied again to the final form of the design and necessary data were obtained to analyze the development process. Descriptions of the final materials developed by ten different working groups are presented in Table 2.

Table 2 Developed Materials' Types and Subjects by Groups

Group Number	Material Type	Grade and Subject
Group 1	Computer-Aided Application	12th Grade; Analytical Investigation of Ellipse, Hyperbola, and Parabola.
Group 2	Computer-Aided Application	12th Grade; Derivative.
Group 3	Instructional Material (Board Game)	10th Grade; Conditional Probability.
Group 4	Computer-Aided Application	12th Grade; Analytical Investigation of Ellipse, Hyperbola, and Parabola. 11th Grade; Trigonometry.
Group 5	Computer-Aided Application	10th Grade; Second Degree Functions and Their Graphs.
Group 6	Computer-Aided Application	12th Grade; Integral: Riemann sum.
Group 7	Computer-Aided Application	11th Grade; Trigonometry: Trigonometric functions and the unit circle.
Group 8	Computer Game; Scenario Study	11th Grade; Equations and Inequalities.
Group 9	Computer-Aided Application	10th Grade; Surface Areas and Volumes of Solid Objects.
Group 10	Computer-Aided Application	10th Grade; Special Quadrilaterals.

Individual interviews were completed for general evaluation of the material development process continuing during the whole semester. Interviews were recorded with the consent of the pre-service teachers interviewed and transcribed to text. Finally, the TPACK scale and TPACK self-confidence scale used at the beginning of the semester were applied again to obtain post-test data.

Data Analysis

As the study group comprised 19 pre-service teachers (N<30), nonparametric tests were used for the analysis of data. However, checks of the normality of data were completed. The Kolmogorov-Smirnov and Shapiro-Wilk tests results related to the total points obtained by pre-service teachers from the TPACK scale and TPACK self-confidence scale indicated normality, while histograms showed that data did not have a normal distribution. Item-based investigations observed that data were not normally distributed.

When analyzing quantitative data (TPACK scale and TPACK self-confidence scale data), the nonparametric Wilcoxon signed ranks test was used. The variation or not of total pre-test points obtained from the scales compared to total post-test points was checked with this test. When investigating the variation of subdimensions and items on the scales, the Wilcoxon signed ranks test was reused.

Content analysis was performed on data transcribed to text for analysis of interview data. The indicative verbs in the Fink Taxonomy (2003) were used as a guide for

differentiation and coding of categories in the interviews with content analysis. In line with this, it was determined whether pre-service teaches displayed behavior related to which learning areas within the Fink Taxonomy. An example of the content analysis conducted in this direction is presented in Table 3:

Table 3 An example of a coding of an interview conducted

Codes	**f**	**Opinions of Pre-service Teacher-1**
Integration	1	*This course has added a lot to my knowledge and skills. I learned how to teach mathematics to students using technology and how to create instructional materials for this purpose. Through this course, I was able to identify the shortcomings in my materials and improve them to create more suitable materials for my students.*
Human Dimensions	0	
Learning How to Learn	0	
Caring	0	
Foundational Knowledge	1	
Application	1	

Validity and Reliability

When obtaining quantitative data in the research, we used scales that had been previously used within the scope of the theoretical framework and tested on study groups appropriate to the target audience. The Cronbach's alpha reliability coefficients of the scales were calculated in previous studies, and both scales had reliability coefficients above 0.90 (TPACK scale 0.91, TPACK self-confidence scale 0.92).

With the aim of ensuring the reliability of qualitative data, the interview data coded within the scope of the theoretical framework of the Fink Taxonomy were coded by two expert researchers. As stated by Miles and Huberman (1994), the compatibility between coding of the two researchers being above 0.70 is accepted as adequate for intercoder reliability. In line with this, the compatibility study calculated the ratio between categories that are compatible to the total number of categories and completed with data from 3 randomly chosen pre-service teachers found the reliability was 0.81. The data obtained from 3 randomly chosen pre-service teachers was recoded 6 months after the first data in the study was coded by the researcher and as a result the compatibility between the two coding was found to be 0.86.

To ensure the data's validity, this study examined previous research that utilized comparable participant groups and similar theoretical frameworks, enabling a comparison and discussion of the findings.

Results

Is there a significant difference in TPACK levels of pre-service teachers at the start and end of the material development process?

The Wilcoxon signed ranks test was used to investigate whether there was variation in TPACK levels at the end of the teaching material design process completed by pre-service teachers within the framework of learning-by-design. The descriptive data related to the variation in TPACK points of participants based on the pre-test and post-test total points on the TPACK scale are shown in Table 4.

Table 4 Descriptive data for pre-test and post-test TPACK scale

	Pre-test	**Post-test**
N	19	19
Mean	92.4737	114.6842
Standard Deviation	6.30140	9.30981
Minimum	85	105
Maximum	95	129

The total points obtained from the TPACK scale displayed a significant increase in the post-test. Data related to this result are shown in Table 5.

Table 5 Comparison of pre-test and post-test total points on TPACK scale

	Post-test – Pre-test
Z	-3.825
p	.000

The results obtained with the Wilcoxon signed ranks test showed a significant difference between pre-test and post-test with significance level $\alpha=0.05$ ($p=0.000$).

The Wilcoxon test results on a category basis to investigate points obtained from all subcategories of the scale are shown in Table 6.

Table 6 Total points variation for TPACK scale subcategories

	Z	p
TK – Technological knowledge	-3.834	.000
CK – Content knowledge	-3.362	.000
PCK – Pedagogical content knowledge	-3.727	.000
TPACK – Technological pedagogical content knowledge	-3.829	.000

When the points are considered separately for all subdimensions of the TPACK scale, again, the post-test points for all dimensions were observed to be higher than the pre-test points. In line with this, the completion of learning-by-design activities by pre-service teachers can be said to clearly contribute positively to TPACK development.

Is there a significant difference in TPACK levels of pre-service teachers at the start and end of the material development process?

To compare the points that pre-service teachers obtained from the TPACK self-confidence scale at the end of the material development process with points obtained at the start of the process, the Wilcoxon signed ranks test was used. The descriptive data related to points obtained on the TPACK self-confidence scale by pre-service teachers on pre-test and post-test are presented in Table 7.

Table 7 Descriptive data for TPACK self-confidence scale pre-test and post-test

	Pre-test	Post-test
N	19	19
Mean	97.000	134.7895
Standard Deviation	14.37977	12.05810
Minimum	70	113
Maximum	119	155

When the variation in total points obtained on the TPACK self-confidence scale are investigated, all 19 pre-service teachers were observed to have increased total points on the post-test, shown in Table 8.

Table 8 Comparison of pre-test and post-test total points for TPACK self-confidence scale

	Post-test – Pre-test
Z	-3.824
p	.000

The results of the Wilcoxon signed ranks test identified p=0.000 at significance level α=0.05 and observed a significant variation. For this reason, there was a positive significant difference in total points obtained by pre-service teachers from the TPACK self-confidence scale at the beginning and end of the material development process.

What were the opinions of pre-service teachers about the teaching process and developed material and did these opinions include significant learning outcomes?

All pre-service teachers agreed that the activities had contributed something to them. The opinions of a pre-service teacher (PST-15) regarding this topic are as follows:

> *As a result of the work, we have done during this course, I can say that I have become more knowledgeable about the internet and programs. I can now easily use programs that I used to struggle with before. My self-confidence has increased a lot. I have gained ideas on conducting research and selecting the best option that suits my work. We encountered different programs, and I can say that I will use most of them when I become a teacher in the future. This process has changed my thoughts on Information and Communication Technologies and their use in the classroom.*

Another pre-service teacher (PST -17) expressed his views as follows:

> *This course has taught me a lot, especially about how important math programs are for a teacher. I saw how helpful they are in teaching math, and I learned that using math programs can have a positive impact on the students' learning process. This has given me experience for my future career. I also learned how to explain something in a way that can be more helpful when teaching. Living in the age of technology, I understood how important technology is and how using it can be beneficial for both teachers and students…*

Direct experience of how effective the use of material within lessons and the process being shaped by peer assessment positively affected their perspective on teaching materials. A point emerging from the answers was that this process increased the self-confidence of pre-service teachers about their ability to prepare material and use technology in teaching. This result may be accepted as a marker of positive development considering they had not

previously prepared any teaching material, completed any teaching designs and had not used technological resources during teaching.

When opinions of pre-service teachers about these questions are investigated, it appeared they proposed three basic topics where positive change occurred:

- Pre-service teachers stated they had the chance to learn and use new technologies which they were not aware of before due to this lesson.
- They stated they saw the importance of considering students' needs when designing material.
- They conceptualized the importance of integration of technology in the teaching process and learned what requires attention during this process.

Within the scope of these three main opinions, the record numbers for analysis of the interview data according to the categories of "acquiring information about new technologies", "considering student needs" and "technology and mathematic integration" are given in Table 9.

Table 9 Record numbers of opinions of pre-service teachers about the process

	Record numbers	**%**
Acquire information about new technologies	9	33.33
Consider student needs	10	37
Integration of technology and mathematics	8	29.66

The opinions of a pre-service teacher (PST-6) regarding this topic are as follows:

Before taking this course, I approached technology with prejudice. More precisely, the educational use of technology intimidated me. It all seemed like difficult and complex applications. Similarly, when we started this assignment, I had questions in my mind such as how it would be done, what do we know, what will we do, etc. However, when I started working on it, I realized that it wasn't that difficult at all. When you work on it a bit and think about it, technology is actually easy to use and worth the effort. At the end of this process, I realized that I could use technology to teach in my own classroom in the future. It really changed my perspective on technological applications in a positive way. I understood that technology could be easy, useful, and educational. After all, technology is an undeniable part of our lives today. Not knowing how to use technology as a teacher is a major deficiency. If we can

transfer what we know to students by knowing and using technology, we can see the contribution of this course in our teaching career.

Data obtained from interviews completed with pre-service teachers underwent content analysis. The analysis determined the main categories as learning areas in the Fink Taxonomy and interviews were coded for suitability to these categories, shown in Table 10.

Table 10 Distribution of opinions according to Fink Taxonomy learning areas

	Record numbers	Code numbers
Integration	14	21
Human Dimensions	15	30
Learning How to Learn	10	12
Caring	19	60
Foundational Knowledge	18	36
Application	19	67

In order for significant learning to occur, it is important for all learning types to emerge due to the structure of the Fink Taxonomy. With the obtained findings, all learning areas were observed to emerge with changes in frequency (Figure 4).

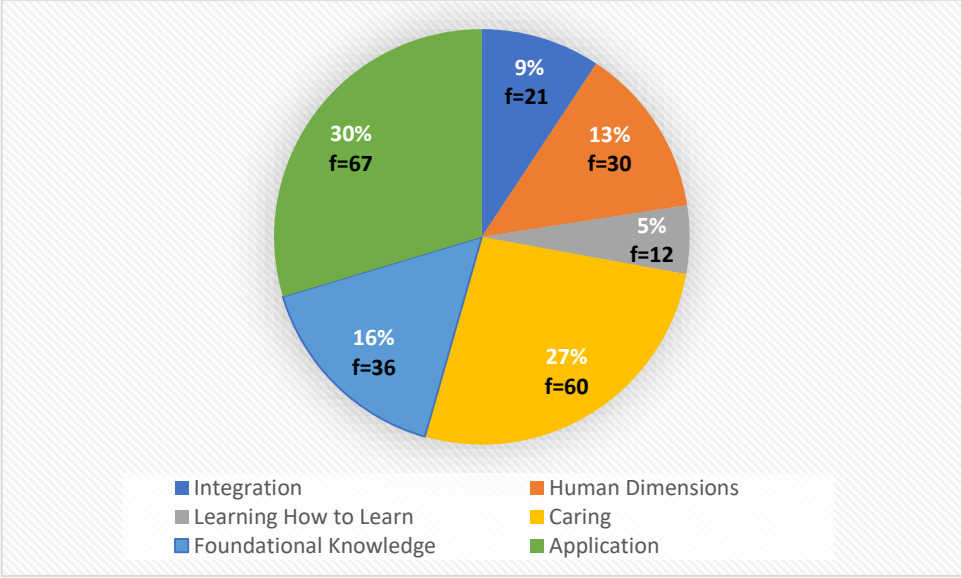


Figure 4 Percentage distribution of Fink Taxonomy dimensions

The observation of all learning areas is proof that the completed teaching process provided the basic criteria required for significant learning. For this reason, it can be stated that the variations in TPACK and TPACK self-confidence levels of pre-service teachers occurred due to significant learning experiences.

Findings and Discussions

In this study, the effects of learning-by-design activities within the scope of the teaching material development processes on the technological pedagogical content knowledge of mathematic pre-service teachers were researched. As required by LBD processes, pre-service teachers were able to work in groups with cooperation and an interactive and free special learning environment was created where they had direct said in the development of each other's products. Within this scope, pre-service teachers were fully free to determine topics like which problem their materials would contribute to solving, what the type of material would be (physical, computer-supported application, game, etc.), how to address which target audience, what the application path would be, and which resources would be used. The basic aim was that pre-service teachers acquire experience in being able to use technologic, physical and teaching resources which are available in the environment when they begin their professional life in the most appropriate way according to student requirements and to discover the relationships between theory and practice with the aid of this experience. In line with this aim, they tested their own TPACK in applications and gained awareness of their own abilities, strong and weak aspects, and saw the results of teaching outcomes. Generally, pre-service teachers in this study had their first professional experience in the planning, design, development, application, and evaluation stages in the technology-supported teaching process.

Pre-service teachers worked in groups and shared their material with friends periodically during development and updated and revised material according to active discussions and feedback. The role of the teacher was played by the group presenting their material, while the other pre-service teachers played the role of students with each of the teaching materials presented in micro-teaching applications evaluated by all pre-service teachers. To investigate the applications in more detail and ensure time savings, lesson presentations were recorded and uploaded to social media accounts that could only be accessed by pre-service teachers in the study group (a private Facebook group) for investigation and comment by other pre-service teachers. In this way, the criticisms of pre-service teachers were recorded, and studies continued outside of lesson hours.

At the beginning and end of the teaching process including learning-by-design activities, TPACK scales were applied to pre-service teachers and the data were used to research whether the teaching had an effect on points obtained or not. In line with this, rather than focus on TPACK levels, the focus was on whether development had occurred or not. The

total points received by pre-service teachers on the TPACK scale were analyzed with the Wilcoxon signed ranks paired tests and all pre-service teachers were observed to have increased post-test points compared to pre-test points (α=0.05, p=0.00). This technology-supported teaching process completed within the LBD framework was observed to have a positive effect on the points obtained by pre-service teachers from the TPACK scale. This situation is parallel to the results of many studies completed previously by different researchers (Agyei & Voogt, 2012; Aygün et al., 2016; Bahçekapılı, 2011; Cavin, 2007; Chai, Koh & Tsai, 2010; Erdoğan, 2014; Figg & Jaipal, 2009; Kafyulilo et al., 2015; Karataş et al., 2016; Koh & Divaharan, 2011; Koh & Chai, 2014; Kurt et al., 2013; Maeng et al., 2013). Additionally, though several studies in the literature stated there are limited effects of teaching processes on TPACK subdimensions, findings in this study showed a change in a positive direction was valid for all subdimensions (Chai et al., 2010; Habowski & Mouza, 2014; Jang & Chen, 2010).

With the guidance of lecturers, pre-service teachers had the opportunity to complete active discussions and brainstorming activities, investigated and criticized different design examples, researched relationships between conceptual frameworks and information technologies, performed reflections, and revealed their TPACK in a real learning environment through a cooperative process where they had a say in the development of both their own designs and their colleagues' designs. When the pre-test and post-test data obtained to investigate the effect of these practices on their TPACK self-confidence is analyzed, a positive change in TPACK self-confidence levels was identified for all pre-service teachers (α=0.05, p=0.00). The results of studies in the literature stating that pre-service teachers should be included in technology-supported teaching process stages support this change (Abbitt, 2011; Canbazoğlu Bilici, 2012; Karataş et al., 2016).

When pre-service teachers evaluated each other's materials, they used an online material assessment form, and each group was evaluated three times at intervals. Due to these forms, data were collected to investigate the degree to which pre-service teachers included TPACK during the material development process. Additionally, at the end of each assessment form, a section was left for pre-service teachers to write their ideas related to the materials developed, teaching, and classmates. Data obtained from this form could only be seen by the researcher, so the evaluations are presented as objective data. Without mentioning names, the research shared comments from the forms under video presentations in the social media group. In this way, continuity was ensured between active discussions occurring during

lessons and the online environment. The materials and teaching process of the pre-service teachers were updated in line with the strong aspects or deficiencies mentioned. During the study lasting 12 weeks, 19 pre-service teachers working in 10 groups completed 10 different material designs. During the semester, teaching was completed using these materials three times and including their own presentations, they actively participated in 30 different teaching processes. Data obtained from the assessment forms shows that the quality of teaching material periodically increased in line with the continuing material development process, presentation in the teaching environment, discussion, and evaluation activities. Total points obtained as a result of assessments for all developed materials (including category-based points) were identified to increase compared to previous evaluations. This situation is a clear indicator of the reflection of TPACK development of pre-service teachers in the teaching process and this indicator has the quality of supporting the findings about TPACK and TPACK self-confidence development (Agyei & Voogt, 2012; Kafyulilo et al., 2015; Kurt et al., 2013; Larkin et al., 2012; Lee & Kim, 2014;).

The positive changes observed overlap with the opinions of pre-service teachers about the process. At the end of the teaching material development process, face-to-face interviews were held with all pre-service teachers. As a result of qualitative analysis of the interview data, pre-service teachers were identified to have a positive view of the LBD-based technology-supported teaching process. All pre-service teachers agreed that the teaching process contributed to their development. They frequently emphasized that they had more self-confidence about the inclusion of technology in teaching processes and preparing teaching materials for their own use. Topics emerging from the results of interview analysis including awareness of new technologies and development of their skills in being able to use these in teaching, learning the importance of technology integration and what factors require attention, and cognition about how to resolve the teaching needs of students. This situation is a clear indicator that pre-service teachers were aware of changes in themselves in becoming qualified teachers. This situation overlaps with results of similar studies and supports quantitative findings (Cavin, 2007; Erdoğan, 2014; Kafyulilo et al., 2015; Karataş et al., 2016; Kurt et al., 2013).

With the aim of investigating the opinions of pre-service teachers in more detail and interpreting results within a theoretical framework, the Fink taxonomy was used. In the literature, there is no other study investigating LBD-based teaching material development processes within the scope of Fink taxonomy learning areas. In the name of investigating

whether the positive changes in TPACK and TPACK self-confidence levels of pre-service teachers were acquired within the scope of significant learning experiences or not, interview data were analyzed within the framework of Fink's significant learning taxonomy. Findings indicate that all learning areas of the Fink taxonomy may be observed within the scope of the research process. For this reason, the LBD-based and technology-supported teaching process led to the acquirement of significant learning experiences, and it can be clearly stated that the changes in pre-service teachers are significant learning outcomes (Fink, 2007; Robinson, 2009; Rama, 2013; Stanny, 2016).

Opinions investigated within the scope of Fink taxonomy are each a representation that pre-service teachers are ready to make efforts to include their students in critical, creative and practical thinking and problem-solving processes. To ensure students gain significant learning experiences, they stated that they are aware of the need to perform studies to raise individuals who are able to create connections between disciplines and people, with self-control and free ideas. In line with this, the presence of an association between the TPACK self-confidence levels, TPACK levels and Fink taxonomy learning areas of pre-service teachers was investigated. Due to the structure of Fink taxonomy, the emergence of all learning areas is proof that significant learning occurred, while the emergence or observation of some learning areas may be more difficult than others. For this reason, the post-test points obtained on the TPACK self-confidence scale of pre-service teachers who emphasized "learning how to learn", accepted as a statement of the importance of student-centered education and with the least record numbers among pre-service teacher interviews, were investigated. All eight pre-service teachers emphasizing this learning area were identified to have TPACK self-confidence scale points that were above the average for the group. Mann-Whitney U test results showed a significant correlation between this learning area and TPACK self-confidence points ($p=0.015$; $p<0.05$). This situation is accepted as a statement about the importance shown by pre-service teachers who trust themselves in performing effective teaching by combining technology, content knowledge, and pedagogy to raise their students to be questioning and researching individuals who learn by themselves. Additionally, for all other learning areas, including between TPACK self-confidence levels and "learning how to learn" area, there was no significant correlation identified between all Fink taxonomy learning areas with TPACK points. This situation is directly related to the small dimensions of the study group ($N=19<30$). For this reason, it is thought that similar analyses completed with larger study groups in future research will offer more significant findings.

In conclusion, due to practices, research and analyses implemented in this study, the LBD-based teaching material development process for mathematic pre-service teachers was observed to have a positive effect on TPACK and TPACK self-confidence. The learning experiences creating this effect can be clearly stated to occur as significant learning experiences within the scope of the Fink taxonomy.

Conclusions and Suggestions

All implementations within the scope of this study were completed with pre-service mathematics teachers. However, it is possible to adapt the teaching process for pre-service teachers attending other departments with similar implementations using appropriate measurement devices. Planning, developing, and running technology-supported teaching processes are important skills necessary for all teachers to develop. In order to provide this, it is possible to use LBD stages as in this study or to use different teaching approaches.

A basic point that requires attention is that the teaching environment should present similar environments to those that will be encountered by pre-service teachers in professional life. Micro-teaching practice leads to very successful results in meeting this need.

In this research, the study group comprised 19 pre-service mathematics teachers. Expanding the study group to complete more comprehensive research on similar research problems will offer more detailed findings for the generalizability of the results.

It is possible to observe the effects on other teaching areas by performing similar studies with pre-service teachers attending other departments. Expansion within this scope will offer important findings about teacher education to compare the TPACK development of pre-service teachers from different branches, and to investigate the interdisciplinary development provided by a cooperative process with different branches receiving assistance from each other.

With the condition of keeping interactions between individuals and groups at the highest levels, similar to the learning-by-design activities used in the implementation process in this research, research may be performed with all special teaching methods directing pre-service teachers toward research, problem-solving, and producing a product.

It is possible to adapt this research as in-service teacher training to investigate the technology-supported teaching process among teachers, to research TPACK levels and development and to investigate the technology-supported teaching methods and material

developed. In this way, the present situation will be revealed, inadequacies will be determined if present and contributions will be made to work on taking corrective precautions.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest

The authors have not disclosed any conflict of interest.

Funding

This study is not funded by any person or organization.

CRediT author statement

Okan Durusoy: Conceptualization, Methodology, Formal Analysis, Investigation, Data Curation, Writing - Original Draft. **Ayşen Karamete**: Supervision, Validation, Writing - Review & Editing.

Research involving Human Participants

This study was produced from the data obtained within the scope of the corresponding author's doctoral dissertation under the supervision of the second author approved by Balıkesir University, Institute of Science in 2019. In this context, all ethical compliance criteria have been completed.

Tasarım Tabanlı Öğrenme ile Öğretmen Adaylarının Teknolojik Pedagojik Alan Bilgilerinin (TPACK) Geliştirilmesi: Fink Taksonomisi Temelli Bir Çalışma

Özet:

Bu çalışmada, öğretim sürecinde tasarım tabanlı öğrenme (Learning by Design - LBD) çerçevesi kullanılarak öğretmen adaylarının teknolojik pedagojik alan bilgilerinin (Technological Pedagogical Content Knowledge - TPACK) geliştirilmesi amaçlamıştır. 19 öğretmen adayı, 12 haftalık bir öğretim ve veri toplama sürecine katılarak 10 farklı öğretim materyali oluşturmuştur. TPACK ve TPACK özgüven seviyeleri, ölçeklerden elde edilen nicel veriler ve görüşmelerden elde edilen nitel veriler kullanılarak değerlendirilmiştir. LBD-TPACK öğretim süreci sonunda elde edilen öğrenme çıktılarının anlamlı öğrenme çıktıları olup olmadığını belirlemek için görüşme verileri Fink Taksonomisi kullanılarak analiz edilmiştir. Bulgular, öğretmen adaylarının TPACK puanlarının ve TPACK özgüven puanlarının öğretim sürecinden sonra arttığını göstermiştir (α=0.05, p=0.00). Sonuçların nitel verilerle desteklendiği ve öğretmen adaylarının anlamlı öğrenme çıktılarına sahip oldukları görülmüştür. Gelecekteki benzer çalışmaların; TPACK gelişimine yönelik etkinliklerin öğretmen eğitimi faaliyetlerine etkin entegrasyonunu sağlamak adına farklı öğretmenlik alanları ve daha büyük çalışma grupları ile yürütülmeleri doğrultusunda önerilerde bulunulmuştur.

Anahtar kelimeler: Öğretmen yetiştirme, TPACK, tasarım tabanlı öğrenme, fink taksonomisi, öğretim materyali

References

Abbitt, J. T. (2011). Measuring technological pedagogical content knowledge in pre-service teacher education: A review of current methods and instruments. *Journal of Research*

on Technology in Education, 43(4), 281-300. https://www.doi.org/10.1080/15391523.2011.10782573

Abell, S. (2008). Twenty years later: Does pedagogical content knowledge remain a useful idea? *International Journal of Science Education, 30*(10), 1405-1416. https://www.doi.org/10.1080/09500690802187041.

Agyei, D., & Voogt, J. (2012). Developing technological pedagogical content knowledge in pre-service mathematics teachers, through collabarative design teams. *Australasian Journal of Educational Technology, 28*(4), 547-564. https://www.doi.org/10.14742/ajet.827.

Alayyar, G. (2011). Developing pre-service teacher competencies for ICT integration through design teams. [Doctoral dissertation, University of Twente]. University Library/University of Twente. https://doi.org/10.3990/1.9789036532341

Aldoobie, N. (2015). ADDIE model. *American International Journal of Contemprorary Research, 5*(6), 68-72. http://www.aijcrnet.com/journals/Vol_5_No_6_December_2015/10.pdf

Artz, A., & Armour–Thomas, E. (1999). A cognitive model for examining teachers' instructional practice in mathematics: A guide for facilitating teacher reflection. *Educational Studies in Mathematics, 40*, 211-235. https://www.doi.org/10.1023/A:1003871918392

Aygün, B., Uzun, N., & Atasoy, E. (2016). The examination of teacher candidates' level of proficiency in technopedagogical education. *Turkish Journal of Computer and Mathematics Education, 7*(2), 393-416. https://www.doi.org/10.17762/turcomat.v7i2.132

Bahçekapılı, T. (2011). *Experiences from Collaboration between Information Technologies Teacher and Classroom Teacher Candidates Orientated by the Technology-Supported Instruction* (Publication No. 276456) [Master's thesis, Karadeniz Technical University]. Council of Higher Education Thesis Center. https://tez.yok.gov.tr/UlusalTezMerkezi/TezGoster?key=veR1mHu9yoWjwcVUjCEoPNXvApwMoc2jhUyttAn60CoyELNpDAEBWexS4T6pTLZS

Baran, E., & Uygun, E. (2016). Putting technological, pedagogical, and content knowledge (TPACK) in action: An integrated TPACK-design-based learning (DBL) approach.

Australasian Journal of of Educational Technology, 3(32), 47-63. https://www.doi.org/10.14742/ajet.2551

Bloom, B. S. (1956). *Taxonomy of educational objectives, the classification of educational goals, handbook I: Cognitive Domain.* David McKay Company.

Byker, E. (2014). Needing TPACK without knowing it: Integrating educational technology in social studies. *Social Studies Research and Practice, 9*, 106-117. https://www.doi.org/10.1108/SSRP-03-2014-B0008.

Canbazoğlu Bilici, S. (2012). *The pre-service science teachers' technological pedagogical content knowledge and their self-efficacy* (Publication No. 317187) [Doctoral dissertation, Gazi University]. Council of Higher Education Thesis Center. https://tez.yok.gov.tr/UlusalTezMerkezi/TezGoster?key=RYan9_S-Z7Eir3xdWGXBiJ5xDhL4oqWu-zymnrZ16CqTmYJeNR8j2FwUk2-Wm7V4

Cavin, R. M. (2007). *Developing technological pedagogical content knowledge in pre-service teachers through microteaching lesson study* [Doctoral dissertation, Florida State University]. Diginole: Florida State University's Digital Repository. http://purl.flvc.org/fsu/fd/FSU_migr_etd-4017

Chai, C., Koh, J., & Tsai, C. (2010). Facilitating pre-service teachers' development of technological, pedagogical, and content knowledge (TPACK). *Educational Technology & Society, 13*(4), 63-73. https://www.jstor.org/stable/jeductechsoci.13.4.63

Chai, C., Koh, J., & Tsai, C. (2013). A review of technological pedagogical content knowledge. *Educational Technology & Society, 16*(2), 31-51. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=2bc25418cd1c160ea3b8c76157f9222a4d2d9436#page=36

Creswell, J., & Plano Clark, V. (2011). *Designing and conducting mixed methods research* (2nd ed.). Sage Publications.

Dikkartın Övez, F., & Akyüz, G. (2013). Modelling technological pedagogical content knowledge constructs of preservice elementary mathematics teachers. *Education and Science, 38*, 170. http://egitimvebilim.ted.org.tr/index.php/EB/article/view/2156

Erdoğan, N. (2014). *Pre-service teachers' technological pedagogical content knowledge developmentin a computer-assisted mathematics instruction course* (Publication No.

361942) [Master's thesis, Boğaziçi University]. Council of Higher Education Thesis Center. https://tez.yok.gov.tr/UlusalTezMerkezi/TezGoster?key=gyLHMouPes-CvnhRcjQsKauFU0uoNhPzfLLRePSy_G4AppC4ZHXsdl1KK6QckqXH

Ertmer, P. (2005). Teacher pedagogical beliefs: the final frontier of in our quest for technology integration? *Educational Technology Research and Development, 53*(4), 25-40. https://www.jstor.org/stable/30221207

Figg, C. & Jaipal, K. (2009). Unpacking TPACK: TPK Characteristics Supporting Successful Implementation. In I. Gibson, R. Weber, K. McFerrin, R. Carlsen & D. Willis (Eds.), *Proceedings of SITE 2009--Society for Information Technology & Teacher Education International Conference* (pp. 4069-4073). Association for the Advancement of Computing in Education (AACE). https://www.learntechlib.org/primary/p/31295/.

Fink, L. D. (2003). *Creating significant learning experiences: An integrated approach to designing college courses, revised and updated.* Jossey-Bass.

Fink, L. D. (2007). The power of course design to increase student engagement and learning. *Peer Review*, *9*(1), 13-17. http://nur655sect2jan12teama.pbworks.com/w/file/fetch/51066806/ThePowerofCourseDesigntoIncrease.pdf

Golas, J. (2010). Effective teacher preparation programs: Bridging the gap between educational technology availability and its utilization. *International Forum of Teaching and Studies, 6*(1), 16-18. https://www.proquest.com/scholarly-journals/effective-teacher-preparation-programs-bridging/docview/208895918/se-2

Graham, C., Burgoyne, N., Cantrell, P., Smith, L., St. Clair, L., & Harris, R. (2009). TPACK development in science teaching: Measuring the TPACK confidence of inservice science teachers. *TechTrends. Special Issue on TPACK*, *53*(5), 70-79. https://www.doi.org/10.1007/s11528-009-0328-0

Habowski, T., & Mouza, C. (2014). Pre-service teachers' development of technological pedagogical content knowledge (TPACK) in the context of a secondary science teacher education program. *Journal of Technology and Teacher Education, 22*(4), 471-495. https://www.learntechlib.org/p/114605/

Han, S., & Bhattacharya, K. (2001). Constructionism, learning by design, and project based learning. In M. Orey (Ed.). *Emerging perspectives on learning, teaching, and technology*. https://pirun.ku.ac.th/~btun/papert/design.pdf

Hur, J., Cullen, T., & Brush, T. (2010). Teaching for application: A model for assisting pre-service teachers with technology integration. *Journal of Technology and Teacher Education, 18*(1), 161-182. https://eric.ed.gov/?id=EJ896293

Jang, S., & Chen, K. (2010). From PCK to TPACK: Developing a transformative model for pre-service science teachers. *Journal of Science Education and Technology, 19*(6), 553-564. https://www.doi.org/10.1007/s10956-010-9222-y

Johnson, L. (2012). *The effect of design teams on pre-service teachers' technology integration.* [Doctoral dissertation, Syracuse University]. Syracuse University Libraries. https://surface.syr.edu/idde_etd/58

Johnson, L., Adams Becker, S., Estrada, V., & Freeman, A. (2014). *NMC horizon report: 2014 K-12 edition.* The New Media Consortium. https://files.eric.ed.gov/fulltext/ED559369.pdf

Kafyulilo, A., Fisser , P., Pieters, J., & Voogt, J. (2015). ICT use in science and mathematics teacher education in Tanzania: Developing technological pedagogical content knowledge. *Australasian Journal of Educational Technology, 31*(4), 381-399. https://www.doi.org/10.14742/ajet.1240

Karataş, İ., Pişkin Tunç, M., Demiray, E., & Yılmaz, N. (2016). The development of pre-service teachers' technological pedagogical content knowledge in mathematics education. *Bolu Abant Izzet Baysal University Journal of Faculty of Education, 16*(2), 512-533. https://www.doi.org/10.17240/aibuefd.2016.16.2-5000194940

Kaya, Z. (2006). *Öğretim teknolojileri ve materyal geliştirme [Instructional Technologies and Material Development]*. Pegem Akademi Yayıncılık.

Koehler, M., & Mishra, P. (2005a). Teachers learning technology by design. *Journal of Computing in Teacher Education, 21*(3), 94–102. https://www.doi.org/10.1080/10402454.2005.10784518

Koehler, M., & Mishra, P. (2005b). What happens when teachers design educational technology? The development of technological pedagogical content knowledge.

Journal of Educational ComputingResearch, 32(2), 131-152. https://www.doi.org/10.2190/0EW7-01WB-BKHL-QDYV

Koehler, M., & Mishra, P. (2008). Introducing TPCK. In J. Colbert, K. Boyd, K. Clark, S. Guan, J. Harris, M. Kelly, & A. Thompson (Eds.), *Handbook of technological pedagogical content knowledge for educators* (pp. 1-29). Routledge. https://www.doi.org/10.4324/9781315759630

Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education, 9*(1), 60-70. https://citejournal.org/wp-content/uploads/2016/04/v9i1general1.pdf

Koehler, M., Mishra, P., Akcaoglu, M., & Rosenberg, J. (2013). The technological pedagogical content knowledge framework for teachers and teacher educators. *ICT integrated teacher education: A resource book* (pp. 2-7). Commonwealth Educational Media Centre for Asia. http://www.matt-koehler.com/publications/Koehler_et_al_2013.pdf

Koehler, M., Mishra, P., Bouck, E., DeSchryver, M., Kereluik, K., Shin, T., & Wolf, L. (2011). Deep-play: Developing TPACK for 21st Century Teachers. *International Journal of Learning Technology, 6*(2), 146-163. https://www.doi.org/10.1504/IJLT.2011.042646

Koehler, M., Mishra, P., Hershey, K., & Peruski, L. (2004). With a little help from your students: A new model for faculty development and online course design. *Journal of Technology and Teacher Education, 12*(1), 25-55. https://www.learntechlib.org/primary/p/14636/

Koehler, M., Mishra, P., & Yahya, K. (2007). Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy, & technology. *Computers & Education, 49*(3), 740-762. https://www.doi.org/10.1016/j.compedu.2005.11.012

Koh, J., & Chai, C. (2014). Teacher clusters and their perceptions of technological pedagogical content knowledge (TPACK) development through ICT lesson design. *Computers and Education, 70*, 222- 232. https://www.doi.org/10.1016/j.compedu.2013.08.017

Koh, J., & Divaharan, H. (2011). Developing pre-service teachers' technology integration expertise through the TPACK-developing instructional model. *Journal of Educational Computing Research, 44*(1), 35-58. https://www.doi.org/10.2190/EC.44.1.c

Koh, J., & Divaharan, S. (2013). Towards a TPACK-fostering ICT instructional process for teachers: Lessons from the implementation of interactive whiteboard instruction. *Australasian Journal of Educational Technology, 29*(2), 233-247. https://www.doi.org/10.14742/ajet.97

Kolodner, J. L., (2002). Facilitating the Learning of Design Practices: Lessons Learned from an Inquiry into Science Education. *Journal of Industrial Teacher Education, 39*(3). https://scholar.lib.vt.edu/ejournals/JITE/v39n3/kolodner.html

Kolodner, J. L., Camp, P. J., Crismond, D., Fasse, B., Gray, J., Holbrook, J., Puntambekar, S. & Ryan, M. (2003). Problem-Based Learning Meets Case-Based Reasoning in the Middle-School Science Classroom: Putting Learning by Design(tm) Into Practice, *Journal of the Learning Sciences, 12*(4), 495-547, https://www.doi.org/10.1207/S15327809JLS1204_2

Kurt, G., Mishra, P., & Kocoglu, Z. (2013). Technological pedagogical content knowledge development of Turkish pre-service teachers of English. *InSociety for Information Technology & Teacher Education International Conference* (pp. 5073-5077). https://www.learntechlib.org/p/48937/

Larkin, K., Jamieson-Proctor, R., & Finger, G. (2012). TPACK and pre-service teacher mathematics education: Defining a signature pedagogy for mathematics education using ICT and based on the metaphor “mathematics is a language”. *Computers in the Schools, 29*(2-1), 207-226. https://www.doi.org/10.1080/07380569.2012.651424

Lee, C., & Kim, C. (2014). An implementation study of a TPACK-based instructional design model in a technology integration course. *Educational Technology Research and Development, 62*(4), 437- 460. https://www.doi.org/10.1007/s11423-014-9335-8

Lu, L. (2014). *Learning by design: Technology preparation for "digital native" pre-service teachers.* [Doctoral dissertation, Syracuse University]. Syracuse University Library. https://surface.syr.edu/etd/124

Lu, L., Johnson, L., Tolley, L., Gilliard-Cook, T. & Lei, J. (2011). Learning by Design: TPACK in Action. In M. Koehler & P. Mishra (Eds.). *Proceedings of SITE 2011-*

Society for Information Technology & Teacher Education International Conference, USA (pp. 4388-4395). https://www.learntechlib.org/primary/p/37022/.

Maeng, J., Mulvey, B., Smetana, L., & Bell, R. (2013). Pre-service teachers' TPACK: Using technology to support inquiry instruction. *Journal of Science Education and Technology, 22*(6), 838- 857. https://www.doi.org/10.1007/s10956-013-9434-z

Miles, M., & Huberman, A. (1994). *Qualitative data analysis* (2nd ed.). Sage Publications.

Mishra, P., & Koehler, M. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *The Teachers College Record, 108*(6), 1017-1054. https://www.doi.org/10.1111/j.1467-9620.2006.0068

Mishra, P., & Koehler, M. (2008). Introducing technological pedagogical content knowledge. *Annual Meeting of the American Educational Research Association, USA.* http://www.matt-koehler.com/publications/Mishra_Koehler_AERA_2008.pdf

Mishra, P., & Koehler, M. (2009). Too cool for school? No way! Using the TPACK framework: You can have your hot tools and teach with them, too. *Learning & Leading with Technology, 36*(7), 14-18. https://files.eric.ed.gov/fulltext/EJ839143.pdf

Ottenbreit-Leftwich, A., Glazewski, K., Newby, T., & Ertmer, P. (2010). Teacher value beliefs associated with using technology: Addressing professional and student needs. *Computers & Education, 55,* 1321-1335. https://www.doi.org/10.1016/j.compedu.2010.06.002

Öztürk, G., Karamete, A., & Çetin, G. (2020). The relationship between pre-service teachers' cognitive flexibility levels and techno-pedagogical education competencies. *International Journal of Contemporary Educational Research, 7*(1), 40-53. https://www.doi.org/10.33200/ijcer.623668

Öztürk, G., Karamete, A., Çetin, G., & Korkusuz, M. E. (2022). The web 2.0 workshop for the teacher candidates: A mixed method research. *Acta Didactica Napocensia, 15*(1), 38-51. https://doi.org/10.24193/adn.15.1.4

Polly, D. (2011). Teachers' learning while constructing technologybased instructional resources. *British Journal of Educational Technology, 42*(6), 950–961. https://www.doi.org/10.1111/j.1467-8535.2010.01161.x

Polly, D., & Orrill, C. (2016). Designing professional development to support teachers' TPACK in elementary school mathematics. In M. Herring, M. Koehler, & P. Mishra (Eds.). *Handbook of technological pedagogical content knowledge* (2nd ed.). Routledge. https://www.doi.org/10.4324/9781315771328

Rama, R. C. (2013). Incorporating Fink's significant learning experience model in the re-designing of the flagship accounting course. *Journal of Accounting and Finance, 13*(5), 116-124. http://www.na-businesspress.com/JAF/GuttikondaRR_Web13_5_.pdf

Robinson, C. (2009). Lessons on learning. *Journal for Quality & Participation 32(1),* 25-27. https://www.proquest.com/scholarly-journals/lessons-on-learning/docview/219151908/se-2

Sang, G., Valcke, M., Braak, J., & Tondeur, J. (2010). Student teachers' thinking processes and ICT integration: Predictors of prospective teaching behaviors with educational technology. *Computers & Education, 54*(1), 103-112. https://doi.org/10.1016/j.compedu.2009.07.010

Schmidt, D., Baran, E., Thompson, A., Mishra, P., Koehler, M., & Shin, T. (2009). Technological pedagogical content knowledge (TPACK): The development and validation of an assessment instrument for pre-service teachers. *Journal of Research on Technology in Education, 42*(2), 123-149. https://doi.org/10.1080/15391523.2009.10782544

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14. https://doi.org/10.2307/1175860

Stanny, C. (2016). Reevaluating Bloom's taxonomy: What measurable verbs can and cannot say about student learning. *Education Sciences, 6*(4), 34. https://doi.org/10.3390/educsci6040037

Timur, B., & Taşar, M. (2011). The adaptation of the technological pedagogical content knowledge confidence survey into Turkish. *Gaziantep University Journal of Social Sciences, 10*(2), 839-856. https://dergipark.org.tr/tr/pub/jss/issue/24242/257006

Tondeur, J., van Braak, J., Sang, G., Voogt, J., Fisser, P., & Ottenbreit-Leftwich, A. (2011). Preparing pre-service teachers to integrate technology in education: A synthesis of qualitative evidence. *Computers & Education, 59*(1), 134-144. https://doi.org/10.1016/j.compedu.2011.10.009

Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi
Cilt 17, Sayı 1, Haziran 2023, sayfa 211-230. ISSN: 1307-6086
Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education
Vol. 17, Issue 1, June 2023, pp. 211-230. ISSN: 1307-6086

Research Article

Teachers' Views on Early Childhood Maths*

Kerem AVCİ [1], Berrin AKMAN [2]

[1] Balikesir University, Necetibey Eğitim Fakültesi Altıeylül, BALIKESİR, keremavci@balikesir.edu.tr, https://orcid.org/0000-0002-8050-9469

[2] Hacettepe University, Eğitim Fakültesi Beytepe Kampüsü, Çankaya, ANKARA, bakman@hacettepe.edu.tr, http://orcid.org/0000-0001-5668-4382

Received : 26.12.2022 Accepted : 20.01.2023

https://doi.org/10.17522/balikesirnef.1224695

Abstract – Some psychological factors related to preschool teachers significantly impact mathematics teaching in early childhood classrooms. Thus, examining teachers' views on preschool mathematics will guide teachers in understanding which concepts were included in early childhood mathematics and preparing an educational environment and program appropriate for children's developmental levels. This research was a descriptive-study and was implemented using general-survey model with 107 preschool teachers. Data were collected by teacher views form on early childhood mathematics. Data were evaluated with descriptive and non-parametric statistical methods. Results showed that the teachers used math activities with games, art, drama activities and used limited methods to assess whether children have learned mathematics concepts. In addition, most teachers stated that data analysis, proof, and probability cannot be taught in preschool. Finally, most teachers considered preschool mathematics moderately important and that there was no significant difference among ages, professional service periods, the institution and school types they work in, and the order of importance of mathematics ($p > .05$).

Keywords: early mathematics education, teacher views, early childhood education

---

Corresponding author: Kerem AVCİ, Balikesir University, Necatibey Eğitim Fakültesi Altıeylül, BALIKESİR

* A part of this research was presented at the 6th International Early Childhood Education Congress (IECEC-UOEK, [2-5 Oct. 2019])

Introduction

In early childhood, mathematics has a significant role in children's cognitive development. Children can make sense of what is happening around them through mathematics. (Fromboluti & Rinck, 1999). The foundations of mathematical development in children are laid

mainly in early childhood (Clement & Sarama, 2007; Çelik & Kandır, 2011; 2013; Erdoğan, 2006). Mathematical experiences in the early years of childhood arise from children's awareness and understanding of the mathematical dimensions of the situations occurring around them from early ages (National Association for the Education of Young Children [NAEYC], 2002). From the first years of their life, children begin to learn mathematical concepts they will use in the future through the experiences they have gained during interacting with their environment. Observations about children's play and daily routines indicate that they acquire many mathematical concepts, develop mathematical thinking, perform mathematical operations, and start using the concepts they have learned (Buldu, 2012).

Mathematics in early childhood is also related to concept development and is closely associated with children's concrete experiences (Akman et al., 2000; Güçhan-Özgül & Saçkes, 2022). "*Classification, comparison, ordering, number concept, operation concept, geometric shapes, measurement and using symbols, etc*." concepts contribute to children's future understanding and learning of mathematics. With the academic skills presented and supported in early childhood, children's readiness for primary school can be increased, and their achievements in later grades can be grounded (Çelik & Kandır, 2011; Uyanık & Kandır, 2010).

Results of numerous studies stated that academic skills gained in early childhood affect children's mathematical skills at later ages (Claessens & Engel, 2013; Çelik & Kandır, 2011; Ergün, 2003; Uyanık & Kandır, 2010) and the effect of teachers on the acquisition of formal math skills in this period (Copley, 2004; Hart, 2002; Jenkins, 2001; Le & Ginsburg, 2007; Orçan Kaçan & Karayol, 2017; Stites et al., 2022; Todd Brown, 2005; Zacharos et al., 2007). In addition, research revealed some problems and deficiencies (e.g. feeling inadequate in teaching math, not having enough knowledge of mathematics concepts and skills, having difficulties in planning mathematics activities etc.) regarding mathematics teaching at early ages within the scope of preschool education practices carried out in Turkey (Ağgül Yalçın & Yalçın, 2018; Güven & Gök-Çolak, 2019; Orçan Kaçan & Halmatov, 2017; Orçan Kaçan & Karayol, 2017; Pekince & Avci, 2016).

It is known that achievements and experiences in mathematics in early childhood also influence children's future success (Clements & Sarama, 2008; Jordan et al., 2009; Lopez et al., 2008; Saxe, 1988; Wolfgang et al., 2001). Observable outputs related to this situation are seen when the scores and rankings of Turkish students are examined in the "*Program for International Student Assessment (PISA*)" project implemented every three years by the "*Organization for Economic Cooperation and Development (OECD).*" PISA exams determine

the levels of 15-year-old students in areas such as mathematical literacy, science literacy, and reading skills (Ministry of Education [MEB], 2012). In the 2018 PISA results, in which 79 countries participated, Turkey ranked 40th in reading (31 in 37 OECD countries), 39th in science (30 in 37 OECD countries), and only 42nd in mathematics (33 in 37 OECD countries). countries) (PISA, 2019). When the PISA results are evaluated, Turkish students are far behind their international counterparts. The report published by the OECD (2004) states that learning experiences gained in early childhood significantly affect the performance of students from different participant countries in mathematics achievement.

Influence of Teachers on Early Childhood Mathematics

Teaching is a complex process that requires three types of teacher knowledge: (1) field knowledge, (2) pedagogical content knowledge, and (3) curriculum knowledge (Youmans et al., 2018). Field knowledge points out an understanding of how mathematics is processed (its scope, depth, structure, procedures, relationship with other fields, etc.) in early childhood. Pedagogical content knowledge focuses on how mathematics can be taught effectively, while curriculum knowledge focuses on what mathematics means (Ernest, 1989). One of the sub-categories of the Ministry of National Education (MoNE) "*Teaching Profession General Competencies*" is "*Domain-Specific Knowledge*" (MEB, 2017). According to this sub-category, the teacher should possess the curriculum and pedagogical content knowledge of his field. In order for the child to gain, develop, and maintain the basic concepts and skills that they will use in their later school life, teachers have to design and provide "*appropriate and effective educational environments, materials, programs and guidance*". These can be provided by the teacher's possession of domain-specific knowledge.

Early math learning experiences affect young children's attitudes, perceptions, and knowledge levels toward mathematics and provide rich learning opportunities for disadvantaged groups. Researchers discovered that children from low-income families quickly close the gap with their peers with preschool math programs (Clements & Sarama, 2008; Dearing et al., 2009; Oktay & Güven, 1998; Starkey et al., 2004). Well-structured and qualified early childhood programs that take into account children's characteristics have a significant impact on and improve children's mathematical skills (Ayvacı, 2010; Clements & Sarama, 2008; Kartal, 2007; Tarım Gözübatık & Artut Dinç, 2004). Teachers will support bridging this gap by providing appropriate and efficient educational environments, materials, activities, and guidance for children in preschool education. Teachers in early childhood education classrooms are supposed to provide a suitable educational environment for effective mathematics teaching.

Besides a suitable learning environment being a prerequisite for teaching mathematics, teachers should prepare and implement an appropriate mathematics program considering the developmental characteristics of children. From this point of view, the significance of preschool teachers' domain-specific knowledge in facilitating mathematics learning becomes even more explicit.

Teachers' attitudes, beliefs, or views toward mathematics and mathematics teaching are generally reflected in their educational practices. Thus, they affect students' attitudes, interests, and achievements toward mathematics and can be important determinants of children's mathematics learning (Zacharos et al., 2007). One of the significant issues with teaching mathematics to young children is that teachers often have misconceptions about the subject, such as the notion that "*children are not ready to learn mathematics*," "*not everyone can learn mathematics*," "*language and literacy are more important than mathematics*," "*mathematics cannot be taught as a subject on its own*," and "*it should only be taught utilizing concrete objects and simple numbers and figures*" (Lee & Ginsburg, 2009). Along with misconceptions, some psychological factors (i.e., self-efficacy, beliefs, and attitudes) related to preschool teachers significantly impact mathematics teaching in early childhood classrooms. Teachers' attitudes towards mathematics can affect mathematics teaching. Although many factors affect teachers' attitudes toward mathematics, it is stated that they have a positive attitude (Çelik, 2019) as well as a negative attitude towards mathematics (Markovits, 2011; Zacharos et al., 2007) and even that these negative attitudes are mainly based on their previous learning (Maloney & Beilock, 2012; Zacharos et al., 2007). As Copley stated (2004), one of the reasons why teachers do not practice mathematics activities may be related to a lack of confidence. However, sometimes the importance they give and the frequency of application can also show an inverse ratio (Orçan Kaçan & Karayol, 2017).

There is a relationship between teachers' beliefs and educational practices (Hart, 2002; Jenkins, 2001; Lee & Ginsburg, 2007) and between teachers' proficiency and mathematics practices (Todd Brown, 2005). Teachers with a high sense of efficacy find mathematics more critical, while teachers with a low sense of competence consider mathematics less important (Todd Brown, 2005). According to Ernest (1989), teachers' practice of teaching mathematics depends on several factors such as 1) mental contents or schemas related to mathematics, especially belief systems related to mathematics and its teaching and learning, (2) the social context of the teaching situation, especially the constraints and opportunities it provides, and (3) the teacher's thought processes and reflection. Ernest (1989) emphasized that "teachers'

mental models of mathematics" are critical because they include what constitutes appropriate and prototypical learning activities, the behaviours and activities the student will be involved in, and, most importantly, the teacher's views on the mathematics teaching process. For this reason, examining teachers' views on preschool mathematics will guide teachers in understanding which concepts are included in early childhood mathematics and preparing an educational environment and program appropriate for children's developmental levels.

Aims of the Study

This study was conducted to examine the views of the preschool teachers on early childhood mathematics. The study sought answers to the following questions:

1. Which concepts do the teachers include in early childhood mathematics?
2. What kinds of activities do the teachers use early childhood mathematics with, and how do they assess whether the children have learned mathematical concepts?
3. Is there a significant difference among the teachers' age, years of service, the type of institution and the school they work in and the importance they give to mathematics?

Method

This research was designed as a descriptive study, and general survey model was used in this study. Survey study model: "*It aims to describe the views or characteristics of a community on the subject. The data needed for the research is based on the answers to the questions posed to the participants, and the data is collected from a sample*" (Frankel & Wallen 2006 cited in Büyüköztürk et al., 2012, p.231). Survey studies are classified under three headings as "*retrospective, longitudinal, and cross-sectional*" (Johnson & Christensen, 2014). In this study, data were collected from the sample at one time, and an existing situation was tried to be generalized to the population in the light of collected data. Therefore, this research is cross-sectional and was conducted using survey model.

Participants

The population of the study consisted of teachers working in public or private kindergartens in various provinces of Turkey. The sample of this research consisted of 107 teachers (n=101 women [%94.4], n=6 men [%5.6]) reached through convenient sampling. 45.8% (n=49) of these teachers are between 23-27 years old, 25.2% (n=27) of them are between 28-32 years old, and 22.4% (n=24) of them are 33 years old and over. The convenient sampling

method was used in the study. "*In convenient sampling, the researcher selects individuals who represent some of the characteristics is investigating. When determining the participants, it considers the suitability and willingness of the participants to work. This provides useful information to answer sample questions and hypotheses.*" (Creswell, 2014, p.193).

Data Collection

Within the scope of the study, the "*Teacher Views Form on Early Childhood Mathematics*" prepared by the researchers was used. The form was developed after consulting with two researchers in the field of early childhood mathematics. In the "*Teacher Views Form on Early Childhood Mathematics*", there were eight questions about the demographic characteristics of the participants, the prioritization of activity types in early childhood programs, the concepts that could be used in activities related to mathematics, the use of early childhood mathematics, and two open-ended questions about early childhood mathematics. Data were obtained online from participants using the "*Teacher Views Form on Early Childhood Mathematics*" after getting ethics commission permissions (16.04.2021, No:E-35853172-900-00001580839O) from Hacettepe University for the study's implementation .

Data Analysis

The data were analyzed with the SPSS-24 package program. Descriptive and non-parametric statistics were operated in the examination of data. Frequency and percentage calculations were used to analyze teachers' gender, years of professional service, the type of institution and school they work in, the level of importance they attach to early childhood mathematics, the mathematics concepts they deal with in the classroom, and their views on early childhood mathematics. Moreover, The Chi-square Independence Test examined the relationship among the teachers' age, years of professional service, the type of institution and the school they work in, and the importance they attach to mathematics.

Findings

The frequencies and percentages of the answers given by the participants to the questions about gender, age, professional service period, the type of institution and the school they work in, the importance given to mathematics, being able to associate mathematics with other fields, preparing an appropriate activity for mathematics and using an appropriate mathematical language are given in Table 1.

Table 1 Descriptive Statistics

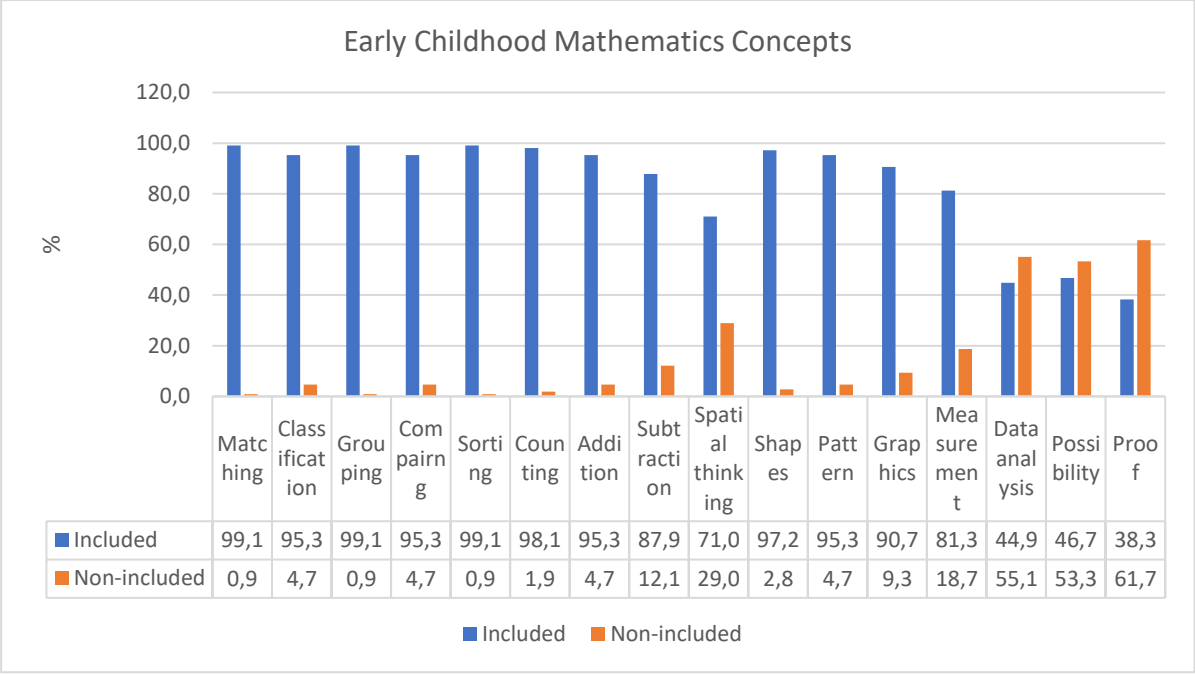
Variables	**N**	**%**	**sd**
Gender			**.23**
Male	101	94.4	
Female	6	5.6	
Age			**.82**
23-27	49	45.8	
28-32	27	25.2	
33 years and above	24	22.4	
No answer	7	6.5	
Professional Service Period			**.70**
0-4 years	77	59.8	
5-10 years	30	28	
11 years and over	13	12.1	
Type of Institution			**.45**
Public school	77	72	
Private school	30	28	
Type of School			**.95**
Kindergarten affiliated to primary school	36	33.6	
Kindergarten	44	41.1	
Nursery	16	15	
Other (High school etc.)	11	10.3	
Importance of Mathematics			**.67**
Less important	25	23.4	
Moderately important	58	54.2	
Very important	24	22.4	
Relating Mathematics to Other Fields			**.19**
Yes	103	96.6	
No	4	3.7	
Being Able to Prepare an Appropriate Activity for Teaching Mathematics			**.16**
Yes	104	97.2	
No	3	2.8	
Using Appropriate Mathematical Language			**.24**
Yes	100	93.5	
No	7	6.5	

Based on the Table 1, 94.4% of the participants are women, and 5.6% are men. When the ages of the participants are examined, it is seen that 45.8% are between 23-27 years old, 25.2% are between 28-32 years old, and 22.4% are 33 years old and over. 59.8% of the

participants have 0-4 years of service period, 28% have a service period of 5-10 years, and 12.1% have a service period of 11 years or more. While 72% of these participants work in public schools, 28% work in private education institutions. When the school types of the participants are examined, 33.6% work in kindergartens affiliated to primary school, 41.1% in kindergartens, 15% at nursery school, and 10.3% in other institutions (classes opened based on high school, institution, etc.). 22% of the participants consider mathematics very important, 54.2% consider it moderately important, and 23.4% consider mathematics less important compared to other activities. 96.6% of the participants stated that they could associate mathematics with other fields, 97.2% were able to prepare an appropriate activity plan for mathematics teaching, and 93.5% stated that they could use mathematical language.

Math Concepts Used in Early Childhood

The answers given by the teachers about the mathematical concepts that can be included in early childhood are shown in Figure 1.



	Matching	Classification	Grouping	Compairng	Sorting	Counting	Addition	Subtraction	Spatial thinking	Shapes	Pattern	Graphics	Measurement	Data analysis	Possibility	Proof
Included	99,1	95,3	99,1	95,3	99,1	98,1	95,3	87,9	71,0	97,2	95,3	90,7	81,3	44,9	46,7	38,3
Non-included	0,9	4,7	0,9	4,7	0,9	1,9	4,7	12,1	29,0	2,8	4,7	9,3	18,7	55,1	53,3	61,7

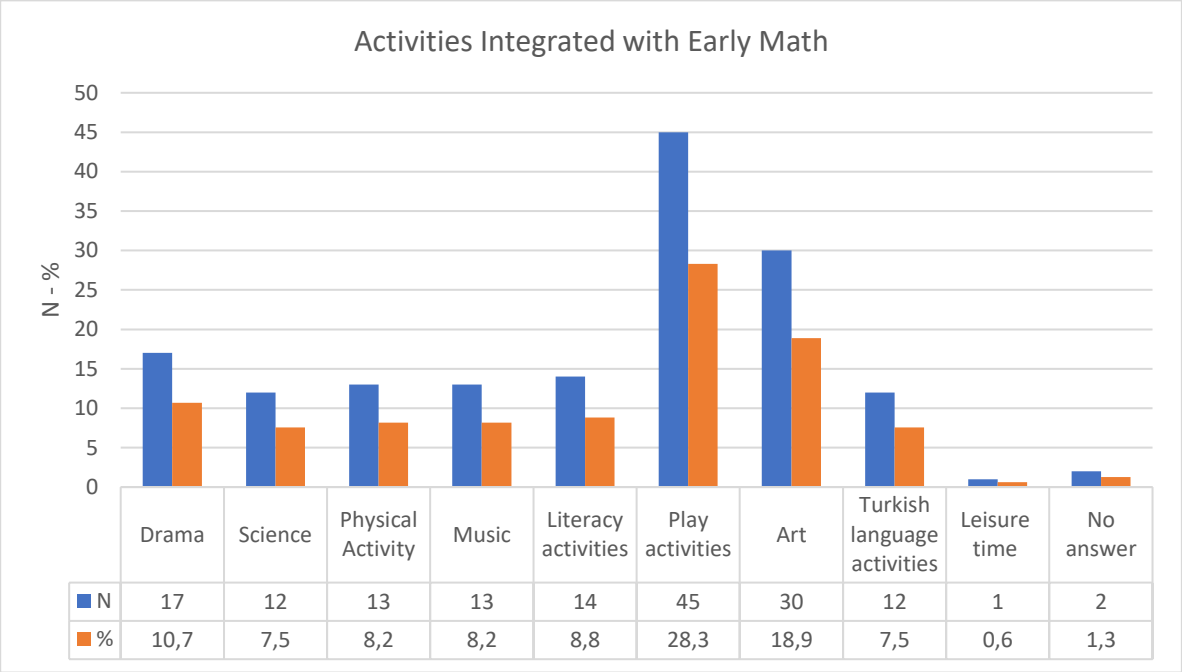
Figure 1 Early Childhood Mathematics Concepts

The majority of the teachers indicated that matching (99.1%), classification (95.3%), grouping (99.1%), comparison (95.3%), sorting (99.1%), counting (98.1%), addition (95.3%), geometric shapes (97.2%), pattern (95.3%), graphics (90.7%), subtraction (87.9%), measurement (81.3%), spatial perception 71% should be included in math activities, while

others were stating that the concepts of proof (61.7%), data analysis (55.1%), probability (55.3%) not be included in early childhood math activities.

Activities Integrated with Math

The answers given by the teachers to the question of which activities you integrate with math to help children learn early childhood mathematics concepts are shown in Figure 2.



	Drama	Science	Physical Activity	Music	Literacy activities	Play activities	Art	Turkish language activities	Leisure time	No answer
N	17	12	13	13	14	45	30	12	1	2
%	10,7	7,5	8,2	8,2	8,8	28,3	18,9	7,5	0,6	1,3

Figure 2 Activities Integrated with Math

When the answers are given to the question of what kind of activities you integrate to teach early childhood mathematics concepts to children,the teachers mostly prefer play (28.4%) and art (18.9%) activities to teach mathematical concepts. These activities were followed by drama (10.7%), literacy (8.8%), physical (8.2%) and music (8.2%) activities. The least preferred activities by the teachers for teaching math concepts were leisure time (0.6%), Turkish-language (7.5%), and science (7.5%) activities.

Assessing Math Concepts in Early Childhood

The answers given by the teachers to the question of how they assess whether children have learned early childhood mathematics concepts are shown in Figure 3.

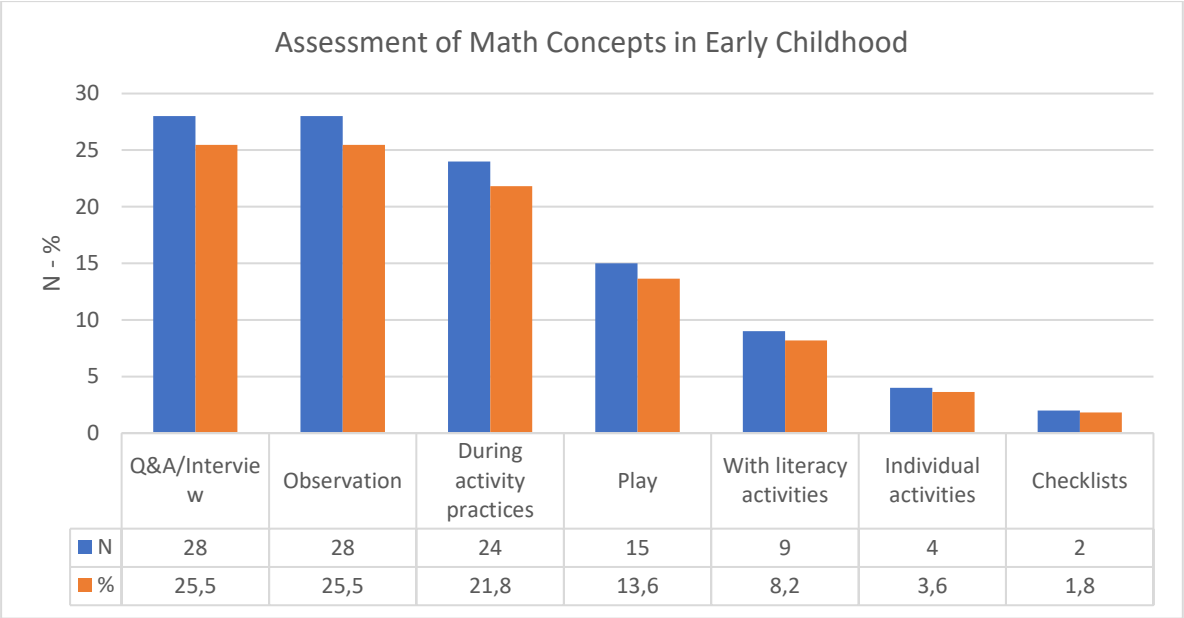


Figure 3 Assessment of Math Concepts in Early Childhood

When the answers given by the teachers to the question, "How do you assess whether children have learned early childhood mathematics concepts?" are examined, the teachers mostly prefer question-answer/interview (25.5%) and observation (25.5%). The type of assessment of mathematics activities was followed by assessing during activity practices (21.8%) and with play activities (13.6%). The activities that teachers used the least in assessment were literacy activities (8.2%), assessing during individual activities (3.6%) and checklists (1.8).

Importance Given to Early Childhood Math

The results of the Chi-square Independence Test, which was conducted to examine whether there is a relationship between the teachers' age, period of professional service, the type of institution and the school they work in, and the importance they give to early childhood mathematics, are shown in Table 2.

Table 2 Chi-Square Independence Test Results

			Less Important	Moderately Important	Very Important	Total	X^2	df	p
Age	23 – 27 years old	N	8	26	15	49	5.02	4	.285
		%	% 16,3	% 53,1	% 30,6	% 100			
	28 – 32 years old	N	8	16	3	27			
		%	29,6	59,3	11,1	% 100			
	33 years and older	N	7	12	5	24			
		%	% 29,2	% 50	% 20,8	% 100			
Period of Professional Service	0 – 4 years	N	13	35	16	64	1.26	4	.868
		%	% 20,3	% 54,7	% 25	% 100			
	5 – 10 years	N	8	16	6	30			
		%	% 26,7	% 53,3	% 20	% 100			
	11 years and above	N	4	7	2	13			
		%	% 30,8	% 53,8	% 15,4	% 100			
Type of Institution	Public school	N	19	40	18	77	.570	2	.752
		%	% 24,7	% 51,9	% 23,4	% 100			
	Private school	N	6	18	6	30			
		%	% 20	% 60	% 20	% 100			
Type of School	Kindergarten affiliated to primary school	N	11	16	9	36	9.77	6	.135
		%	% 30,6	% 44,4	% 25	% 100			
	Kindergarten	N	6	28	10	44			
		%	% 13,6	% 63,6	% 22,7	% 100			
	Nursery	N	4	11	1	16			
		%	% 25	% 68,8	% 6,3	% 100			

There was a decrease in the importance given to mathematics as the age and period of service of the teachers increased, and in the same way, those working in special education institutions gave less importance to mathematics. However, according to the results of the Chi-square independence test, no significant difference was found between ages (X^2 (4, n= 100)= 5.02, p = .285, τ_b= -.160, period of professional service (X^2 (4, n= 107)= 1.26, p = .868, τ_b= -.098), type of institution (X^2 (2, n= 107)= .570, p = .752, V= -.073), type of school (X^2 (6, n= 107)= 9.77, p = .135, V= -.214) and the importance given to early childhood mathematics.

Discussions, Conclusions, and Suggestions

This research examined teachers' views on early childhood mathematics from a descriptive perspective. The teachers (1) can associate early childhood mathematics with other fields and prepare appropriate math activities, (2) state that some concepts that should be taught in early childhood math cannot be used, (3) they prefer non-permanent assessments such as observation and interview rather than assessment methods that children can record their learning and check later, (4) there is no relationship between the age of teachers, their professional service period, type of institution they work in, type of school they work in, and the importance they attach to mathematics. Still, there is a tendency to decrease the importance given to mathematics as age and length of service increase. Similarly, there is a decrease in the importance given to mathematics by those working in special institutions.

The majority of the teachers indicated that matching, classification, grouping, comparison, sorting, counting, addition, geometric shapes, pattern, graphics, subtraction, measurement, and spatial perception should be included in math activities. In contrast, others stated that the concepts of proof, data analysis, and probability not be included in early childhood math activities. Ernest (1989) stated that pedagogical knowledge is critical as it explains how to teach mathematics effectively. For this reason, preschool teachers need to know which concepts should be included in early childhood mathematics. NCTM (2000) listed the concepts that should be in early childhood mathematics as "number, operation, algebra, geometry, measurement, data analysis, probability, problem-solving reasoning, communication, association, and representation. Similarly, Smith (2009) identified early childhood mathematics concepts as "*matching, classification, grouping, comparison, ordering, counting, data analysis, graphics, pattern, problem-solving, operation, geometry, measurement*." It is noteworthy that the participants in this study neglected to include some essential mathematics concepts in mathematics education activities. Considering that these

concepts could be addressed in early mathematics, teachers are expected to include them equally in mathematics activities. Research accounts for some reasons teachers' curriculum decisions stress domain-specific knowledge and psychological factors about mathematics. As Youmans et al. (2018) stated, early childhood education teachers have limited knowledge of mathematics education, but they emphasized that teachers should have content knowledge, pedagogical content knowledge, and curriculum knowledge. Accordingly, Lee and Ginsburg (2009) remarked that teachers' attitudes, beliefs, and opinions about mathematics are reflected in their educational practices.

The results of this study showed that the teachers mostly used mathematical concepts with play, arts, and drama activities. The teachers assessed whether children learned mathematics concepts such as question-answer/interview, observation, and activity applications, and they did not use applications such as checklists. Koç (2017) underlined that teachers feel inadequate in evaluating children's mathematics achievement. Contrary to the results of the current study, Yazlık and Öngören (2018) found that teachers mainly carry out math activities together with Turkish and science activities.

In the current study, 22.4% of the teachers stated that they considered mathematics very important, 54.2% moderately important, and 23.4% less important. Several studies indicated a relationship between teachers' beliefs and educational practices (Hart, 2002; Jenkins, 2001, Stites et al., 2022). Lee and Ginsburg (2009) pointed out that some teachers have false beliefs that children are not ready to learn mathematics. Such beliefs and attitudes may lead to ignoring the importance of early math practices in the classroom. Teachers' knowledge, competence, and beliefs about mathematics (Todd Brown, 2005; Zacharos et al., 2007), as well as negative attitudes (Markovits, 2011), can affect children's math development.

When the chi-square independence test results were examined, no significant difference was found between the age of the teachers ($p > .05$), the length of their professional service ($p > .05$), the type of institution they work in ($p > .05$), type of school they work in ($p > .05$), and the importance they attach to mathematics. Teachers' beliefs about math and the importance they give can be affected by numerous factors. It is believed that teachers' beliefs about teaching mathematics are related to their professional service time (Karakuş & Akman, 2009; Şeker & Alisinanoğlu, 2015). However, Karakus et al. (2019) stated that teachers' beliefs about mathematical development did not differ significantly according to age, type of school they work at, education level, and professional service period.

This study has certain limitations, even though it is believed that the findings will help both preschool teachers and those interested in teacher education. This research was descriptive, and data were collected online based on teachers' expressions. It is recommended that the views of a larger sample group should be examined together with their classroom practices in future studies. It is also suggested to contrast the results of this study with the information to be gathered from various measurement instruments. In addition, when the research results were examined, it was observed that most teachers had false beliefs about some concepts, such as data analysis, probability, and proof, that could not be taught in the preschool period. More research is needed to better understand preschool teachers' false beliefs about early math teaching. Finally, the results of this study indicated that some critical implementation gaps in early math learning assessment exist. There is, therefore, a definite need for training teachers on early math assessments, which will allow them more permanent and evidence-based practices in assessing children's conceptual skills.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest

No conflict of interest.

Funding

None.

CRediT author statement

The study was a two-author study, with both authors contributing equally.

Research involving Human Participants and/or Animals

The study involves human participants. Ethics committee permission was obtained from Hacettepe University Ethics Boards and Commissions for the study's implementation (16.04.2021, No:E-35853172-900-00001580839O).

Erken Çocukluk Matematiğine Yönelik Öğretmen Görüşleri

Özet:

Okul öncesi öğretmenleriyle ilgili bazı psikolojik faktörler, erken çocukluk sınıflarında matematik öğretimini önemli ölçüde etkilemektedir. Bu nedenle öğretmenlerin okul öncesi matematiğe ilişkin görüşlerinin incelenmesi, erken çocukluk matematiğinde hangi kavramların yer aldığını anlamada ve çocukların gelişim düzeylerine uygun bir eğitim ortamı ve programı hazırlamada öğretmenlere yol gösterici olacaktır. Bu araştırma; betimsel araştırma olup, 107 okul öncesi öğretmeni ile genel tarama modeli kullanılarak gerçekleştirilmiştir. Veriler erken çocukluk matematiğine ilişkin öğretmen görüş formu ile toplanmıştır. Veriler tanımlayıcı ve parametrik olmayan istatistiksel yöntemlerle değerlendirilmiştir. Analiz sonuçları öğretmenlerin matematik etkinliklerini oyun, resim ve drama etkinlikleriyle birlikte kullandıkları ve çocukların matematik kavramlarını öğrenip öğrenmediklerini değerlendirmek için sınırlı yöntemler kullandıklarını göstermiştir. Ayrıca öğretmenlerin çoğu veri analizi, ispat ve olasılığın okul öncesi eğitimde öğretilemeyeceğini belirtmektedir. Son olarak öğretmenlerin çoğu okul öncesi matematiğini orta düzeyde önemli görmekle birlikle analiz sonuçları yaş, mesleki hizmet süresi, görev yaptıkları kurum ve okul türü ve matematiğin önem sıralaması arasında anlamlı bir fark olmadığını ($p > .05$) göstermektedir.

Anahtar kelimeler: erken matematik eğitimi, öğretmen görüşleri, erken çocukluk eğitimi

References

Ağgül Yalçın, F., & Yalçın, M. (2018). Preschool teachers' views of preschool educational problems: Agri city sample. *Elementary Education Online, 17(*1), 367-383. https://doi.org/10.17051/ilkonline.2018.413784

Akman, B., Yükselen, A. İ., & Uyanık, G. (2000). *Okul öncesi dönemde matematik etkinlikleri [Mathematics activities in preschool period]*. Epsilon Yayınları.

Ayvacı, H. Ş. (2010). A pilot survey to improve the use of scientific process skills of kindergarten children. *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education, 4*(2), 1-24. Retrieved from https://dergipark.org.tr/en/pub/balikesirnef/issue/3371/46524

Buldu, M. (2012). Okul öncesi dönemde matematiksel kavram gelişimi [Mathematical concept development in preschool period]. Akman, B. (Ed). In *Okul öncesi matematik eğitimi [Preschool mathematics education]* (3rd ed.), (pp. 28-45). Pegem Akademi.

Büyüköztürk, Ş., Çakmak-Kılıç, E., Akgün-Erkan, Ö., Karadeniz, Ş., & Demirel, F. (2012). *Bilimsel araştırma yöntemleri [Scientific research methods]* (11th ed.). Pegem Akademi.

Claessens, A., & Engel, M. (2013). How important is where you start? Early mathematics knowledge and later school success. *Teachers College Record*, *115*(6), 1-29. https://doi.org/10.1177/0161468113115006

Clement, D. H., & Sarama, S. (2007). Early childhood mathematics learning. Lester, F. K. (Ed.) In *Second Handbook of Research on Mathematics Teaching and Learning*, (pp. 461-566). Information Age Publishing.

Clements, D. H., & Sarama, J. (2008). Experimental evaluation of the effects of a research-based pre-school mathematics curriculum. *American Educational Research Journal, 45*(2), 443-494. https://doi.org/10.3102/0002831207312908

Copley, J. V. (2000). *The young child and mathematics*. National Association for the Education of Young Children.

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches.* SAGE Publications.

Çelik, M. (2017). Preschool teachers' level of attitudes toward early mathematics education, *Inonu University Journal of the Faculty of Education, 18*(1), 58-70. https://doi.org/10.17679/inuefd.295712

Çelik, M., & Kandır, A. (2011). The study of validity and reliability test of progress in maths 6 for 60-77, month old children. *Journal of Theoretical Educational Science, 4*(1), 146-153. Retrieved from https://dergipark.org.tr/en/pub/akukeg/issue/29342/313998

Çelik, M., & Kandır, A. (2013). The effect of "big maths for little kids" curriculum on mathematical development of 61-72 month-old children. *Journal of Theoretical Educational Science, 6*(4), 551-567. Retrieved from https://dergipark.org.tr/en/pub/akukeg/issue/29351/314081

Dearing, E., McCartney, K., & Taylor, B. A. (2009). Does higher quality early child care promote low-income children's math and reading achievement in middle childhood? *Child Development, 80*(5), 1329-1349. https://doi.org/10.1111/j.1467-8624.2009.01336.x

Erdoğan, S. (2006). *Altı yaş grubu çocuklarına drama yöntemi ile verilen matematik eğitiminin matematik yeteneğine etkisinin incelenmesi [A study on the effects of mathematics education given with drama method to six years old children mathematics ability]* [Unpublished doctoral dissertation]. Ankara University.

Ergün, S. (2003). *Okul öncesi eğitim alan ve almayan ilköğretim birinci sınıf öğrencilerinin matematik yetenek ve başarılarının karşılaştırmalı olarak incelenmesi [Comparison of mathematical successes and ability of the first year students who studied in*

kindergartens in primary school to those who didn't] [Unpublished master's thesis]. Marmara University.

Ernest, P. (1989). The knowledge, beliefs and attitudes of the mathematics teacher: A model. *Journal of Education for Teaching*, *15*(1), 13-33. https://doi.org/10.1080/0260747890150102

Fromboluti, C. S., & Rinck, N. (1999). *Early Childhood: Where Learning Begins: Mathematics: Mathematical Activities for Parents and Their 2-to 5-year-old Children*. US Department of Education, Office of Educational Research and Improvement, National Institute on Early Childhood Development and Education.

Güçhan Özgül, S., & Saçkes, M. (2022). Bilişsel gelişim ve kavram gelişimi [Cognitive development and concept development]. In A. B. Ayhan, & U. Beyazıt (Eds.), *Bilişsel gelişim ve desteklenmesi [Cognitive development and support]* (pp. 175-191). Atlas Akademik Basım Yayıncılık.

Güven, Y., & Gök-Çolak, F. (2019). Difficulties of early childhood education teachers' in mathematics activities, *Acta Didactica Napocensia*, *12*(1), 89-106, https://doi.org/10.24193/adn.12.1.6.

Hart, L. C. (2002). Preservice teachers' beliefs and practice after participating in an integrated content/methods course. *School Science and Mathematics*, *102*(1), 4-14. https://doi.org/10.1111/j.1949-8594.2002.tb18191.x

Jenkins, K. L. (2001). *The early childhood field collaborative: A collection of longitudinal case studies revealing Pre-service teachers' beliefs about mathematics*. [Unpublished doctoral dissertation]. University of Houston. Available from ProQuest Dissertation and Theses database. (UMI No: 3003150).

Jordan, N. C., Kaplan, D., Nabors Oláh, L., & Locuniak, M. N. (2006). Number sense growth in kindergarten: A longitudinal investigation of children at risk for mathematics difficulties. *Child Development*, *77*(1), 153-175. https://doi.org/10.1111/j.1467-8624.2006.00862.x

Orçan Kaçan, M., & Halmatov, M. (2017). Mathematics in pre-school education program in Turkey: Planning and implementation. *Pamukkale University Journal of Education, 42*(42), 149-161. Retrieved from https://dergipark.org.tr/en/pub/pauefd/issue/33905/375411

Orçan Kaçan, M., & Karayol, S. (2017). Time allocation in teaching math in preschools and preschool teachers' views on teaching math. *International Journal of Education Sciences, 4*(12), 172-186. http://dx.doi.org/10.16991/INESJOURNAL.1461

Kartal, H. (2007). The effect of mother-child education program which is one of the early childhood education programs on cognitive development of six age children. *Elementary Education Online*, *6*(2), 234-248. Retrieved from https://www.ilkogretim-online.org/fulltext/218-1596624756.pdf?1688145229

Lee, J. S., & Ginsburg, H. P. (2007). Preschool teachers' beliefs about appropriate early literacy and mathematics education for low-and middle-socioeconomic status children. *Early Education and Development*, *18*(1), 111-143. https://doi.org/10.1080/10409280701274758

Lee, J. S., & Ginsburg, H. P. (2009). Early childhood teachers' misconceptions about mathematics education for young children in the United States. *Australasian Journal of Early Childhood*, *34*(4), 37-45. https://doi.org/10.1177/183693910903400406

Lopez, E. M., Gallimore, R., Garnier, H., & Reese, L. (2007). Pre-school antecedents of mathematics achievement of Latinos: The influence of family resources, early literacy experiences, and pre-school attendance. *Hispanic Journal of Behavioral Sciences*, *29*(4), 456-471. https://doi.org/10.1177/0739986307305910

Maloney, E. A., & Beilock, S. L. (2012). Math anxiety: Who has it, why it develops, and how to guard against it. *Trends in Cognitive Sciences*, *16*(8), 404-406. https://doi.org/10.1016/j.tics.2012.06.008

Markovits, Z. (2011). Beliefs hold by pre-school prospective teachers toward mathematics and its teaching. *Procedia-Social and Behavioral Sciences*, *11*, 117-121. https://doi.org/10.1016/j.sbspro.2011.01.045

Mazzocco, M. M., & Thompson, R. E. (2005). Kindergarten predictors of math learning disability. *Learning Disabilities Research & Practice*, *20*(3), 142-155. https://doi.org/10.1111/j.1540-5826.2005.00129.x

Ministry of Education (MEB) (2012). *Yenilik ve eğitim teknolojileri genel müdürlüğü, PISA 2012 [General directorate of innovation and educational technologies, PISA 2012]*. Retrived August 08, 2013, from http://yegitek.meb.gov.tr/pisa.html

Ministry of Education (MEB) (2017). *Öğretmen yetiştirme ve geliştirme genel müdürlüğü, Öğretmenlik mesleği genel yeterlilikleri 2017 [General directorate of teacher training and development, General competencies for teaching profession 2017]*. Retrived January 08, 2018, from https://bit.ly/2sIdCVV.

National Association for the Education of Young Children (NAEYC), (2002). Early childhood mathematics: Promotting good beginnings. *A joint position statement of the National Association for the Education of Young Children (NAEYC) and the National Coulcil for Teachers of Mathematics (NCTM). NAEYC.* Retrived April 04, 2014, from https://bit.ly/3iNLihv

National Council of Teachers of Mathematics (NCTM), (2000). *Principles and standards for school mathematic.* The National Council of Teachers of Mathematics, Inc. Retrived March 25, 2014, from https://bit.ly/3W2fMuP

Oktay, A., & Güven, Y. (1998). *Sosyo-kültürel faktörlerin matematik yeteneği ile ilişkisi üzerine bir araştırma [A research on the relationship between socio-cultural factors and mathematical ability]*. VII. Ulusal Eğitim Bilimleri Kongresi [VII. National Educational Sciences Congress]. Konya, Selçuk University.

Organization for Economic Cooperation and Development (OECD), (2004). *Learning for tomorrow's world: First results from PISA 2003 (Paris, OECD).*

PISA, (2019). *PISA 2018 Türkiye ön raporu [PISA 2018 Türkiye preliminary report]*. MEB Yeğitek. Retrived October 18, 2022, from https://bit.ly/3FAVAL3

Pekince, P., & Avcı, N. (2016). Pre-school teachers' applications related to early childhood mathematics: A qualitative look at activity plans. *Kastamonu Education Journal, 24*(5), 2391-2408. Retrived from https://dergipark.org.tr/tr/pub/kefdergi/issue/27735/317889

Saxe, G. B. (1988). Candy selling and math learning. *Educational Researcher, 17*(6), 14-21. https://doi.org/10.3102/0013189X017006014

Smith, S.S. (2006). *Early childhood mathematics* (3rd Ed.). Pearson.

Starkey, P., Klein, A., & Wakeley, A. (2004). Enhancing young children's mathematical knowledge through a pre-kindergarten mathematics intervention. *Early childhood research quarterly, 19*(1), 99-120. https://doi.org/10.1016/j.ecresq.2004.01.002

Stites, M. L., Gursoy, H., Cosgun, A. A., & Sonnenschein, S. (2022). Preschool classroom libraries in Turkey: Are they used to support early mathematics skills? *Education Sciences, 12*(6), 387, 1-12. https://doi.org/10.3390/educsci12060387

Tarım Gözübatık, K., & Artut Dinç, P. (2004). Teaching Addition and Subtraction Skills to Preschool Children with Cooperative Learning Method. *Eurasian Journal of Educational Research, 17*, 210-220. Retrived from https://search.trdizin.gov.tr/tr/yayin/detay/39931/okul-oncesi-cocuklarda-kubasik-calismalarda-toplama-ve-cikarma-becerilerinin-kazandirilmasi

Todd Brown, E. (2005). The influence of teachers' efficacy and beliefs regarding mathematics instruction in the early childhood classroom. *Journal of Early Childhood Teacher Education, 26*(3), 239-257. https://doi.org/10.1080/10901020500369811

Uyanık, Ö., & Kandır, A. (2010). Early academic skills in preschool period. *Journal of Theoretical Educational Science*, 3(2), 118-134. Retrived from https://dergipark.org.tr/en/pub/akukeg/issue/29341/313983

Wolfgang, C. H., Stannard, L. L., & Jones, I. (2001). Block play performance among preschoolers as a predictor of later school achievement in mathematics. *Journal of Research in Childhood Education, 15*(2), 173-180. https://doi.org/10.1080/02568540109594958

Youmans, A., Coombs, A., & Colgan, L. (2018). Early childhood educators' and teachers' early mathematics education knowledge, beliefs, and pedagogy. *Canadian Journal of Education/Revue Canadienne de l'éducation*, *41*(4), 1079-1104. Retrived from https://www.jstor.org/stable/26732972

Zacharos, K., Koliopoulos, D., Dokimaki, M., & Kassoumi, H. (2007). Views of prospective early childhood education teachers, towards mathematics and its instruction. *European Journal of Teacher Education*, *30*(3), 305-318. https://doi.org/10.1080/02619760701486134

Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi
Cilt 17, Sayı 1, Haziran 2023, sayfa 231-256. ISSN: 1307-6086
Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education
Vol. 17, Issue 1, June 2023, pp. 231-256. ISSN: 1307-6086

Research Article

A Descriptive Content Analysis of the Articles Published in Turkey on Numbers and the Operations Learning Area

Rüveyda KANDAL [1], Fatih BAŞ [2]

[1] Ministry of National Education, Ziya Gökalp Middle School, ruveydakandal@gmail.com, http://orcid.org/0000-0001-7469-2597

[2] Erzincan Binali Yıldırım University, Faculty of Education, fbas@erzincan.edu.tr, http://orcid.org/0000-0002-0035-4912

Received : 31.07.2022 Accepted : 04.03.2023

https://doi.org/10.17522/balikesirnef.1151223

Abstract – Numbers have found a wide place in many studies and curricula from the past to the present. Within the scope of the research, which was designed with the descriptive content analysis method, a total of 5021 volumes of the 124 journals in our country were reviewed, 301 articles were determined, and the data obtained were analyzed with the content. The results are as follows: It was determined that the number of articles first published in Turkey in 1986 on numbers and operations learning area began to increase from 2013. The reviewed articles were designed mostly with the case study method, and the secondary school level was mostly used as the sample in the articles. Besides, addition and subtraction with natural numbers were mainly studied at the primary school level, and at the secondary school level, respectively fractions, operations with natural numbers and fractions were studied in sub-learning areas.

Key words: Arithmetic operations, content analysis, Curriculum, Numbers.

Corresponding author: Rüveyda Kandal, Ministry of National Education, Ziya Gökalp Middle School, Erzincan, Türkiye.

Introduction

Today's developing and changing world brings forward individuals with the characteristics such as those who can produce knowledge and use it functionally, think critically, are entrepreneurs, problem solvers, etc. (Ministry of National Education [MoNE], 2018). Individuals with these characteristics keeping up with the dynamism in science and technology can be achieved by understanding and doing mathematics (National Council of

[*] This study was produced from the master's thesis prepared by the first author under the supervision of the second author.

Teachers of Mathematics (NTCM), 2000). And this case directs us to the educational perspective in which the mathematical thinking style that integrates with our values and competencies beyond mere achievements is discussed to achieve and understand mathematics and be successful (MoNE, 2018).

In a mathematics education, which is integrated with values and competencies, it is stressed that the numbers that constitute the fundamentals of mathematics should primarily be handled before teaching the abstract and upper-level concepts to the individuals to achieve success and gain high-level mathematical skills (Christou & Vosniadou, 2012; Vlassis, 2004). It is known that a similar situation is valid even for calculation skills (four operations) such as counting, addition, subtraction, multiplication and division (McCallum & Schmitt, 2011; Stein et al., 1997). For instance, it is observed that children cannot achieve upper-level calculation operations and fractions when the basic skills related to counting and numbers are not gained (National Mathematics Advisory Panel, 2008; Waltemire, 2018). This case directs us to the critical concept of numbers that should be learned at earlier ages (Sullivan et al., 2017).

When the literature related to the concept of numbers is reviewed, it is seen that the numbers have three different uses cardinal, ordinal and nominal numbers (Montague-Smith et al., 2018). For instance, the numbers are applied in determining the number of objects in groups such as five cars, ten apples, eight people … (cardinal number); defining the location of the objects as first, second and third (ordinal number) or describing something as just labelling or naming (nominal number) (Haylock & Manning, 2019). When the skill of counting that includes a one-to-one relationship between the counted object and numbers is considered (Blenkin & Kelly, 1996), it is seen that the amount of counting skill is gathered under six developmental headings as recognition-detection, audible-acoustic counting, asynchronous counting, simultaneous counting, consequential counting and abbreviation counting (Ruijssenaars et al., 2006). Pre-school students use their fingers to count within the scope of these six developmental stages (Van De Walle et al., 2012). Besides, they demonstrate that they have the first understanding related to the counting and number concepts by making comparisons between sets by using the concepts of more or less (Baroody & Wilkins, 1999; Fuson, 1988; Gelman & Meck, 1986; NRC, 2001). In addition, between the pre-school period and second grade, children are expected to acquire the concept of amount related to the concept of counting, understand the relationship between ordinal and cardinal numbers and represent numbers differently (Charlesworth & Lind, 2010; NCTM, 2000).

These significance and necessity, which numbers have provided the numbers and operations to be included in the curricula and studies from the past till now. In this scope, when the curricula applied by the MoNE were analyzed, the students between 36 and 72 months are expected to make addition and subtraction operations with the numbers from 1 to 10 in addition to counting from 1 to 20 rhythmically, arraying, matching the numbers and object groups, creating simple patterns, showing half and whole objects (MoNE, 2013). Similarly, When the mathematics course curricula applied by MoNE between 2005 and 2018 were analyzed, it was noticed that the primary school curricula consisted of learning areas such as Numbers (and Operations), Geometry, Measurement and Data Processing, the secondary school curricula consisted of Numbers (and Operations), Geometry (and Measurement), Measurement (Data Process), probability (and Statistics) and Algebra and the most gains and course time was given to the Numbers and Operations learning areas among these learning areas (İlhan & Aslaner, 2019; MoNE, 2005, 2009, 2013, 2015, 2018). In the numbers and operations learning area, the students are expected to develop their number concepts, learn the relationship between numbers and develop their basic arithmetic skills in primary school to form the basis for different sub-learning areas and achievements at the secondary school level (MoNE, 2018). Accordingly, the secondary school consists of various sub-learning areas such as numbers and operations learning area sets of numbers and numbers, relationships between numbers and operations, ratios and fractions, and multipliers and multiples (MoNE, 2018). Within the scope of all these sub-learning areas, it was observed that several studies were conducted on various topics such as natural numbers and operations with natural numbers (Albayrak et al., 2019; Ercive & Narlı, 2019; Paydar & Doğan, 2021; Tuluk & Akyüz, 2019), fractions and operations with fractions (Altıparmak & Palabıyık, 2019; Topçu & Gürefe 2020; Özer et al., 2020), decimal notations (Işık et al., 2012; Karataş et al., 2021), rates (Erdem et al., 2018; Yapıcı & Altay, 2017), multipliers and multiples (Karakuş & Yeşilpınar, 2018), sets (Biber & Tuna, 2016; Yücesan, 2011), integers and operations with integers (Berkant & Yaren, 2020; Bozkurt & Polat, 2011; Erdem et al., 2015; Kiraz & Cemalettin, 2020; Şengül & Zengin, 2015), rational numbers and operations with rational numbers (Altun & Çelik, 2018; Gürbüz & Birgin, 2008; Macit & Nacar, 2019; Yenilmez & Yıldız, 2018), ratio and proportion (Deveci, 2021; Güler & Didiş Kabar, 2017; Şengül & Erdoğan, 2017), exponential expressions (Eymen & Duatepe Paksu, 2015; Eymen İkizoğlu & Duatepe Paksu, 2016; Güzel & Yılmaz, 2020) and rooted expressions (Aksu et al., 2013; Aydoğdu, 2020; Toluk Uçar, 2015). In these studies, it was found that the students had

deficiencies in reading and writing the numbers, grouping numbers and writing the groups according to their digits after grouping the numbers or they over and under-used the 0 concepts (Albayrak et al., 2019), tended to do different types of errors such as not being able to establish the part-whole relationship in problem posing for operations with fractions, attribute natural number meaning to fraction dimensions, have an inability to attribute meaning to integer parts of integer fractions, lack of expression in the problem, and lack of data (Işık, 2011; Işık & Kar, 2012; Özer et al., 2020), their images of a rational number and fraction concept were not clear enough (Berkant & Yaren, 2020), pre-service teachers had problems or were insufficient in deciding the size of the given rooted numbers (Aksu et al., 2013).In addition to considering several studies conducted within the scope of any topic as a source of wealth for literature, it has been claimed that this situation made it difficult to follow the literature (Ertane Baş, 2019; Özturan Sağırlı & Baş, 2020). Handling the general tendencies related to a topic in certain periods is crucial in terms of shedding light on new studies and realizing the trends of the studies (Cohen et al., 2007; Erdem, 2011). From this point, the investigation of the researchers' knowledge related to the trends and current situation of the studies related to their fields with content analysis is thought to contribute to the literature (Falkingham & Reeves, 1998). Accordingly, it is noticed that there are studies in which the general trends related to mathematics education in the literature (Arı & Demir, 2020; Kutluca et al., 2018; Ulutaş & Ubuz, 2008; Yaşar & Papatğa, 2015; Yıldız Altan et al., 2021). In addition, it has been realized that there are researches in which the tendencies related to a certain topic such as metacognition (Baş & Özturan Sağırlı, 2017; Kandal & Baş, 2022), technology-supported education (Bayram, 2019; Tatar et al., 2013; Kutluca et al., 2016), mathematical model and modelling (Albayrak & Çiltaş, 2017; Birgin & Öztürk, 2021; Yenilmez & Yıldız, 2019), mathematics anxiety (Toptaş & Gazel, 2018), realistic mathematics education (Tabak, 2019), problem-solving (Coşkun & Soylu, 2021) and problem-themed (Özturan Sağırlı & Baş, 2020).

In light of these studies, no studies have been encountered in which numbers and operations learning areas in mathematics education are analyzed and evaluated. Considering all this information, it has been aimed to present the trends of articles by investigating the articles conducted related to numbers and operations learning area and contribute to mathematics education by creating a background to new research with this study in Turkey. For this purpose, these research questions were asked.

1. How is the distribution of the articles conducted with the participants at pre-school, primary school and secondary school level in Turkey on the numbers and operations learning area in mathematics education and published in Turkey according to their publication years?

2. How is the distribution of the articles conducted at pre-school, primary school and secondary school levels in Turkey on the numbers and operations learning area in mathematics education and published in Turkey according to their methods?

3. How is the distribution of the articles conducted at pre-school, primary school and secondary school levels in Turkey on the numbers and operations learning area in mathematics education and published in Turkey according to their samples?

4. How is the distribution of the articles conducted with pre-school, primary school and secondary school levels in Turkey on the numbers and operations learning area in mathematics education and published in Turkey according to their data collection tools?

5. How is the distribution of the articles conducted at pre-school, primary school and secondary school levels in Turkey on the numbers and operations learning area in mathematics education and published in Turkey according to their data analysis methods?

6. How is the distribution of the articles conducted at pre-school, primary school and secondary school levels in Turkey on the numbers and operations learning area in mathematics education and published in Turkey according to their publication languages?

7. How is the distribution of the articles conducted at pre-school, primary school and secondary school levels in Turkey on the numbers and operations learning area in mathematics education and published in Turkey according to their sub-learning areas?

Method

Research Design

This research aimed to review the structures and trends of the articles conducted on mathematics education and published within the scope of the topic of numbers and operations sub-learning in Turkey. Accordingly, the research was designed with a descriptive content analysis method which is one of the content analysis methods in which a general trend is determined by reviewing and arranging the quantitative and qualitative research which are put forth differently (Cohen et al., 2007; Çalık & Sözbilir, 2014; Selçuk et al., 2014).

Data collection

In the first stage of the data collection process, 124 journals of faculty of education, institutes of social sciences journals and journals of private institutions and organizations in Tukey were determined. Only the volumes of the journals presented to the readers only online were handled; a total of 1617 volumes and 5021 issues, by taking all of the issues of 2020 into consideration, were included in the process and analyzed. In the second stage of the data collection process, each issue of the journals reached was analyzed individually. The articles were reviewed within the scope of the learning areas and gains in the curriculum with the keywords as numbers, natural numbers, integers, four operations and/or skills, arithmetic, arithmetic operations, ratio proportion, sets, factors and multiples, proportional reasoning, fractions, operations with fractions, rational numbers, operations with rational numbers, exponential expressions and square root expressions. In addition, the articles, including words such as verbal problems, problem-solving and problem-posing, were also reviewed considering the acquisitions within the scope of numbers and operations learning area. In this stage, articles whose samples were foreigners were excluded from the research. In the third stage of the data collection process, the articles were aimed to be classified considering the numbers and operations and sub-learning areas within the scope of the 2013 pre-school curriculum and primary and secondary school 2018 Mathematics Course Curriculum. For this purpose, it was noticed that the articles consisted of even the high school curriculum among the recorded articles. Since secondary school and high school gains are different learning contexts and the numbers and algebra in the high school curriculum take place together in the same learning area, the articles that took place in the high school curriculum were excluded from the research. At the end of this stage, a total of 301 articles were recorded and prepared to be ready for data analysis.

Analysis of the Data

A descriptive analysis method was employed in the analysis of the data. The data obtained in the descriptive analysis are summarized and interpreted according to the theme determined earlier, and obtained results are presented to the reader (Yıldırım & Şimşek, 2018, p. 239, 242). The researcher carried out the analysis process in line with the codes and categories draft prepared by Baş and Özturan Sağırlı (2017) and listed in Figure 1.

The Codes and Categories

- **Study Group**
  - Pre-school
  - Primary School; 1, 2, 3, 4, not specified
  - Secondary School; 5, 6, 7, 8, not specified
  - Pre-service Teacher
  - Teacher
  - Supervisor
- **Method**
  - **Quantitative Approach**
    - Descriptive
    - Experimental
    - Correlational
    - Scale Development
    - Design/activity development
  - **Qualitative Approach**
    - Case study
    - Phenomenology
    - Action research
    - Teaching experiment
    - Review
    - Phenomographic research
  - **Mixed Approach**
- **Data Collection Tools**
  - Achievement test
  - Questionnaire/open-ended questionnaire/scale/test
  - Problem-posing test
  - Problem-solving inventory/test
  - Activity development form
  - Interview
  - Observation
  - Document review
  - Video
  - Other(game/reward/Graphic/instruction/notebook)
  - Mat Diaries
  - Table of specifications
  - Scale of rating
  - Tape recorder
  - Study paper/activity
  - Scale classification form
  - Evaluation inventory
- **Analysis of the Data**
  - **Analysis of the Qualitative Data**
    - Content analysis
    - Descriptive analysis
    - Constant comparative analysis
    - Discriminant analysis
    - Discourse analysis
    - Document analysis
    - Visual analysis
    - Phenomenological analysis
  - **Analysis of the Quantitative Data**
    - Descriptive statistics
    - Independent samples t-test
    - Paired samples t-test
    - Single sample t-test
    - One way ANOVA
    - Two way ANOVA
    - One way MANOVA
    - Kruskal Wallis H test
    - Mann Whitney U
    - ANCOVA
    - Factor analysis
    - Wilcoxon signed-row test
    - Path analysis
    - Implied growth model
    - Item analysis
    - Covariance analysis
    - Chi-square
    - Cochran Q test
    - McNemar test
    - Graphical analysis
- **Sub-learning Area**
  - **Primary School**
    - Natural Numbers
    - Addition with Natural Numbers
    - Subtraction with Natural Numbers
    - Multiplication with Natural Numbers
    - Division with Natural Numbers
    - Fractions
    - Operations with Fractions
  - **Secondary School**
    - Natural Numbers
    - Operations with Natural numbers
    - Fractions
    - Operations with fractions
    - Decimal notations
    - Rates
    - Multipliers and Multiples
    - Sets
    - Integers
    - operations with integers
    - Rational numbers
    - Operations with rational numbers
    - Ratio
    - Ratio and Proportions
    - Exponential Expressions
    - Rooted Expressions
- **Publication Language**
  - Turkish
  - English
  - Turkish-English

Figure 1 The list of codes and categories used in data analysis

The list in Figure 1 consists of 6 categories comprising 88 codes as the sample, method, data collection tools, data analysis methods, sub-learning area and language. The coding process within the scope of categories was realized as follows:

Method; The analysis of this category was realized with the method names expressed by the researchers in the method sections of the articles. In the cases when the methods of the articles were not stated, the methods of the articles were specified by considering the topic, study group, data collection tool and data analysis method in line with the expert opinions.

Sample; In the analysis of this category, it was tried to determine the level among all the levels of pre-school, primary school and secondary school and pre-service teachers. While coding was performed in the primary and secondary samples, the class level was determined based on the 4+4+4 system. In addition, frequencies were recorded for each class level in the sample of each article reviewed during coding. If the class level was not stated, although the article was carried out with secondary school students, it was coded in the section of secondary school not specified. For instance, in the S275 coded article, which consisted of the special education students, since the class levels of the students were not specified despite claiming that they were at the ages of 11, 12 and 14, it was coded in the secondary school, not specified section.

Data Collection Tools; In the analysis of this category, the tools, which were applied to collect only the data related to numbers and operations learning areas among the articles, were subjected to the analysis. For instance, while coding was done to the data collection tool which was used to determine the number senses of students in the S267 coded article, in which the effects of number sense-based teaching on the students' self-efficacy and performance in mathematics were investigated, the coding was done to the data collection tool applied to determine the students' self-efficacy perceptions to mathematics.

Data Analysis Method; In the analysis of this data, in coding, only the analyses related to the measurements related to the numbers and operations learning area were considered in the relevant articles.

Language; In the analysis of this category, the articles were included in the analysis process according to their language by coding as English, Turkish or both English and Turkish.

Sub-learning Area; In the analysis of this category, the data related to which sub-learning area between the primary and secondary school numbers and operations learning area were analyzed. In addition, if the reviewed article consisted of more than one sub-learning area, one frequency was coded for each sub-learning area. In addition, the unit contents that took place in the curriculum of 1997 and earlier were coded within the basis of the sub-learning areas within the scope of the current mathematics curriculum.

Validity and reliability

During the process of collecting, examining and analyzing the process of the data related to each sub-problem that took place in the study, cooperation was carried out with an academician who was an expert in the field of qualitative methods, and arrangements were made within the scope of the processes in line with the feedback and suggestions from him. For instance, in the S90 coded research, whose method was not stated, the proportional reasoning skills and the solution strategies of the pre-service secondary school mathematics teachers brought to the problems involving ratio-proportion were subjected to content analysis after the data were collected with the help of semi-structured interviews prepared by the researcher. A consensus was reached by taking the topic, problem, data collection tools and data analysis of this study, and the research was analyzed in the qualitative category with the case study code.

In the analyses, the coding and analysis process was carried out twice, eight weeks apart, by the researcher for the reliability of the coding process. The consistency of the results and coding was calculated as 93%. The parts, coded separately, were specified by taking the expert opinion, and the findings were prepared to be reported.

Findings and Discussions

Findings related to the sub-problems in the study are presented in the order in this section.

Findings related to the publication years of the articles published in Turkey on the numbers and operations learning area-themed articles in Turkey

Findings related to the distribution of the reviewed articles by year are presented in Figure 2.

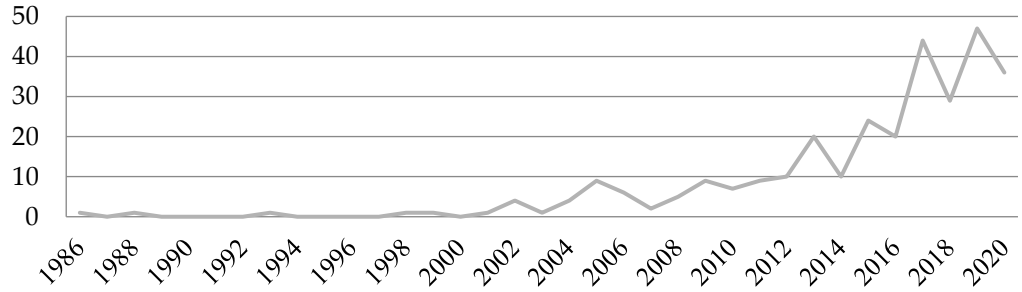


Figure 2 Distribution of the reviewed articles by years

As it was presented in Figure 2, it is seen that the articles on the topic of numbers and operations themed were first published in 1986. In the reviewed articles, it was observed that there had been no regular publications until 2004; however, an increase in the number of articles occurred until recent years. The highest numbers of articles which have been reviewed belonged to 2019 and 2017 in order.

Findings related to the methods of the articles published in Turkey on the numbers and operations learning area-themed articles in Turkey

The findings of the reviewed articles related to their methods are presented in Figure 3.

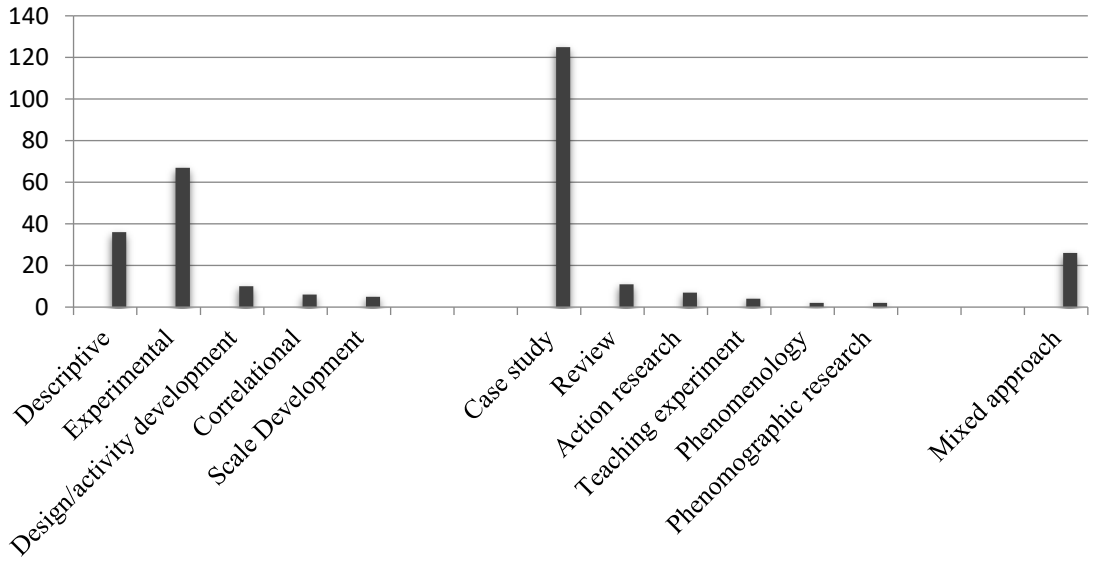


Figure 3 Distribution of the reviewed articles related to their methods

As presented in Figure 3, the numbers and operations learning area-themed articles which have been reviewed were designed with the case study method (125; 42%), experimental (67; 22%) and experimental (36; 12%) methods. In order these methods were

followed by the mixed method (26; 9%) and review (11:4%). The least preferred methods in the articles were phenomenology (2; 0.7%) and phenomographic research (2; 0.7%).

Findings related to the samples of the articles published in Turkey on the numbers and operations learning area-themed articles in Turkey

The findings of the reviewed articles related to their samples are presented in Figure 4.

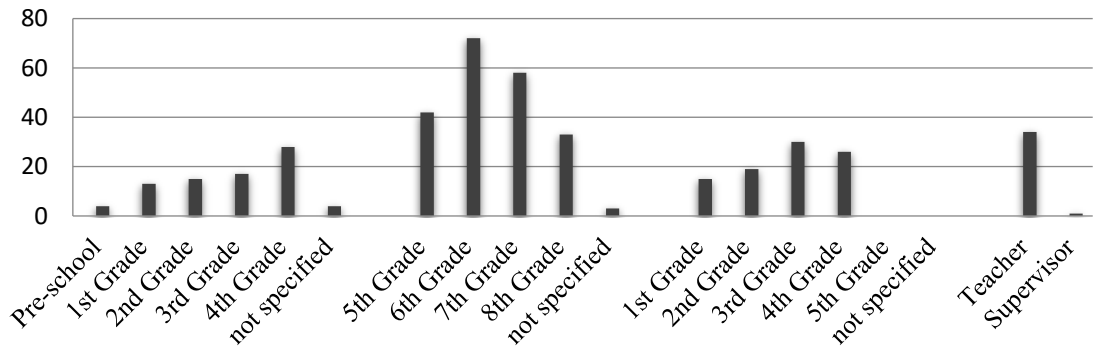


Figure 4 Distribution of the reviewed articles related to their samples

As presented in Figure 4, the secondary school level was the most preferred sample group applied as samples in the numbers and operations learning area-themed articles (208). This sample was orderly, followed by the primary school level (91), the pre-service teachers (90) and the teachers (34). In addition, when the class level which was a study on most was taken into consideration, it was noticed that there were (29) at the 4th class level of the scope of primary school, (72; 58) at the 6th and 7th class levels of the secondary school level and (30) at the 3rd class level of the university. The students in the pre-school level (10) and supervisors (1) were the samples included in the articles least. In addition, no studies were encountered related to the postgraduate level, manager, parents and academicians.

Findings related to the data collection tools of the articles published in Turkey on the numbers and operations learning area-themed articles in Turkey

The findings of the reviewed articles related to their data collection tools are presented in Figure 5.

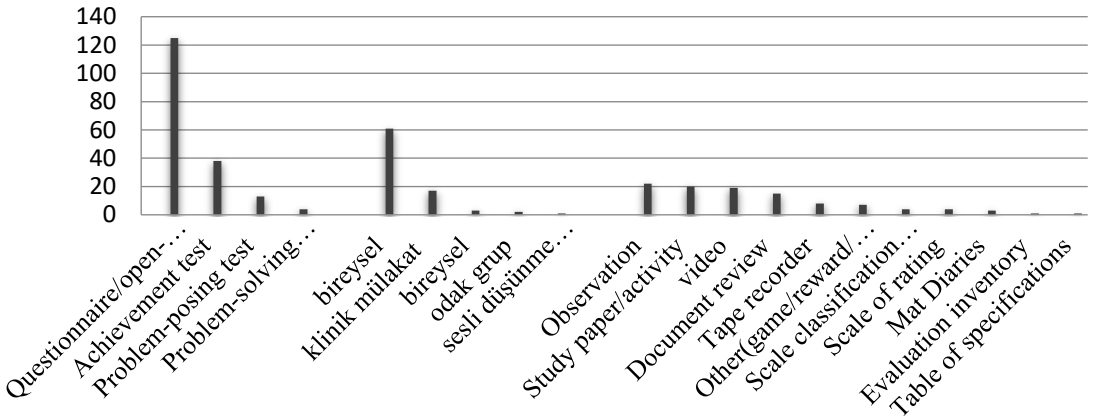


Figure 5 Distribution of the reviewed articles related to their data collection tools

As presented in Figure 5, the most preferred data collection tool in the numbers and operations learning area-themed articles were questionnaires/open-ended questionnaires/scales/tests (125). This was followed by individual interviews (61) and achievement tests (38). The least applied data collection tools in the articles were evaluation inventory (1), table of specifications (1) and activity development form (1).

Findings related to the data analysis methods of the articles published in Turkey on the numbers and operations learning area-themed articles in Turkey

The findings of the reviewed articles related to their data analysis methods are presented in Figure 6.

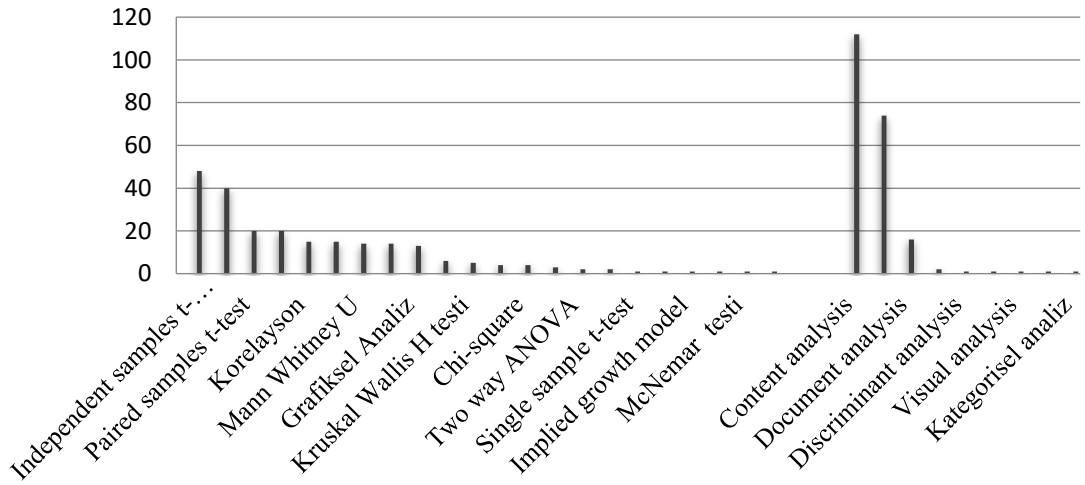


Figure 6 Distribution of the reviewed articles related to their data analysis methods

As presented in Figure 6, the content analysis (112) and descriptive analysis (74) were the methods which were mostly applied in the analysis of the qualitative data in the numbers

and operations learning area-themed articles. In the qualitative data analysis, it can be claimed that the predictive methods were mainly used, and the correlational and hypothesis tests were applied most in these methods. In the analysis of the quantitative data, the independent samples t-test (48) and the descriptive statistics (40), paired-samples t-test (20), and one-way variance analysis (ANOVA) (20) were preferred most in order. Besides, it was determined that the non-parametric tests were also applied in the data analysis.

Findings related to the publication languages of the articles published in Turkey on the numbers and operations learning area-themed articles in Turkey

The findings of the reviewed articles related to their publication languages are presented in Figure 7.

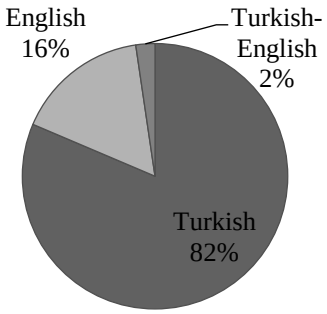


Figure 7 Distribution of the reviewed articles related to their publication language

As presented in Figure 7, approximately 81% (245) of the reviewed articles were published in Turkish, 17% (49) in English and 2% (7) both in Turkish and English.

Findings related to the sub-learning areas of the articles published in Turkey on the numbers and operations learning area-themed articles in Turkey

The findings of the reviewed articles related to their sub-learning areas are presented in Figure 8.

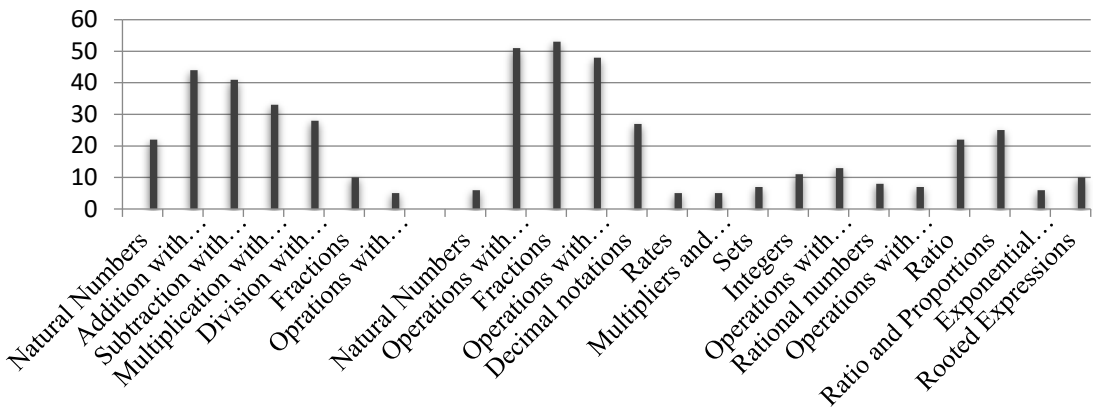


Figure 8 Distribution of the reviewed articles related to their sub-learning areas

As presented in Figure 8, the sub-learning areas of the numbers and operations learning area-themed articles at the secondary school level were fractions (53), operations with natural numbers (51) and operations with fractions (48). The most applied sub-learning areas in the articles at the primary school level were addition operations with natural numbers (44) and subtraction with natural numbers (41). In addition, the least applied learning areas at the secondary school level were exponential expressions (6), rates (5), multipliers and multiples (5); at the primary school level were fractions (10) and operations with fractions (5). In addition, it was determined in the reviewed articles that the researchers had conducted for each sub-learning area.

Conclusion, Discussion and Suggestions

The results related to the publication years, methods, samples, data collection tools, data analysis methods, publication languages and bub-learning areas of the articles published in the journals of Turkey and conducted in Turkey on the numbers and operations learning area-themed articles can be summarized as follows.

It was determined that the articles on numbers and operations learning area-themed articles had been published in 1986 first. It was also observed that they were hardly any research from 1986 till 2004, and the number of published articles from this date has continued to increase until recently. It was noticed that the most published articles in number were in 2019 and 2017. It is thought that the various revisions carried out in the learning area and subject content in the curriculum, especially between 2005 and 2018, have affected the increase in the number of the numbers and operations themed articles in recent years. Accordingly, when the mathematics curricula between 2005-2018 are examined, adding or

omitting the periods or contents of gains of the subjects such as fractions, ratios, proportion, natural numbers, and square root expressions in the scope of learning numbers and operations at some grade levels increases the number of articles covered in this context can be seen as a reason for this increase (MoNE, 2005; 2009; 2013; 2018).

When the articles were analyzed according to their methods, it was determined that the researchers preferred to research with the qualitative approach and case study in their articles most; this was followed by the articles designed with the quantitative and mixed approaches. This may indicate that the researchers wished to explore the topics related to numbers and operations in depth. It was seen in different studies examining various trends in mathematics education that the case study pattern was preferred more than other patterns in qualitative studies (Albayrak & Çiltaş, 2017; Kutluca et al., 2018; Özturan Sağırlı & Baş 2020; Yıldız & Yenilmez, 2019). Besides, it was observed that the experimental and descriptive methods came forward in the qualitative studies. On the other hand, in experimental studies, the number of articles in which the achievement and skill concepts related to the topics, particularly fractions/ operations with fractions and natural numbers/ operations with natural numbers, can be regarded as a result of this case. In addition, the scale development, design and activity development patterns were preferred less in the articles in which the quantitative design was employed can be seen as a deficiency. Similarly, it was determined that the action research, teaching experiment, phenomenology and phenomenological research patterns were preferred relatively less, even in the articles in which the qualitative design was employed.

When the articles were examined according to their sample groups, the most studied group was the secondary school level. This was followed by the articles carried out with primary school level, pre-service teachers and teachers. It was noticed that the secondary school level was studied more in the studies in the various trends examined in mathematics education (Arı & Demir, 2020; Birgin & Öztürk, 2021; Kandal & Baş, 2022; Özturan Sağırlı & Baş, 2020; Toptaş & Gözel, 2018; Yıldız & Yenilmez, 2019). Besides, as the class levels studied most in the articles were analyzed, it was determined that 4th class levels in primary school, 6th and 7th class levels in secondary school, and 3rd class levels in undergraduate level were studied most. That the 4th class level was the level which was studied more within the scope of primary school is thought to be originated from the fact that students' literacy and basic processing skills are provided up to this class level and that comprehensive topic such as fractions and problems are handled at this class level. In addition, the students at the last class levels at the secondary school and undergraduate levels study for the exams, which

can be a reason the students in this group were less preferred by the researchers. In addition, it was noticed that very few studies were carried out with pre-school students. This result of the research demonstrates similarity with the study conducted by Özturan Sağırlı and Baş (2020). In addition, it was seen that there was no study carried out with the postgraduate level, academicians and parents.

When the articles were analyzed with their data collection tools, it was determined that the most preferred data collection tools were questionnaires/ open-ended questionnaires/ tests/ scales and interviews. Achievement tests followed this. That the misconceptions of the participants were dealt with more in the topics such as fractions/ operations with fractions, natural numbers/ problem-posing related to operations with natural numbers (Arıkan & Ünal, 2013; Biber et al., 2013; Işık, 2011; Işık & Kar, 2012; Kılıç, 2013; Soylu & Soylu, 2005) can be presented as a result of this situation. In addition, this situation can be evaluated as a result of the articles being designed with case patterns in qualitative research and experimental and descriptive designs in quantitative research.

The articles' most preferred data analysis methods in qualitative data analysis are the content analysis method and the descriptive analysis method. A similar result was presented in various research (Özturan Sağırlı & Baş, 2020; Yıldız & Yenilmez, 2019). Accordingly, it can be claimed that the case study pattern used more in the qualitative studies was influential. The quantitative data analysis preferred the independent samples t-test, descriptive statistics, paired-samples t-test, and one-way variance analysis. This situation can indicate that comparative analyses were made several times in the quantitative research. It is thought that the researchers prefer these analysis methods because the investigated features are relatively interpreted easier, and the transfer of the relationship between the variables to the reader can be realized by fictionalizing more easily (Selçuk et al., 2014).

When the articles were reviewed in terms of their publication languages, it was realized that most of the reviewed articles were published in Turkish (81%). This was orderly followed by the articles published in English with approximately 17% and both in Turkish and in English with approximately 2%. It can be claimed that selecting only the articles conducted in Turkey and published in educational journals in Turkey in the study sample is effective in the high number of articles published in Turkish. A similar situation was observed to be expressed in the content analysis studies in which the general trend in mathematics education was investigated (Baş & Özturan Sağırlı, 2017; Ulutaş & Ubuz, 2008; Özturan Sağırlı & Baş, 2020).

When the articles were analyzed according to their sub-learning areas, it was noticed that while mostly the addition and subtraction with natural numbers of operations were studied at the primary school level, the sub-learning areas orderly as fractions, operations with natural numbers and operations with fractions were studied at the secondary school level. That the addition and subtraction operations were performed from the 1st class at the primary school level; examining the relationship between these operations, determining their essential characteristics, developing the problem-posing, and solving skills related to these operations are among the targets that should be carried out in the curriculum (MoNE, 2018). This situation, without doubt, is seen as a reason the addition and subtraction of natural numbers are more emphasized in the articles at the primary school level. That the inclusion of numbers and operations as a prerequisite in teaching abstract and advanced mathematical concepts (Christou & Vosniadou, 2012; Vlassis, 2004), that fractions are one of the most difficult concepts encountered by primary school children (Charalambous & Pinta-Pantazi, 2005; Hansen, 2014) and that it forms the basic building block of many topics such as decimals, percentages, and rational numbers within the scope of secondary school (NTCM, 2000) can be seen among the reasons why researchers have focused on these issues.

Some recommendations below are thought to contribute to the literature from this research results.

- ✓ It was noticed that there was no study with the postgraduate, academicians and parents among the reviewed studies on numbers and operations. From this point, these sample groups can be included in future research.
- ✓ In the reviewed research, it was seen that the researchers focused on certain research patterns, such as mostly experimental, descriptive or case studies. From this point, the number of studies related to phenomenology, design, and scale development patterns can be increased or considering the research results, a meta-analysis study can be conducted.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, author-ship, and/or publication of this article.

CRediT author statement

The study was conducted and reported with equal collaboration of the researchers.

Research involving Human Participants and/or Animals

Ethics Committee Approval for this research was obtained from the Human Research Committee on Ethics at Erzincan Binali Yıldırım University (Reference number: E-85748827-050.06.04-57538; Date: 28/01/2021).

Türkiye'de Yayımlanan Sayılar ve İşlemler Öğrenme Alanı Temalı Makalelere İlişkin Betimsel İçerik Analizi

Özet: Sayılar, geçmişten günümüze birçok çalışmada ve müfredatta geniş yer bulmuştur. Betimsel içerik analizi yöntemiyle tasarlanan araştırma kapsamında ülkemizde yer alan 124 dergiye ait toplam 5021 sayı incelenerek 301 makale belirlenmiş ve ulaşılan veriler betimsel analiz yöntemiyle analiz edilmiştir. Analiz sonucunda elde edilen sonuçlar şu şekildedir: Türkiye'de sayılar ve işlemler öğrenme alanında ilk olarak 1986 yılında yayınlanan makale sayılarının 2013 yılından itibaren genel olarak artış göstermeye başladığı belirlenmiştir. İncelenen makaleler daha çok durum çalışması deseniyle tasarlanmış ve makalelerde en fazla ortaokul örneklemi üzerinde çalışılmıştır. Ayrıca ilkokul düzeyinde; en fazla doğal sayılarla toplama ve çıkarma işlemi, ortaokul düzeyinde ise sırasıyla kesirler, doğal sayılarla ve kesirlerle işlemler alt öğrenme alanları üzerinde çalışılmıştır.

Anahtar kelimeler: Aritmetik işlemler, İçerik analizi, Öğretim programı, Sayılar

References

Aksu, Z., Gedik, S. D., & Konyalıoğlu, A. C. (2013). Not to decide the magnitude of root numbers and not to show these numbers on number line. *Journal of Research in Education and Teaching (JRET), 2*(2), 169-175. http://www.jret.org/FileUpload/ks281142/File/19._zeki_aksu_solmaz_damla_gedik_alper_cihan_konyalioglu.pdf

Albayrak, E., & Çiltaş, A. (2017). Descriptive content analysis of mathematical modeling research published in the field of mathematics education in Turkey. *International Journal of Turkish Education Science* , 2017(9), 258-283. https://dergipark.org.tr/en/pub/goputeb/issue/34356/380612

Albayrak, M., Yazıcı, N., & Şimşek, M. (2019). Difficulties of students in reading and writing big natural numbers. *YYU Journal of Education Faculty, 16*(1), 1419-1441. http://dx.doi.org/10.23891/efdyyu.2019.166

Altıparmak, K., & Palabıyık, E. (2019). Analyzing learning objectives to content domain of fractions, operations with fractions and decimal notation in grades 1-8 by the revised bloom's taxonomy. *Elementary Education Online, 18*(1), 158-173. http://doi.org/10.17051/ilkonline.2019.527183

Altun, H., & Çelik, A. (2018). Interests and thoughts of students related to fractions and rational numbers. *International Journal of New Trends in Arts, Sports & Science Education, 7*(1), 1-14. http://www.ijtase.net/index.php/ijtase/article/view/141

Arı, A. A., & Demir, B.(2020). Analysis of thesis in Turkey between the years 2008-2020 on mathematics literacy. *Sakarya University Journal of Education, 10*(3), 667-685. https://doi.org/10.19126/suje.796422

Arıkan, E. E., & Ünal, H. (2013). The analysis of mathematical problem posing skill of elementary second grade students. *Amasya Education Journal, 2*(2), 305-325. https://dergipark.org.tr/en/pub/amauefd/issue/1729/21192

Aydoğdu, M. (2020). Determining the misconceptions of eighth grade students about exponents and rooted numbers. *International Journal of Education Science and Technology*, *6*(3), 240-257. https://doi.org/10.47714/uebt.799116

Baroody, A. J., & Wilkins, J. L. M. (1999). The development of informal counting, number and arithmetic skills and concept. In J. V. Copley (Ed.), *Mathematics in the early years* (48-65). NTCM.

Baş, F., & Özturan Sağırlı, M. (2017). A content analysis of the articles on metacognition in education in Turkey. *Education and Science*, *42*(192), 1-33.https://doi.org/10.15390/EB.2017.7115

Berkant, H. G., & Yaren, R. (2020). The effect of realistic mathematics education on secondary school sixth grade students' motivations in mathematics. *Journal of Social Sciences of Kahramanmaraş Sütçü İmam University*, *17*(2), 543-571. https://doi.org/10.33437/ksusbd.555770

Biber, A. Ç., & Tuna, A. (2016). Altıncı sınıf öğrencilerinin kümeler konusunda kurdukları problemlerin incelenmesi. *Erzincan Eğitim Fakültesi Dergisi*, *18*(1), 270-298. https://doi.org/10.17556/jef.22237

Biber, A. Ç., Tuna, A., & Aktaş, O. (2013). Students' misconceptions of fractions and its effect on solving fractions problems. *Trakya University Journal of Education, 3*(2), 152-162. https://dergipark.org.tr/en/pub/trkefd/issue/21474/230175

Birgin, O., & Öztürk, F. N. (2021). Research trends on mathematical modelling in mathematics education in Turkey (2010-2020): a thematic content analysis. *E-*

International Journal of Educational Research, *12*(5), 118-140. https://doi.org/10.19160/e-ijer.937654

Blenkin, G. M., & Kelly, A. V. (Eds.) (1996). *Early childhood education: a developmental curriculum* (2nd ed.). Sage Publications.

Bozkurt, A., & Polat, M. (2011). Teachers' views on the effect of modeling with counters on learning integers. *Gaziantep University Journal of Social Sciences*, *10*(2), 787-80. https://dergipark.org.tr/en/pub/jss/issue/24242/256999

Charalambous C. Y., & Pinta-Pantazi, D. (2005). Revisiting a theoretical model on fractions: implications for teaching and research. In Chick, H.L. & Vincent, J. L. (Eds.), *Proceedings of the 29th Conference of the International Group for the Psychology of Mathematics Education*, (pp. 233-240).

Charlesworth, R., & Lind, D. (2010). *Science and math for young children.* (6th ed.). Wadsworth/Cengage Learning.

Christou, K. P., & Vosniadou, S. (2012). What kinds of numbers do students assign to literal symbols? Aspects of the transition from arithmetic to algebra. *Mathematical Thinking and Learning*, *14*(1), 1-27. https://doi.org/10.1080/10986065.2012.625074

Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education* (6th ed.). Routledge.

Coşkun, A., & Soylu, Y. (2021). A content analysis of research for the problem-solving in mathematics education in turkey. *International Journal of Educational Studies in Mathematics* , *8* (3), 230-251. https://doi.org/0.17278/ijesim.984843

Çalık, M., & Sözbilir, M. (2014). Parameters of content analysis. *Education and Science***,** *39*(174), 33-38. http://dx.doi.org/10.15390/EB.2014.3412

Deveci, A. (2021). *Sorgulayıcı öğrenme ve problem çözme yoluyla oran orantı konusundaki kavram yanılgılarının giderilmesi* [Elimination of misconceptions about ratio and proportion using inquiry driven learning and problem solving] [Unpublished doctoral dissertation]. Necmettin Erbakan University.

Ercire, Y. E., & Narlı, S. (2019). How do prospective mathematics teachers define natural numbers? *Amasya Education Journal*, *8*(2), 240-271. https://dergipark.org.tr/en/pub/amauefd/issue/50660/588662

Erdem, D. (2011). Türkiye'de 2005-2006 yılları arasında yayımlanan eğitim bilimleri dergilerindeki makalelerin bazı özellikler açısından incelenmesi: Betimsel bir analiz [Examination of articles in educational sciences journals published in Turkey between 2005 and 2006 in terms of some characteristics: A descriptive analysis]. *Journal of Measurement and Evaluation in Education and Psychology*, *2*(1), 140-147. https://dergipark.org.tr/tr/pub/epod/issue/5806/77236

Erdem, E., Başıbüyük, K., Gökkurt, B., Şahin, Ö., & Soylu, Y. (2015). Difficulties in teaching whole numbers and suggested solutions. *Erzincan University Journal of Education Faculty, 17*(1), 97-117. https://doi.org/10.17556/jef.53497

Erdem, E., Özçelik, A., & Gürbüz, R. (2018). Difficultiıes encountered by 7th graders in the subject 'percent' and suggestions. *İnönü University Journal of the Faculty of Education, 19(*3), 638-653. https://doi.org/10.17679/inuefd.345749

Eymen, E., & Duatepe-Paksu, A. (2015). Analysis of 8th grade students' number sense related to the exponents in terms of number sense components . *Education and Science, 40*(177), 109-125. http://dx.doi.org/10.15390/EB.2015.2710

Eymen İkizoğlu, E., & Duatepe Paksu, A. (2016). Development of number sense scale related to exponentials. *Journal of Buca Faculty of Education, 41*, 42-65. https://dergipark.org.tr/en/pub/deubefd/issue/35753/399448

Falkingham, L., & Reeves, R. (1998). Context analysis—A technique for analyzing research in a field, applied to literature on the Management of R&D at the section level. *Scientometrics*, *42*(2), 97-120. https://doi.org/10.1007/BF02458351

Fuson, K. C. (1988). *Children's counting and concepts of number.* (1st ed.). Springer-Verlag.

Gelman, R., & Meck, E. (1986). The notion of principle: The case of counting. In J. Hiebert (Ed.), Conceptual and procedural knowledge: The case of mathematics (29-57). *Erlbaum*

Güler, H. K., & Didiş Kabar, G. (2017). Investigation of middle-grade students' problem solving processes and problem solving strategies for solving daily life problems . *Journal of Research in Education and Teaching (JRET), 6*(4), 147-154. http://www.jret.org/FileUpload/ks281142/File/17b.hatice_kubra_guler.pdf

Gürbüz, R., & Birgin, O. (2008). The comparison of students' performance at different grades regarding to making operation with different types of representation of the rational

numbers. *Pamukkale University Journal of Education, 23*(23), 85-94. https://dergipark.org.tr/en/pub/pauefd/issue/11120/132992

Güzel, S., & Yılmaz, S. (2020). 8th grade students' mathematical language usage levels regarding exponential expressions and their views about language. *International Journal of Active Learning, 5*(1), 33-56. https://dergipark.org.tr/en/pub/ijal/issue/55589/733548

Hansen, A. (2014). *Children's errors in mathematics*. (4th ed.). Sage Publications.

Işık, C. (2011). Conceptual analysis of multiplication and division problems in fractions posed by preservice elementary mathematics teachers. *Hacettepe University Journal of Education*, 41, 231-243. http://www.efdergi.hacettepe.edu.tr/shw_artcl-694.html

Işık, C., & Kar, T. (2012). Analyzing problems posed by 7th grade students for addition operation with fractions. *Elementary Education Online, 11*(4), 1021-1035. https://www.ilkogretim-online.org/fulltext/218-1596968743.pdf?1688208668

Işık, A., Çiltaş, A., & Kar, T. (2012). The effect of problem posing instruction on problem solving success of 6th grade students with different number sense. *Pegem Eğitim ve Öğretim Dergisi*, *2*(4), 71-80. https://doi.org/10.14527/C2S4

İlhan, A., & Aslaner, R. (2019). Evaluation of middle school mathematics course curriculums from 2005 to 2018. *Pamukkale University Journal of Education*, *46*(1), 394-415. https://doi.org/10.9779/pauefd.452646

Kandal, R., & Baş, F. (2022). The descriptive content analysis of theses with the topic of metacognition published in Turkey on mathematics education. *Journal of Education and Future*, (21), 83-97. https://doi.org/10.30786/jef.835078

Karataş, K., Aksoy, N. C., & Çakmak, D. (2021). The effect of realistic mathematics education on the success of 5th grade students in decimal notation. *International Journal of Science and Education, 4*(2), 111-126. https://doi.org/10.47477/ubed.975353

Kılıç, Ç. (2013). Determining performance of elementary students related to problem posing activities requiring four arithmetical operations with natural numbers. *Dicle University Journal of Ziya Gökalp Education Faculty, 20*, 256-274. https://dergipark.org.tr/en/pub/zgefd/issue/47944/606585

Kiraz, K. Ş., & Işık, C. (2020). Analysis of teachers' usage of models at teaching of integers. *Journal of Bayburt Education Faculty*, *15*(29), 81-108. https://doi.org/10.35675/befdergi.519552

Kutluca, T., Birgin, O., & Gündüz, S. (2018). Evaluation of the published articles in Turkish journal of computer and mathematics education according to content analysis. *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, *9*(2), 390-412. https://doi.org/10.16949/turkbilmat.332518

Kutluca, T., Hacıömeroğlu, G., & Gündüz, S. (2016). Evaluation of basic field studies on computer assisted mathematics teaching in Turkey. *Journal of Theory and Practice in Education***,** *12*(6), 1253-1272. https://dergipark.org.tr/en/pub/eku/issue/26696/280842

Macit, E., & Nacar, S. (2019). Concept images for rational number and fraction of the students at the elementary mathematics education department. *Inonu University Journal of the Graduate School of Education*, *6*(11), 52-62. https://doi.org/10.29129/inujgse.547277

McCallum, E., & Schmitt, A. J. (2011). The taped problems intervention: increasing the math fact fluency of a student with an intellectual disability. *International Journal of Special Education*, *26*(3), 276-284. https://eric.ed.gov/?id=EJ959019

Ministry of National Education (MoNE) (2008). *Matematik dersi öğretim programı (6-8. sınıflar)* [Mathematics lesson curriculum (6-8 grades)]. MoNE.

Ministry of National Education (MoNE) (2009). *Matematik dersi öğretim programı (1.2.3.4.5. sınıflar)* [Mathematics lesson curriculum (1.2.3.4.5 grades)]. MoNE.

Ministry of National Education (MoNE) (2009). *Matematik dersi öğretim programı (6-8. sınıflar)* [Mathematics lesson curriculum (6-8 grades)]. MoNE.

Ministry of National Education (MoNE) (2013). *Matematik dersi öğretim programı (1.2.3.4. sınıflar*) [Mathematics lesson curriculum (1.2.3.4 grades)]. MoNE.

Ministry of National Education (MoNE) (2015). *Matematik dersi öğretim programı (1.2.3.4. sınıflar)* [Mathematics lesson curriculum (1.2.3.4 grades)]. MoNE.

Ministry of National Education (MoNE) (2018). *Matematik dersi öğretim programı (ilkokul ve ortaokul 1, 2, 3, 4, 5, 6, 7 ve 8. sınıflar)* [Mathematics lesson curriculum (primary and secondary school 1, 2, 3, 4, 5, 6, 7 and 8 grades]. MoNE

Montague-Smith, A., Cotton, T., Hansen, A., & Price, A. (2017*). Mathematics in early years education*. Routledge.

National Council of Teachers of Mathematics (NCTM) (2000). *Principles and standards for school mathematics*. NCTM,

National Mathematics Advisory Panel (2008). *Foundations for success*. U.S. Department of Education.

National Research Council (2001). Adding it up: Helping children learn mathematics. In J. Kilpatrick, J. Swafford & B. Findell (Eds.), *Mathematics learning study committee, center for education division of behavioral and social science and education*. National Academy Press.

Özer, A., Karacaköylü, A., & Tekin Sitrava, R. (2020). Analysis of the problems 5th grade students posed related to addition and subtraction in fractions. *Ege Journal of Education*, *21*(1), 19-37. https://doi.org/10.12984/egeefd.556447

Özturan Sağırlı, M., & Baş, F. (2020). A content analysis of the problem-themed articles published in turkey. *Gazi University Journal of Gazi Educational Faculty (GUJGEF), 40*(3), 1105-1135. https://doi.org/10.17152/gefad.565265

Paydar, S., Doğan, A., & Şahin, A. E. (2019). An analysis of primary first grade students' readiness in natural numbers, *Elementary Education Online*, *18*(3), 1059-1072. https://doi.org/10.17051/ilkonline.2019.610645

Paydar, S., & Doğan, A. (2021). An action research on teaching natural numbers to the first grade primary school student with low readiness. *Journal of Qualitative Research in Education*, 27, 26-51. https://doi.org/10.14689/enad.27.3

Ruijssenaars, A.J.J.M., Van Luit, J.E.H., & Van Lieshout, E. C. D. M. (2006). *Rekenproblemen en dyscalculie*. Lemniscaat.

Selçuk, Z., Palancı, M., Kandemir, M., & Dündar, H. (2014). Tendencies of the researches published in education and science journal: content analysis. *Education and Science, 39*(173), 430- 453. http://egitimvebilim.ted.org.tr/index.php/EB/article/view/3278

Soylu, Y., & Soylu, C. (2005). Learning difficulties of 5th class in primary education at fraction: ordering, adding, subtraction, multiplication in fraction and problems related to fraction. *Erzincan University Journal of Education Faculty*, *7*(2), 101-117. https://dergipark.org.tr/en/pub/erziefd/issue/6005/80075

Stein, M., Silbert, J., & Carnine, D. (1997). *Designing effective mathematics instruction a direct instruction approach* (3rd edition). Prentice Hall.

Sullivan, P., Gervasoni, A., & Philison, S. (2017). Describing the mathematical intentions of early learning childhood experiences. In S. Phillipson, A. Gervasoni & P. Sullivan (Eds.), Engaging families as children's first mathematics educators, *Early Mathematics Learning and Development*, (pp. 3-15). Springer.

Şengül, S., & Erdoğan, N. (2017). A study on the impact of 7th graders' perception of mathematical self- efficacy on their mathematical competency in ratio-proportion . *Journal of Research in Education and Teaching (JRET), 6*(2), 220-231. http://www.jret.org/FileUpload/ks281142/File/20a.sare_sengul.pdf

Şengül, S., & Zengin, N. (2009). The effect of mathematics lessons designed in accordance with the principles of whole learning and delivered using different techniques on children's attitude to mathematics. *Milli Eğitim Dergisi, 39*(184), 290-305. https://dergipark.org.tr/tr/pub/milliegitim/issue/36201/407179

Tabak, S. (2019) Research tendencies in Turkey on the "realistic mathematics education": a research of thematic content analysis. *Ahi Evran University Journal of Kırşehir Education Faculty, 20*(2), 481-526. https://dergipark.org.tr/en/pub/kefad/issue/59082/850406

Tatar, E., Kağızmanlı, T. B., & Akkaya, A. (2013). Content analysis of the researches on technology-assisted mathematics instruction in Turkey. *Buca Faculty of Education Journal, 35*, 33-50. https://dergipark.org.tr/en/pub/deubefd/issue/25114/265146

Toluk Uçar, Z. (2016). The role of representations in middle school preservice teachers' conceptions of real numbers. *Kastamonu Education Journal, 24*(3), 1149-1164. https://dergipark.org.tr/tr/pub/kefdergi/issue/22607/241650

Topçu, M., & Gürefe, N. (2020). 7 determination of fraction schemas of 7th grade students. *The Journal of International Education Science*, 22(7), 97-118. http://dx.doi.org/10.29228/INESJOURNAL.41685

Tuluk, G., & Akyüz, H. İ. (2019). Investigation of EBA contents by teacher and teacher candidates: 5th grade natural numbers unit. *Usak University Journal Of Social Sciences, 12*(2), 32-47. https://dergipark.org.tr/en/pub/usaksosbil/issue/51480/640268

Ulutaş, F., & Ubuz, B. (2008). Research and Trends in Mathematics Education: 2000 to 2006. *Elementary Education Online, 7*(3), 614-626. https://www.ilkogretim-online.org/fulltext/218-1596682871.pdf?1688206771

Waltemire, C. L. (2018). *Pre-school counts: A case study investigating pre-school's role in early numeracy* [Unpublished doctoral dissertation]. University of Miami.

Van De Walle, J. A., Karp, K. S., & Bay-Williams, J. M. (2012). *İlkokul ve ortaokul matematiği: Gelişimsel yaklaşımla öğretim* [Elementary and middle school mathematics - teaching developmentally] (S. Durmuş, Trans.). Nobel Yayıncılık.

Vlassis, J., (2004). Making sense of the minus sign or becoming flexible in negativity. *Learning and Instruction, 14*(5), 469-484. https://doi.org/10.1016/j.learninstruc.2004.06.012

Yapıcı, A., & Altay, M. K. (2017). An investigation of middle school students' number sense regarding percent. *Abant İzzet Baysal University Journal of Faculty of Education, 17*(4), 2221-2243. https://doi.org/10.17240/aibuefd.2017..-337984

Yaşar, Ş., & Papatğa, E. (2015). The analysis of the graduate theses related to mathematics courses. *Trakya University Journal of Faculty of Education, 5*(2), 113-124. https://dergipark.org.tr/en/pub/trkefd/issue/21482/230218

Yenilmez, K., & Yıldız, Ş. (2018). Investigation of number sense strategies of 7th grade students on rational numbers. *Journal of Theoretical Educational Science*, 11, 457-485. https://doi.org/10.30831/akukeg.349650

Yıldırım, A., & Şimşek, H. (2011). *Sosyal bilimlerde nitel araştırma yöntemleri* [Qualitative research methods in social sciences] (12th ed.). Seçkin Yayıncılık.

Yıldız Altan, R., Genç, H., & Dağlıoğlı, H. E. (2021). A content analysis on studies conducted on math education in preschool in Turkey. *OPUS International Journal of Society Researches, 17*(33), 619-653. https://doi.org/10.26466/opus.778998

Yücesan, C. (2011). *Bilgisayar destekli öğretimin 6. sınıf kümeler konusunda öğrenci başarısına etkisi* [The effect of computer-aided instruction on student achievement in 6th grade clusters] [Unpublished master's thesis]. Rize University.