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Contact Information
Web: https://dergipark.org.tr/itall
E-Mail: itall.journal@gmail.com
Address: Eregli Faculty of Education/ Ereğli/KONYA

İletişim Bilgileri
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Research Article

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Investigation of Preservice Science Teachers' STEM Awareness and STEM Views

Feyza EKİCİ [1], Kemal İZCİ *[2]

* *Corresponding kizci@erbakan.edu.tr*

[1, 2]*Necmettin Erbakan University, Türkiye*

Abstract

This study aims to examine the STEM awareness and perspectives of science teacher candidates, employing a convergent parallel design, which is a mixed research method combining quantitative and qualitative approaches. The participants of the research consist of 65 science teacher candidates studying in the third year of a state university. The data regarding the participants' STEM awareness were obtained through a scale, while the data regarding their STEM perspectives were gathered through semi-structured interviews. Descriptive statistics were used to analyze the quantitative data, whereas content analysis was employed for the qualitative data analysis. The findings of the study indicate that the participants generally scored high on the scale measuring their STEM awareness, with the lowest score obtained in the sub-factor of the scale related to the impact of STEM on teaching. The participants' STEM perspectives were interpreted under five themes, namely STEM definition, the importance of STEM, the advantages and disadvantages of STEM for students, the advantages and disadvantages of STEM for teachers, and their inclination towards using STEM. Based on the study findings, it was concluded that science teacher candidates are capable of accurately defining STEM, they are aware of the importance of STEM and its contributions to both teachers and students, and they have a tendency to incorporate STEM in their lessons. The relevant findings were discussed within the scope of the literature, and recommendations were provided.

Keywords: STEM, Preservice science teachers, STEM awareness, STEM views.

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Fen Bilgisi Öğretmen Adaylarının STEM Farkındalıklarının ve STEM Görüşlerinin İncelenmesi

Özet

Bu çalışma fen bilimleri öğretmen adaylarının STEM farkındalıklarını ve STEM görüşlerini incelemeyi amaçlamaktadır. Bu amaç doğrultusunda nicel ve nitel araştırma yöntemlerinin birlikte kullanıldığı karma araştırma yöntemlerinden olan yakınsayan paralel desen kullanılmıştır. Araştırmanın katılımcılarını bir devlet üniversitesinin 3. sınıfında öğrenim gören 65 fen bilgisi öğretmen adayı oluşturmaktadır. Katılımcıların STEM farkındalıklarıyla ilgili veriler bir ölçek yardımıyla, STEM görüşleriyle ilgili veriler ise yarı-yapılandırılmış görüşmeler aracılığı ile elde edilmiştir. Elde edilen nicel verilerin analizinde betimsel istatistik, nitel verilerin analizinde ise içerik analizi kullanılmıştır. Çalışmanın bulguları fen bilgisi öğretmen adaylarının STEM farkındalıkları ile ilgili ölçekten aldıkları puanların genel olarak yüksek olduğu, ilgili ölçeğin STEM'in derse yönelik etkisi alt faktöründen katılımcıların en düşük puanı aldıklarını göstermektedir. Katılımcıların STEM görüşleri ise STEM tanımı, STEM'in önemi, STEM'in öğrenci açısından avantajları ve dezavantajları, STEM'in öğretmen açısından avantaj ve dezavantajları ve STEM kullanma yönelimleri olmak üzere 5 tema altında yorumlanmıştır. Çalışma bulguları sonucunda fen bilgisi öğretmen adaylarının STEM tanımını doğru bir şekilde yapabildiklerine, STEM'in önemini, öğretmene ve öğrenciye yönelik katkılarını farkında olduklarına ve derslerinde bu yaklaşımı kullanma yöneliminde olduklarına ulaşılmıştır. İlgili bulgular alanyazın kapsamında tartışılmış ve önerilerde bulunulmuştur.

Anahtar Kelimeler: STEM, fen bilgisi öğretmen adayları, STEM görüşleri

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1. Introduction

In the century we live in, developments in science and technology have caused the dynamics of society to evolve in a new direction. The changes and transformations experienced in the past under the influence of the industrial revolution are today shaped by technological products emerging as a result of scientific developments (National Reseach Council [NRC], 2012). In a century where information is constantly changing, the economic development of a country is only possible by using information creatively and producing creative solutions to the problems that arise in daily life (Aydeniz, 2017). Beyond being a follower of the rapid progress in science and technology, the way to exist in science and technology is to give importance to science, technology engineering and mathematics disciplines both today and in the future (NRC, 2012). Developments in science and technology greatly affect the employment of engineers, technicians and workers, and the economic development of countries in terms of the place they occupy in the market (Bozkurt Altan, Kırıkkaya & Yamak, 2015).

The progressions in different aspects of modern society are rapidly moving towards high standards, with advancements in the fields of science, technology, engineering, and mathematics (STEM) playing crucial roles in tackling the current and future obstacles encountered by humanity to enable the achievement of high standards (NRC, 2012). Therefore, it is imperative to raise a generation that is interested in STEM fields, innovative, entrepreneurial and creative thinkers. Educational institutions are primarily responsible for the realisation of this goal (Aktan & Tunç, 1998). In order to meet this need and to maintain the progress in science and technology, countries are making changes in the educational policies and programs to be implemented in educational institutions. The United States of America (USA) has played a pioneering role in finding solutions in this regard. The increasing need for engineering in the USA and the inability to find the desired quality in the workers have increased the interest of the business world in education and caused them to publish many reports on education (Akgündüz et al., 2015). Reports published in Europe have recognised that science and technology education is alarming and that young people's interest in science and mathematics has declined significantly. Reports published in Europe and the USA (NRC, 2012) advocate a new approach to basic sciences education. The message of these reports about education is to move from a philosophical framework to an approach that provides technical knowledge and skills, prepares students for real life, and prioritises the needs/skills of modern business life. These messages have led to the emergence of approaches that require a new understanding of the education and training process.

Both the solution of global problems and progress in science and technology are not problems that can be solved by only one discipline. The fact that many of the problems we face in an increasingly globalised world require the integration of many fields including STEM fields (Glancy et al., 2014). Therefore, the STEM approach, which proposes the integration of science, technology, engineering and mathematics as one of the new understandings in the education process, has emerged in order to respond to the need. STEM, named as a result of the abbreviation of the first letters of the words 'Science, Technology, Engineering and Mathematics', was first introduced in the USA as an educational approach that involves the realisation of teaching by using more than one discipline together. STEM is also expressed as 'an endeavour to connect the fields of science, technology, engineering and mathematics in a course through connections between these fields and real life problems' (Moore et al., 2014, p.30). Thanks to the STEM approach, it is possible for students to gain knowledge and skills related to more than one discipline, as well as 21st century skills, which are the requirements of the age, by producing solutions to real life problems. The STEM approach provides students with a problem situation. It is an approach that requires students to design to solve this problem, and in order to make this design, they analyse the current situation, collect information, access information from more than one discipline, obtain the most useful information for their purposes, brainstorm for the solution, put forward creative ideas, and in the light of this information, develop a product, a prototype, a design by blending this information and test whether this prototype developed meets the desired criteria (Çorlu, 2018; NRC, 2012).

In Turkey, STEM has started to be given importance with the changes made in the current curricula. In the 2018 science curriculum, a new skill area called engineering and design skills was added to scientific process skills and life skills in the skills learning area, and this group of skills was named domain-specific skills (Ministry of National Education [MoNE], 2013; 2018). Under the sub-heading of engineering and design skills, innovative thinking skills were included. With engineering and design skills, it is aimed to have students design a product with the knowledge and skills they have acquired (MoNE, 2018). Within the scope of 'Science, Engineering and Entrepreneurship Practices' in the science curriculum (MoNE, 2018), students are expected to define a problem from daily life related to the topics covered in the units, compare alternative solutions to solve the problem, select the appropriate one within the scope of the criteria, make plans for the selected solution, and present the product in the next stage. From this situation, it is understood that the 2018 curriculum aims to provide higher level skills than other curricula (Özcan & Koştur, 2019). However, in order for this approach to be successful, theory must be put into practice.

Teachers are an important factor in the implementation of any approach in classroom environments as targeted. At this point, teachers need to adapt and develop themselves to the STEM approach. In order for any approach to be implemented in classroom environments, teachers should have both cognitive infrastructure and affective competences related to this approach. STEM teacher competences constitute the cognitive dimension for the successful implementation of STEM approach and these competences consist of STEM content knowledge, context knowledge, integration knowledge and 21st century knowledge. Brown et al. (2011) emphasised that if the vision of STEM education is intended to yield results, it is necessary to start with increasing teachers' competencies and awareness levels regarding the STEM approach.

1.1. STEM Awareness

Teachers have a key role in preparing learning environments for the implementation of STEM approach and guiding students. It is important to determine the STEM awareness of teachers and prospective teachers in order to reflect the holistic and interdisciplinary perspective of the STEM approach to teaching (Buyruk & Korkmaz, 2016). Raising awareness about the nature of STEM professions is seen as one of the important strategies in many countries in order to further the economic development of countries (Freeman et al., 2013). At this point, it is important to determine the STEM awareness of teachers working in STEM fields. According to Öztürk (2017), teachers' awareness of STEM approach will shape the students' interest in STEM fields. In order to increase the capacity of the labour force trained in STEM fields, teachers need to shape their students' current beliefs about future careers and occupational fields (Angle et al., 2016). It is important for teachers to apply this approach in their lessons in order to guide students about how science is useful for their future careers. Teachers should have high STEM awareness in order to implement the STEM approach. Awareness is seen as a factor that closely affects the relationship between attitudes and behaviours and leads people to the disered attitudes and behaviours over time (Çevik, 2017). In addition to being one of the basic and latent processes of positive change (Fletcher et al., 2010), the concept of awareness also means that individuals and society are sensitive to the environment (Keleş, 2007). STEM awareness can be defined as knowing the importance of STEM approach for teachers, lessons and students and being aware of its positive and negative aspects. According to Koyunlu Ünlü and Dere (2019), STEM awareness means being conscious and sensitive about STEM. Teachers' STEM awareness is seen as a prerequisite for individuals to interact, to have self-efficacy and to improve themselves (Cohen et al., 2013).

Self-awareness refers to the understanding that individuals attain regarding the process of learning and their inclination to oversee said process (Heo, 2000). From this standpoint, STEM awareness can be delineated as the cognizance of equipping individuals with advanced skills, amalgamating science, technology, engineering, and mathematics disciplines, fostering creativity within engineering, exhibiting courage, demonstrating self-assurance, fostering collaboration, and effectively communicating through the application of the STEM methodology (Deveci, 2018). It is crucial for educators to comprehend the significance and benefits of the STEM approach in order to effectively implement it. Concurrently, educators' favorable perspectives and familiarity with STEM have a positive impact on their self-efficacy, which pertains to educators' convictions regarding their ability to generate a desired outcome (Stohlmann et al., 2012). Determining teachers' comprehension and perspectives on the STEM approach could enhance their capacity to implement this approach by bolstering their self-efficacy for its execution.

1.2. Purpose of the Study

For the applicability of the STEM approach, it is important that teachers, who are the realisers of this approach, are both cognitively and affective ready for the STEM approach. One of the important indicators of affective readiness is to be aware of the positive and negative aspects of STEM approach. In addition, in order for this awareness to turn into classroom practices, teachers should have positive views about the STEM approach. Because teachers who do not have awareness and positive views about STEM education do not want to apply this approach. According to Öztürk (2017), teachers' awareness of the STEM approach will also shape the interest of the students they will raise in STEM fields. While the adoption of the STEM approach by teachers and teacher candidates, who are the educators of the future, may positively affect their students' self-development and their future career lives, their failure to adopt it may have a negative impact. For this reason, it is very important for teacher educators to train prospective teachers as STEM literate and STEM aware teachers with high STEM awareness and positive views about the STEM approach in order to raise future generations (Murat, 2018). Therefore, perceptions, beliefs and views towards STEM should be evaluated and analysed at the university level (Capraro, Capraro & Çorlu, 2014). While previous studies have investigated pre-service science teachers' awareness of STEM and found mixed results (e.g. Şahin, 2019; Yaman & Aşılıoğlu , 2022), the study is unique in that it aims to investigate participants' awareness during the development of environmental STEM projects that they are required to complete for their environmental education course. In this context, this study aims to examine the STEM awareness and STEM views of pre-service science teachers who are candidates to teach science course, which is one of the important courses where STEM approach can be applied. In order to achieve this aim, the following research questions were sought to be answered:

1. What is the level of STEM awareness of pre-service science teachers?

2. What are the opinions of pre-service science teachers about STEM approach?

2. Method

In this study, mixed research method, in which qualitative and quantitative research methods are used together, was preferred in order to examine the STEM awareness and STEM views of pre-service science teachers. Mixed method is an approach in which quantitative and qualitative methods with two different paradigms are handled within their theoretical frameworks within a long-term program or research process (Creswell, 2017; Çepni, 2021). In the first step of this research, quantitative data were used to determine STEM awareness, while qualitative data were used to determine STEM opinions in the second step.

In this study, convergent parallel design, one of the mixed research method designs, was preferred. Depending on how the data will be used, each database is handled independently of each other in the convergent parallel design. In this study, the scale used for STEM awareness (quantitative) and the semi-structured interview form used for STEM views (qualitative) were collected and analysed independently. In the convergent parallel design, while the data are analysed separately, the process of interpreting or explaining the convergent or divergent findings by making comparisons or associations to determine whether the findings confirm each other or not is important (Creswell, 2013). In this study, the findings obtained from quantitative and qualitative data were combined in the conclusion and discussion section of the study.

2.1. Participants

The participants of the study consist of pre-service science teachers who were studying in the third year of the Science Teacher Education program of a state university in Turkey. Purposeful sampling method was used to select participants in line with the purpose of the study. Purposive sampling is the purposeful selection of target audience groups in some special research situations in order to examine and explain the phenomena and events in depth (Çepni, 2021; Şimşek & Yıldırım, 2013). One of the reasons why pre-service science teachers were selected as the study group in this study is that science teachers are among the educators who will train students in STEM career fields. Another reason is that pre-service science teachers have a subject area curriculum that can use the STEM approach in the future and the course includes more than one discipline together.

The participants of this study consisted of a total of 65 pre-service science teachers, 13 (20%) male and 52 (80%) female. The 65 pre-service science teachers responded to the scale applied to determine their STEM awareness, while 11 pre-service science teachers, who were determined voluntarily, participated in semi-structured interviews to determine their STEM views. Codes like P-1 (participant-1) and P-2 were employed for the purpose of elucidating the viewpoints of participants based on their responses to interview questions. Based on the information gained from the interview participants, it seen that almost all of the pre-service teachers who participated in the interview received STEM-related training and attended different courses such as Arduino, robotics coding and web design courses. We can say that such STEM experiences supported the participants to participate in the interviews voluntarily.

2.2. Data Collection Tools

In this study, a scale was used to determine the STEM awareness of pre-service science teachers and a semi-structured interview form was used as a data collection tool to examine their STEM views. Detailed information about the related data collection tools is presented below.

2.2.1. STEM awareness scale

In order to determine the STEM awareness of pre-service science teachers the STEM Awareness Scale developed by Çevik (2017) was used. The scale) was applied face-to-face at the beginning of the spring semester of the 2022-2023 academic year.

The scale was 5-point Likert type and offers options such as Strongly Disagree (1), Disagree (2), Neutral (3), Agree (4) Strongly Agree (5). The scale, which contains 15 items in total, consists of 12 positive and 3 negative items. Items 8, 9 and 10 are reverse scored items because they are negative. The scale consists of three sub-dimensions: the effects of STEM on students (6 items), lessons (5 items)and teachers (4 items). While the Cronbach's Alpha reliability coefficient of the sub-dimensions were. 81, .71 and. 70 respectively, the Cronbabch's Alpha of the whole scale was found to be .82 (Çevik, 2017). When the literature is reviewed, it is stated that the reliability coefficient of a data collection tool being. 70 or above is a sufficient value for reliability (Büyüköztürk, Kılıç-Çakmak, Akgün, Karadeniz & Demirel, 2010; Bayram, 2004). For the validity of the scale, Çevik (2017) reapplied the scale within the scope of the test-retest method and determined the standard deviation and mean as 0.52 and 3.95 in the first application and 0.53 and 3.91 in the second application. The fact that the first and second application values are very close to each other shows that the validity of the scale is high.

When examining the sub-components of the scale within a specific context, the impact of STEM on students is associated with how pre-service teachers assess aspects such as analytical thinking, critical perspective, hands on skills, motivation, and self-assurance. Conversely, the influence of STEM on the educational program pertains to appraisals of the instructional procedure concerning the utilization of advanced resources, classroom authority, time allocation, application of acquired knowledge in real-world scenarios, and integration of extracurricular tasks into the syllabus. The effect dimension of the scale for the teacher is related to the views of pre-service teachers on the use of technology for the teacher, planning activities, being active in the lesson and self-development. One of the reasons why this scale was preferred in this study is that the questions related to the same subject are collected in the same category and provide convenience in presenting the data regularly. In addition, the related scale was used as a data collection tool in this study because it was in contextual agreement with the semi-structured interview questions, another data collection tool used to determine the STEM views of the participants.

2.2.2. Semi-structured interview

In order to reveal the STEM views of pre-service science teachers, 12 semi-structured interview questions were developed to enable the participants to present their STEM views in a broad scope. The questions were examined by an academician who is an expert in qualitative research, and based on the examination; some of the questions were removed because they focused on the same concepts. The final version of the form was created to include 10 questions (Appendix-1). In general terms, the interview questions aimed to reveal the participants' views about the STEM approach, their experiences with STEM education, the advantages and disadvantages of the STEM approach, and their orientation towards using the STEM approach in the future.

In this study, semi-structured interviews were conducted with 11 pre-service science teachers who were determined voluntarily in order to elaborate the scale applied to determine the STEM awareness of pre-service science teachers. After a general picture of the situation being studied is revealed through scales, special case studies are initiated by taking a very special section from this picture (Çepni, 2021). In determining the participants' thoughts about the STEM approach, data diversification was provided by collecting data from different data sources (scale and semi-structured interview) on the same subject. Multiple tools used in data generation contribute to the credibility, realism and originality of the research (Patton, 2002).

2.3. Data analysis

The data obtained through the scale were transferred to the SPSS (Statistical Package for Social Sciences) programme and descriptive statistical analyses were performed. The positive items in the scale were scored as Strongly Disagree (1), Disagree (2), Neutral (3), Agree (4), Strongly Agree (5), while items 8, 9 and 10, which contain negative items, were coded in a way that this scoring was reversed. Then, the score range of the scale was calculated. To determine the score range of the scale, the range coefficient was found with the formula Score Range = (Highest

Value - Lowest Value)/5= (5 - 1) / 5 = 4/5 = 0.80). The score ranges determined in the interpretation of the data obtained from the STEM Awareness Scale are given in Table 1.

Table 1.

Rating Used to Interpret the Arithmetic Mean of the Scale

Score Range	Grading
1.00/1.79	Strongly Disagree
1.80/2.59	Disagree
2.60/3.39	Neutral
3.40/4.19	Agree
4.20/5.00	Strongly Agree

Using the score ranges determined in Table 1, the data were interpreted by considering the averages of the items forming the scale and the averages of the three sub-dimensions of the scale. The results indicated that participants who scored within the agree or strongly agree range demonstrated a heightened level of awareness regarding the specific item. Conversely, those who scored within the disagree or strongly disagree range exhibited a diminished level of awareness. For items corresponding to the neutral range, it was interpreted that they were undecided.

In the second part of this study, the qualitative data were analysed by using content analysis method. The content analysis method involves the process of analysing data in four stages. These are: (1) coding the data, (2) identifying codes, sub-themes and themes, (3) organising the codes, sub-themes and themes, and (4) defining and interpreting the findings (Eysenbach & Köhler, 2002; Miles & Huberman, 1994). These four stages were employed to analyze the qualitative data in the study. To ensure the reliability of the analyses of STEM views peer review process was used (Creswell, 2017). The first author carefully read all the interview data to develop the codes, sub-themes and themes. The analyses of the interviews were also carried out a second time by the second author. In cases of disagreement, both authors met to reach a consensus on the discrepancies.

3. Results

In this section, findings related to the participants' STEM awareness are presented first, followed by findings concerning their views on STEM, in order to address the two relevant research questions aligned with the purpose of the study.

3.1. Findings on the STEM Awareness of Science Teacher Candidates

3.1.1. Impact of the STEM approach on students

Six different items were used in the scale to assess the impact of the STEM approach on students. The overall average of these six items, as well as the mean and standard deviation values of the responses to each item, were calculated. Findings related to the responses of science teacher candidates are presented in Table 2. A general examination of Table 2 indicates that participants are highly aware (M= 4.41) of the positive effects of the STEM approach on students. As shown by the averages of the six items related to the impact on students, participants' preferences fell within the "agree" and "strongly agree" range, indicating high awareness in this section of the scale.

Table 2.

Results on the Impact of the STEM Approach on Students

Items		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	M	sd
STEM education contributes to the enhancement of students' manual skills.	f	1	1	0	26	37	4.49	.732
	%	1.5	1.5	0	40.0	56.9		
STEM education develops students' analytical thinking skills.	f	2	0	1	25	35	4.46	.812
	%	3.1	0	1.5	38.5	56.9		
STEM education motivates students in the classroom.	f	1	2	3	33	26	4.25	.811
	%	1.5	3.1	4.6	50.8	40.0		
STEM education increases students' problem-solving abilities.	f	1	2	2	20	40	4.48	.831
	%	1.5	3.1	3.1	30.8	61.5		
STEM education practices boost students' self-confidence.	f	2	1	5	22	35	4.34	.923
	%	3.1	1.5	7.7	33.8	53.8		
STEM education supports students in gaining a critical perspective.	f	2	1	5	14	43	4.46	.937
	%	3.1	1.5	7.7	21.5	66.2		
				The impact on students: 4.41				

3.1.2. Impact of the STEM approach on the course

In the context of the impact of the STEM approach on the course, five items were used in the scale. The overall average of these five items, as well as the mean and standard deviation values for each response, were calculated. Findings related to the responses of science teacher candidates are presented in Table 3. A general review of Table 3 indicates that participants are highly aware (M= 3.78) of the positive effects of the STEM approach on the course. As shown by the averages of the five items concerning the course impact, participants' preferences fall within the "neutral" and "agree" range, indicating high awareness in this section of the scale.

Table 3.

Results of Impact of the STEM Approach on the Course.

Items		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	M	sd
The reflection of STEM education in daily life is inevitable.	f	1	2	6	31	25	4.18	.846
	%	1.5	3.1	9.2	47.7	38.5		
*High-quality materials are needed for STEM education.	f	9	10	20	19	7	3.08	1.203
	%	13.8	15.4	30.8	29.2	10.8		
*The implementation of STEM education negatively affects classroom management.	f	4	5	16	28	12	3.60	1.072
	%	6.2	7.7	24.6	43.1	18.5		
*STEM education activities waste a lot of time in the classroom.	f	2	6	20	20	17	3.68	1.062
	%	3.1	9.2	30.8	30.8	26.2		
STEM education activities should be included in the curricula.	f	1	1	6	24	33	4.34	.834
	%	1.5	1.5	9.2	36.9	50.8		
							The impact on course: 3.78	

**The marked items are negative statements, so they have been reversed in the analyses.*

3.1.3. Impact of the stem approach on teachers

In the scale assessing the impact of the STEM approach on teachers, four different items were used. The overall average of these four items was calculated, along with the mean and standard deviation for each response. The results relating to the responses of the science teacher candidates are presented in Table 4. A general review of Table 4 shows that participants are highly aware (M= 4.09) of the positive effects of the STEM approach on teachers. As can be seen from the mean scores of the four items relating to the impact on teachers, participants' preferences fall within the range of 'agree' and 'strongly agree', indicating a high level of awareness in this section of the scale.

Table 4.

Results on the Impact of the STEM Approach on Teachers

Maddeler		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	M	sd
STEM education requires the teacher to use technology in the classroom.	f	2	3	5	24	31	4.22	.992
	%	3.1	4.6	7.7	36.9	47.7		
STEM education practices provide an opportunity for teachers to improve themselves.	f	2	0	2	25	36	4.43	.829
	%	3.1	0	3.1	38.5	55.4		
Teachers should take an active role in STEM education activities.	f	5	10	6	19	25	3.75	1.323
	%	7.7	15.4	9.2	29.2	38.5		
Teachers can easily plan STEM education in both classroom and extracurricular activities.	f	2	4	12	22	25	3.98	1.053
	%	3.1	6.2	18.5	33.8	38.5		
					The impact on teacher: 4.09			

Overall, participants rated the STEM Awareness Scale, which consists of three sections: the impact of the STEM approach on students, the course and teachers. Analysis of the mean responses for these three sections showed that participants had the highest level of awareness of the impact of the STEM approach on students (M= 4.41). Following this, the section with the second highest level of awareness was the impact of the STEM approach on teachers (M= 4.09). In contrast, the impact of the STEM approach on the course lagged behind the other two sections ($\bar{x}$: 3.78).

3.2. Findings on the Views of Preservice Science Teacher Regarding STEM

Five distinct themes were identified from the interviews: definition of STEM, Importance of STEM, Advantages and disadvantages of STEM from a teacher's perspective, Advantages and disadvantages of STEM from the students' perspective, Tendencies to use the STEM approach in teaching. In the following, we present the themes and the findings related to each of them.

3.2.1. Definition of STEM

In the semi-structured interviews conducted with science teacher candidates, they were asked "What disciplines do you think are related to science? What is the relationship between science and the fields of technology, engineering and mathematics?" and "How would you define STEM, or its adapted version in Turkish, FeTeMM?" The focus was on how participants defined and interpreted STEM. Based on the answers to these questions, the teacher candidates' definitions of STEM were identified. The participants' views on the definition of STEM are summarized in Table 5.

Table 5.

Views of Preservice Science Teachers on the Definition of STEM

Theme	Sub-Theme	Code	Sample Quotations
The Definition of STEM	An interdisciplinary approach	P1, P2, P5, P8	"In everyday life, when we solve a problem or issue, we use several of the disciplines of science, technology, engineering and mathematics depending on the problem. The application of using the knowledge and skills from these disciplines is STEM". (P5)
	Science, technology, engineering and mathematics	P3, P7	“"STEM is a term related to the fields of science, technology, engineering, and mathematics.".” (P7)
	A teaching method that teachers should know	P6, P10	"It is an approach that every science teacher should know, learn, and use in their teaching." (P10)
	A system aimed at promoting scientific literacy.	P4	"It is a system aimed at cultivating scientifically literate individuals." (P4)
	Solving problems and creating products	P9	"It is an educational approach that seeks solutions to problems through science and mathematics knowledge with the assistance of engineering, resulting in product creation." (P9)
	An approach that facilitates the transformation of knowledge from theory to practice.	P11	"Students observe the real-life applicability of subjects such as science, technology, mathematics and engineering through this [STEM] system." (P11)

As can be seen in Table 5, teacher candidates coded as P1, P2, P5 and P8 emphasised the interdisciplinary nature of the STEM concept in their explanations. In addition, candidates coded P3 and P7 defined STEM as an acronym for the disciplines of science, technology, engineering and mathematics. Candidates P6 and P10 referred to STEM as a teaching method that teachers should be familiar with. Furthermore, teacher candidates also expressed the definition of STEM as a system aimed at cultivating scientific literacy (P4), as a method for problem solving and product creation (P9), and as an approach that facilitates the transformation of knowledge from theory to practice (P11).

3.2.2. The importance of STEM

Science teacher candidates were asked, "Why do you think STEM education is important?" Their responses were used to identify the importance of STEM and its contributions. The views expressed by the participants on the importance of STEM are summarised in Table 6.

Table 6.

Views of Science Teacher Candidates on the Importance of STEM

Theme	Sub-Theme	Code	Sample Quotations
The importance of STEM	Develop higher order thinking skills	P6, P7, P8,P10, P11	"STEM has improved my problem-solving skills, analytical thinking skills, and manual dexterity." (P7)
	Gain technological skills	P2, P3, P9	"I learned to build basic Arduino circuits. We had the opportunity to work with robots like Macblock. I also learned basic programming on the computer." (P2)
	Ability to apply theoretical knowledge to real life	P4, P11	"STEM has improved my creativity and problem-solving skills. I have learnt about real-life applications that can be achieved with science". (P11)
	Ability to produce more than one solution to a problem	P5	It became evident that a given problem can be approached from a variety of perspectives, thereby facilitating the generation of multiple solutions. (P5)
	Change of perspective on science	P1	"Receiving STEM education allowed me to change my perspective on science." (P1)

As evidenced in Table 6, teacher candidates coded as P6, P7, P8, P10, and P11 underscored the pivotal role of STEM in fostering advanced cognitive abilities. Furthermore, candidates P2, P3, and P9 asserted that STEM is crucial for imparting technological competencies that are pertinent to the contemporary era. Candidates P4 and P11 observed that STEM enables the practical application of theoretical knowledge in real-world scenarios. Additionally, other participants emphasised the significance of STEM for facilitating the development of diverse solutions to a problem (P5) and for fostering a shift in perspectives on science (P1).

3.2.3. Advantages and disadvantages of STEM from a teacher's perspective

Science teacher candidates were posed the following questions: "What are the advantages of utilising STEM-based activities in science classes from the perspective of the teacher?" and "What are the disadvantages of employing STEM-based activities in science classes from the perspective of the teacher?" The objective was to ascertain the participants' perceptions of the advantages and disadvantages that STEM offers teachers. Based on the responses provided to these questions, the participants' views on the advantages and disadvantages of STEM from the teacher's perspective are presented in Table 7.

Table 7.

Advantages and Disadvantages of STEM from a Teacher's Perspectiv0065

Theme	Sub-Theme	Code	Sample Quotations
Advantages of STEM for Teachers	It contributes to the teacher's self-development.	P4, P6, P10	It is my contention that teachers and students alike benefit from the development of their STEM skills, which in turn contribute to their growth as individuals who possess a nuanced understanding of the world around them, are able to generate ideas about the events they encounter, and are solution-oriented. (P4)
	Let teachers to provide meaningful learning.	P9, P11	It is my conviction that an effective teacher will facilitate enduring learning, enabling students to synthesise and apply knowledge in a way that goes beyond mere rote memorisation. Concurrently, it will provide children with a broader range of career options. (P9)
	Provides opportunities for higher-level learning and evaluation of the learning.	P2, P7	The STEM approach enables educators to observe students' creativity and their ability to utilise technology effectively. It also allows them to assess students' performance in practical tasks beyond theoretical knowledge and to determine their understanding of the steps involved in scientific research. (P2)
	It guarantees the nurturing of productive students.	P3, P8	The implementation of STEM in education has the potential to enhance the quality of learning experiences, facilitating more memorable and productive outcomes for students. (P8)
	Let teachers to conduct lessons with the integration of technology and science.	P1	"The teacher's use of STEM-based activities enables a more efficient lesson delivery by integrating evolving technology with science." (P1)
	Decrease work load of techers	P5	In light of the increased level of student engagement, the role of the teacher will evolve to that of a guide, facilitating learning in a more passive manner. Consequently, the teacher's workload will be reduced, and as students will be responsible for discovering and constructing knowledge, the learning will be more enduring. (P5)
Disadvantages of STEM for Teachers	Lack of time	P3, P4, P5, P7, P9, P10	In the event that the lesson is not meticulously planned, there may be insufficient time for the implementation of STEM activities, which could result in the activities being incomplete. (P7)

	Material supply problem	P1, P4, P5, P9	"Of course, if there is insufficient technology and environment at school for these activities, it will also cause problems for the teacher in implementing the activities." (P4)
	Classroom management	P4, P7	"...The teacher needs to maintain classroom management." (P7)
	Guidence	P2, P6	"It can be challenging to provide guidance to students." (P2)
	The challenge of supporting all learners	P8	"It can be somewhat exhausting to convey information in a manner that is accessible to all children." (P8)

As evidenced in Table 7, prospective science teachers with the codes P4, P6, and P10 most frequently identified the advantages of STEM in facilitating personal development as a key benefit for teachers. Additionally, prospective teachers with the codes P9 and P11 indicated that STEM can facilitate meaningful learning experiences for students. Conversely, prospective teachers with the codes P2 and P7 emphasised the pedagogical aspects of STEM, asserting that it provides avenues for advanced learning and the assessment of these attainments. Moreover, participants indicated that STEM can facilitate the development of productive students (P3, P8) and that lessons are taught through the integration of technology and science (P1). One other participant (P5), who appeared to hold a misconception of the STEM approach, asserted that it reduces the lesson load.

As evidenced in Table 7, regarding the disadvantages of STEM for teachers, prospective teachers with the codes P3, P4, P5, P7, P9, and P10 most frequently expressed the view that time constraints could be a disadvantage for teachers. Participants with the codes P1, P4, P5, and P9, on the other hand, considered the unavailability of materials to be a potential disadvantage. Additionally, some participants reported disadvantages related to classroom management (P4, P7), providing guidance (P2, P6), and explaining in a way that every child can understand (P8).

3.2.4. Advantages and disadvantages of STEM from the student's perspective

The prospective science teachers were invited to respond to the following questions: The participants were asked to identify the advantages and disadvantages of using STEM-based activities in science classes from their perspective. The investigation was centred on the participants' perspectives on the advantages and disadvantages of STEM for students. The responses provided by the participants to these questions were used to construct a summary of their views on the advantages and disadvantages of STEM from the perspective of the student (see Table 8).

Table 8.

Advantages and Disadvantages of STEM from the Student's Perspective

Theme	Sub-Theme	Code	Sample Quotations
Advantages of STEM from the Student's Perspective	Developing higher-order thinking skills	P2,P4, P5, P7, P9, P11	"The implementation of STEM-based activities will facilitate the growth of students into self-assured, science-oriented individuals who are capable of critical thinking, analytical reasoning, and maintaining their creative faculties." (P4)
	Boosting students' self-confidence	P4, P5	"The student's confidence will be restored as they achieve things on their own, while group activities will enhance their ability to communicate, make decisions, think critically, and think creatively." (P5)
	Increasing student interest and motivation	P10, P3	"Such STEM experiences will enhance their confidence in technology and the future, thereby providing motivation." (P3)
	Fostering active participation	P6, P11	This approach encourages students to be actively engaged in the learning process. (P6)
	Permanent learning	P1	"It (STEM) increases retention in learning." (P1)
	Raising productive individuals	P8	"The STEM curriculum encourages students to become productive members." (P8)
Disadvantages of STEM from the Student's Perspective	Lack of time	P3, P5	"The overcrowding of classrooms will impede the ability of each individual to engage in hands-on activities, and some students may lack the opportunity to participate or may be unable to do so. (P5)
	Material supply problem	Ö8, P10	"There may not always be access to the required materials." (P8)
	Lack of experienced teachers	P1, P4	"A STEM-based activity conducted by a teacher who has not received STEM education may be difficult for students to understand." (P1)
	Can be boring for students	P2, P7	"It could be an activity that bothers students who are not interested in science subjects." (P2)
	Concerns about product development	P9	"It could create a fear of not being able to find a solution to the problem and not being able to develop a product." (P9)
	No disadvantages	P6, P11	"I don't think STEM has a disadvantage." (P11)

As can be seen in Table 8, when teacher candidates coded P2, P4, P5, P7, P9 and P11 discuss the benefits of STEM from the students' perspective, they emphasise that STEM-based activities contribute to the development of students' higher-order thinking skills. In addition, teacher candidates coded P4 and P5 state that STEM-based activities will help students to achieve things on their own and gain confidence, while teacher candidates coded P10 and P3 mention that STEM-based activities will increase students' interest/motivation towards the lesson. In addition, participants indicated that STEM-based activities offer benefits such as ensuring students' active participation in the lesson (P6, P11), promoting sustained learning (P1), and providing opportunities for students to grow as productive individuals (P8).

As seen in Table 9, in their views on the disadvantages of STEM from the students' perspective, teacher candidates coded P3 and P5 mention that students may not be able to participate in activities due to time constraints. Teacher candidates coded P8 and P10 suggest that factors such as difficulties in obtaining materials or insufficient technological resources could also be a disadvantage for students. In addition, teacher candidates coded P1 and P4 state that they believe that STEM-based activities can be disadvantageous for students if teachers (or trainers) are not adequately trained, as the activities may not be understood by students, resulting in a disadvantage. Some participants also reported disadvantages such as students who are not interested in science being bored or struggling (P2, P7), while another participant focused on the implementation phase of STEM and mentioned that students may feel anxious about product development (P9). Finally, in the section on the disadvantages of STEM for students, there are two participants (P6, P11) who believe that STEM does not have any disadvantages for students.

3.2.5. Views on using the STEM approach in teaching

The pre-service science teachers were asked the question: "Do you think that STEM-based science teaching can be used to strengthen science teaching in middle schools? The participants' responses focused on their inclinations to use the STEM approach in future science teaching, whether these inclinations are conditional, and the reasons for using the approach. Based on the participants' answers to this question, their inclinations to use the STEM approach are summarized and presented in Table 9.

Table 9.

Views on Using the STEM Approach in Teaching

Theme	Sub-Theme	Code	Sample Quotations
Views on Using the STEM Approach in Teaching	Preference to use	P1, P2, P3, P7, P9, P10, P11	"I will use STEM in my future lessons." (P3)
	Conditional usage	P4, P5, P6, P8	"As long as the right environment, materials and time are provided, it can be used in the classroom". (P4)
Reasons for using STEM	Develop ciritical skills	P2	"I will definitely use it [STEM]. Project-based education promotes both creativity and productivity." (P2)
	Support meaningful learning	P5	"When the appropriate environment and necessary conditions are provided, receiving STEM-based education will help students produce knowledge on their own, using their own methods and approaches, rather than being passively prepared with information."(P5)
	Increase interest	P7	"Yes, I will use it. If I use the STEM approach in science lessons, students' interest in the lesson will increase." (P7)
	Support use of technology	P6	"I definitely want to use this [STEM] approach. Because technology has become a part of our lives, and I think it would be beneficial to use this technology that is so integrated into our lives in our education system". (P6)

As can be seen in Table 9, all teacher candidates who expressed their views indicated that they planned to use the STEM approach in science education. Teacher candidates coded P1, P2, P3, P7, P9, P10, and P11 most often stated that they would prefer to use the STEM approach in their future teaching, indicating that they believe it can be used in science education. The remaining participants coded P4, P5, P6 and P8 stated that they would consider using the STEM approach if certain physical conditions such as an appropriate environment, necessary materials and time were provided. Having established the teacher candidates' propensity to use the STEM approach, the reasons for their propensity were also observed. In this regard, the participants explained their reasons for using the approach as follows: project-based learning, promoting creativity and fostering productive individuals (P2), providing meaningful learning (P5), increasing interest in the classroom (P7), and integrating technology into the education system (P6).

4. Discussion and Conclusion

The aim of the study was to investigate the STEM awareness of pre-service science teachers based on their responses to a scale and semi-structured interview questions. The results showed that the participants were aware of the benefits of STEM education for students, teachers and the classroom. For a new teaching approach such as STEM education to be implemented, teachers must be aware of its positive and negative aspects and be convinced to use it. Therefore, for the STEM approach to be successfully implemented in teaching, it is essential that pre-service teachers are aware of the positive aspects of the STEM approach and are willing to integrate it into their teaching. The results of this study show that the pre-service teachers involved in the study have this awareness. Discussions of the critical findings and related literature are provided below.

4.1. STEM for Students

The study reveals that pre-service science teachers perceive STEM as highly beneficial for students, fostering higher-order thinking skills, confidence, motivation, active participation, sustained learning and the development of productive individuals (Aslan & Bektaş, 2019; Bakırcı & Kutlu, 2018; Eroğlu & Bektaş, 2016; Özdemir & Cappellaro, 2020; Doğan & Saraçoğlu, 2019; Türk & Korkmaz, 2023). Teachers play a pivotal role in shaping students' perceptions of STEM careers, and inadequate guidance may limit students' exposure to opportunities (Angle, Colston, French, Gustafson, O'Hara & Shaw, 2016). Teachers are undoubtedly the most important factor influencing student success. In order to increase the capacity of the STEM workforce, teachers need to shape their students' beliefs about future careers and occupational fields. If teachers do not inform students about career options, students will have little knowledge about many STEM career opportunities (Angle, Colston, French, Gustafson, O'Hara & Shaw, 2016). In order for teachers to show students how science is useful for future careers, they need to use this approach in their teaching.

Studies confirm that STEM enhances science education by promoting creativity and hands-on learning (Bakırcı & Kutlu, 2018; Özdemir & Cappellaro, 2020). However, challenges include time constraints, lack of materials, comprehension difficulties due to inexperienced teachers, disinterest among some students, and anxiety about product creation (Eroğlu & Bektaş, 2016; Özdemir & Cappellaro, 2020). Addressing these issues requires classroom adaptations for group work and access to equipped laboratories (Doğan, Savran Gencer & Bilen, 2017; Bakırcı & Kutlu, 2018). Overcoming these barriers is crucial for the role of STEM in skills development and economic contribution (Kartopu & Duran, 2023).

4.2. STEM for Teachers

Pre-service science teachers demonstrate high STEM awareness, aligning with literature findings of elevated awareness among teachers and pre-service teachers (Yaman & Aşılıoğlu, 2022; Özdemir, 2019). This awareness is essential for integrating STEM into education and guiding students toward STEM careers (Angle, Colston, French, Gustafson, O'Hara & Shaw, 2016). Benefits for teachers include personal growth, facilitating meaningful learning, assessing higher-order skills, integrating technology, and nurturing productive generations (Aslan & Bektaş, 2019; Özdemir & Cappellaro, 2020; Doğan & Saraçoğlu, 2019). STEM training boosts awareness, with studies noting improvements among participants in STEM-focused activities (Angle, Colston, French, Gustafson, O'Hara & Shaw, 2016; Dönmez, 2020; Holland, Knowles & Kelley, 2018; Şahin, 2019). Additional studies emphasize a productive, enjoyable teaching atmosphere and increased motivation (Aslan & Bektaş, 2019; Eroğlu & Bektaş, 2016; Özdemir & Cappellaro, 2020). In conclusion, the study aligns with existing literature and underscores STEM's contributions to assessing higher-order learning and developing productive individuals, indicating prospective teachers' readiness to implement STEM in their future practice.

Some challenges, such as time constraints, access to materials, classroom management and student guidance, were also identified by participants as making it difficult for teachers to implement STEM education. These findings are in line with the existing literature that identifies similar disadvantages such as material scarcity, high costs, time-intensive activities, and classroom management difficulties, especially in large classes (Aslan & Bektaş, 2019; Eroğlu & Bektaş, 2016; Özdemir & Cappellaro, 2020). However, in contrast to this study, other research suggests additional challenges for teachers lacking STEM training, such as knowledge gaps and a tendency to view STEM as a tool rather than a goal (Aslan & Bektaş, 2019; Eroğlu & Bektaş, 2016; Özdemir & Cappellaro, 2020; Özcan & Koştur, 2018). Some studies point to knowledge gaps among untrained teachers (Özcan & Koştur, 2018), highlighting the need for robust training.

4.3. STEM for Teaching

Pre-service science teachers express their readiness to adopt STEM in their teaching, valuing its project-based approach, creativity and enhancement of meaningful learning (Özdemir & Cappellaro, 2020; Doğan & Saraçoğlu, 2019; Eroğlu & Bektaş, 2016). While some studies report moderate awareness of the impact of STEM education due to limited experience (Yaman & Aşılıoğlu, 2022; Yaşar, 2021; Çevik, Danıştay & Yağcı, 2017; Dadacan, 2021; National Academies [NA], 2014), this study finds positive attitudes without uncertainty ($\bar{x}$: 3.78). As noted by Yaman and Aşılıoğlu (2022), a possible reason for the medium level of awareness of the impact of STEM on teaching in this study could be the lack of practical classroom experience of the pre-service science teachers involved. This lack of real classroom experience and lack of practical experience in delivering STEM-based lessons could explain the moderate level of awareness in this dimension.

The participants defined STEM as interdisciplinary and application-focused, which is in line with the literature that emphasises integration across disciplines (Bölükbaşı & Arı, 2019; Bakırcı & Kutlu, 2018; Eroğlu & Bektaş, 2016; Hacıoğlu, Karslı Baydere, Kocaman & Şahin Çakır, 2021; Uğraş, 2017). The value of STEM lies in fostering thinking skills, technical competence and real-world applications (Bölükbaşı & Arı, 2019; Bakırcı & Kutlu, 2018; Bybee, 2010). Practical experience gaps may limit implementation (Özdemir & Cappellaro, 2020), suggesting the need for enhanced teacher training with STEM courses and hands-on practice to improve effectiveness (Aktürk & Çalışkan, 2024; Çevik, 2018).

One of the themes reflecting pre-service science teachers' perspectives on STEM is their views on its importance. The pre-service science teachers' perspectives on the importance of the STEM approach, emphasising its role in developing higher-order thinking skills, teaching modern technological skills, linking theoretical knowledge to everyday life, promoting diverse problem solving, and changing negative attitudes towards science. These views are consistent with the existing literature, which similarly highlights the impact of STEM on higher-order thinking (Bölükbaşı & Arı, 2019; Bakırcı & Kutlu, 2018; Erdoğan & Çiftçi, 2017; Özcan & Koştur, 2018; Uğraş, 2017). Teachers' emphasis on practical application, multiple solutions and attitude change is also reflected in the research findings. For example, Bakırcı and Kutlu (2018) found that STEM enhances science education by making learning concrete, encouraging hands-on experience, enabling tangible product design, increasing engagement, and supporting long-term retention.

Suggestion The study investigated the STEM awareness of pre-service science teachers and their views on the STEM approach. The results show that the participants generally have a high level of STEM awareness and positive views of STEM. Based on the findings of the study, the following suggestions are made to guide future research in this area and to support educators.

The findings of this study indicate that participants perceive some contextual difficulties, such as lack of infrastructure and materials, and classroom-related difficulties, such as classroom management challenges and heavy teaching loads, as barriers to the implementation of STEM. Therefore, schools should ensure that necessary laboratory technologies, infrastructure and equipment are provided to both teachers and students to support STEM activities. In addition, collaboration with teachers from other disciplines could be a viable solution to classroom-related barriers. Schools should ensure that the necessary infrastructure and coordination are in place to support such collaboration.

Effective implementation of STEM requires teachers to have certain competencies. In the literature, the necessary competencies for teachers are discussed under the concept of STEM literacy, which includes STEM integration knowledge, pedagogical knowledge, 21st century skills and contextual knowledge. Supporting the STEM literacy of future teachers is essential for the success of STEM applications. In addition, ensuring the availability of the necessary infrastructure and technological resources in schools and in the wider educational context is equally important to enable STEM-literate teachers to implement the approach effectively in their teaching. In this context, activities and training focused on developing STEM literacy should be provided to prospective teachers to ensure their preparedness. Teachers should be trained to develop STEM lesson plans. This includes activities related to organising lessons, providing materials and preparing the classroom environment for STEM teaching.

The study found that participants believed that STEM activities require advanced materials, creating a perception that a lack of materials hinders the implementation of STEM. To address this perception, teacher candidates should experience STEM activities that can be carried out with simple and accessible materials, demonstrating that effective STEM teaching does not always require high-level resources.

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APPENDIXES

Appendix 1. Semi-structured interview quations

1. Which disciplines are related to science?
2. What is the relationship between science, technology, engineering, and mathematics?
3. How would you define STEM or its Turkish adaptation, FeTeMM?
4. Have you ever received STEM education? If yes, where and what kind of training did you receive? What are the benefits of the STEM education you received?
5. Do you think STEM-based science teaching can be used to strengthen science lessons in middle school?
6. What are the advantages of using STEM-based activities in science lessons from a teacher's perspective?
7. What are the advantages of using STEM-based activities in science lessons from a student's perspective?
8. What are the disadvantages of using STEM-based activities in science lessons from a teacher's perspective?
9. What are the disadvantages of using STEM-based activities in science lessons from a student's perspective?
10. during the implementation of STEM-based activities?

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Research Article

Adaptation of the Social Presence Scale into Turkish: A Validity and Reliability Study

Yalın Kılıç TÜREL[1], Mustafa ALPSÜLÜN *[2]

*Corresponding musalp@harran.edu.tr
[1]Fırat University, Türkiye
[2]Harran University, Türkiye

Abstract

This study aims to adapt the Social Presence Scale (SPS), developed by Kizilcec et al. (2015), into Turkish to measure perceptions of social presence in online learning environments. Social presence refers to individuals' ability to perceive the physical or psychological presence of others in a digital environment, which plays a significant role in fostering interaction, motivation, and engagement in learning processes. The study evaluates the validity and reliability of the Turkish version of the scale and its applicability in the Turkish context.The research was conducted with 221 associate degree students enrolled in a distance education program at a public university. The validity of the scale was tested using confirmatory factor analysis (CFA), confirming its single-factor structure. Fit indices (χ^2/df = 2.33, RMSEA = 0.065, CFI = 1.0) indicate a high level of model fit. Reliability analysis revealed a Cronbach's alpha value of 0.918, demonstrating a high level of internal consistency.The findings indicate that the Turkish version of the SPS is a valid and reliable instrument for measuring social presence in online learning contexts. This scale will serve as a valuable tool for evaluating social presence perceptions and their impact on learning processes.

Keywords: Social Presence Perception, Instructor presence, Validity and Reliability, Scale Adaptation

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Sosyal Varlık Ölçeğinin Türkçeye Uyarlanması: Geçerlik ve Güvenirlik Çalışması

Özet

Bu çalışma, çevrimiçi öğrenme ortamlarında sosyal varlık algısını ölçmek için Kizilcec ve arkadaşları (2015) tarafından geliştirilen Sosyal Varlık Ölçeği'nin (SVÖ) Türkçeye uyarlanmasını amaçlamaktadır. Sosyal varlık, bireylerin çevrimiçi bir ortamda diğer bireylerin fiziksel veya psikolojik varlığını algılama düzeyiyle ilişkilidir ve öğrenme süreçlerindeki etkileşim, motivasyon ve katılım gibi önemli değişkenler üzerinde etkili olduğu bilinmektedir. Çalışmada, ölçeğin Türkçe versiyonunun geçerlik ve güvenirlik analizleri gerçekleştirilmiş ve Türkiye bağlamında kullanımına uygunluğu değerlendirilmiştir.Araştırma, bir devlet üniversitesinde uzaktan eğitim programlarında öğrenim gören 221 ön lisans öğrencisi üzerinde yürütülmüştür. Ölçeğin geçerlik testi doğrulayıcı faktör analizi (DFA) ile yapılmış ve tek faktörlü yapısı doğrulanmıştır. Uyum indeksleri ($\chi^2/df = 2.33$, RMSEA = 0.065, CFI = 1.0), model uyumunun yüksek olduğunu göstermektedir. Güvenirlik analizi kapsamında Cronbach Alfa katsayısı 0.918 olarak hesaplanmış ve ölçeğin iç tutarlılığının oldukça yüksek olduğu ortaya konulmuştur.Elde edilen bulgular, SVÖ'nün Türkçeye uyarlanmış versiyonunun geçerli ve güvenilir bir ölçüm aracı olduğunu göstermektedir. Bu ölçek, özellikle çevrimiçi öğrenme ortamlarında sosyal varlık algısını değerlendirme ve bu algının öğrenme süreçleri üzerindeki etkilerini inceleme konusunda önemli bir araç sağlayacaktır.

Anahtar Kelimeler: Sosyal Varlık Algısı, Eğitmen Varlığı, Geçerlik ve Güvenirlik, Ölçek Uyarlama

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1. Introduction

In recent years, the proliferation of online education platforms has enabled educational processes to take place independently of spatial and temporal limitations and has radically transformed individuals' learning experiences. This transformation has been supported not only by technological tools but also by the design of learning environments that foster social interactions among learners. Social interaction, which plays a vital role in the success of online learning environments, increases learners' participation, motivation, and satisfaction in the learning process and also contributes positively to learning outcomes (Richardson & Swan, 2019). In this context, learners' perception of the presence of others in an online setting and their ability to establish a sense of connection play a critical role in understanding and improving the quality of educational processes. In the literature, this phenomenon is referred to as social presence.

Social presence refers to the degree to which individuals perceive the physical or psychological presence of others in a communication environment and the social bonds they form through this perception (Gunawardena ,1995). It serves several functions, such as reducing learners' sense of isolation and enhancing their interactions with instructors and peers, making it a significant variable in determining the quality of online learning environments (Tu & McIsaac, 2002). Studies have shown that a high level of social presence perception enhances learners' satisfaction, motivation, and engagement with course content (Song et al., 2015). However, the impact of social presence perception is not limited to these factors; it also contributes to learners' cognitive processes and their ability to concentrate on lessons (Gu et al., 2024).

Given the importance of social presence, it becomes essential to measure this construct accurately and reliably across different educational contexts. The Social Presence Scale (SPS), developed by Kizilcec et al. (2015), was designed to measure learners' perceptions of social presence in online learning environments. The scale specifically focuses on evaluating the impact of instructor visibility in online video-based courses.

Instructor visibility—whether constant or strategically timed—has been identified as an important factor influencing learners' perception of social presence. The literature frequently highlights the positive effects of the instructor's visible presence on student motivation and interaction in video lectures (Ng & Przybyłek, 2021). However, these effects do not always directly translate into improved learning performance. For instance, Ng and Przybyłek (2021) found that while instructor visibility increases motivation and the perception of social presence, its influence on learning outcomes remains limited. Similarly, Gu et al. (2024) reported that instructor visibility contributes to the learning process by enhancing students' visual attention.

These findings suggest that social presence is a strong predictor of learners' connection with the instructor and classroom participation, yet its impact on learning outcomes may vary based on contextual and individual differences.

Considering the growing importance of online education in Turkey and other non-English-speaking contexts, the adaptation of the SPS into Turkish is of particular importance. As online learning becomes more prevalent in Turkish higher education, there is a clear need for validated tools that can measure psychological constructs like social presence within local cultural and linguistic frameworks. Adapting the SPS into Turkish will enable researchers and practitioners to assess learners' perceptions more accurately and help improve the design and evaluation of online learning environments in Turkey.

Furthermore, a valid and reliable Turkish version of the SPS will facilitate experimental and descriptive studies, promote cross-cultural comparisons, and provide valuable insights into how social presence correlates with motivation, satisfaction, and learning outcomes in Turkish-speaking populations.

Social presence plays a crucial role in shaping learners' emotional, cognitive, and behavioral engagement in online learning environments. The development and adaptation of valid measurement tools such as the SPS are vital to enhancing online learning practices and designing socially rich digital learning spaces. Thus, adapting the SPS into Turkish and analyzing its psychometric properties constitutes a critical step toward promoting effective online education in Turkish contexts.

2. Method

2.1. Participants

In this study, the convenience sampling method was preferred in determining the participants. Convenience sampling is a method that ensures that individuals who are suitable for the purposes of the study and easily accessible are included in the sample (Büyüköztürk, 2017).

Within the scope of adapting the SPS to Turkish, after the completion of the translation and language equivalence process, data were collected from associate degree students studying in distance education programs at a state university in order to perform the validity and reliability tests of the scale. In this process, the data of a total of 221 students were analyzed.

During the data collection process, no information that could reveal personal or identity information was requested from the participants. Throughout the study, great importance was given to participant confidentiality within the framework of ethical rules. Participation in the study was based entirely on a voluntary basis and the participants were informed about the process. All stages of the study were carried out in accordance with scientific and ethical principles. This approach aimed to ensure both the scientific validity and ethical integrity of the study. Accordingly, the demographic data of the participants are given in Table 1.

Table 1.

Demographic Data of Participants

Variable	Category	f	%
Gender	Female	130	58.8
	Male	91	41.2
Age	18 or below	7	3.2
	19-23	174	78.7
	24-28	26	11.8
	29-33	2	0.9
	34 and above	12	5.4
Device Used	Computer	33	14.9
	Phone	185	83.7
	Tablet	3	1.4

2.2. Instrument and Application

SPS, was developed by Kizilcec et al. (2015) to assess participants' perception of social presence in online learning environments. The scale consists of five items in total and aims to measure the extent to which participants establish social interaction and feel "there" during the online learning process. Each item is evaluated with a five-point Likert scale (ranging from 1 = "Strongly Disagree" to 5 = "Strongly Agree"). This scale was developed to examine the effects of social presence perception on the learning process in online education and has a single-factor structure. The original version of the scale was calculated as Cronbach's Alpha = 0.72 in reliability analyses and it was stated that it exhibited sufficient internal consistency. In addition, the validity of the scale was examined with confirmatory factor analysis and it was concluded that it was a suitable tool for measuring social presence.

In the adaptation process to Turkish, the study was initiated after obtaining the necessary permissions from the researchers who developed the scale. The original scale was translated into Turkish by the researchers and both the original and Turkish versions were evaluated by four field expert faculty members in terms of language and content suitability. In the language equivalence study, the original English form was first applied to 18 English teacher candidates who were fluent in English and Turkish, and then the Turkish version was applied two weeks later. The obtained data were evaluated with Pearson product-moment correlation analysis and a high level positive relationship was found between the original English form and the Turkish form of SPS ($r = 0.912$, $p < 0.01$). In the next stage of the adaptation process, the scale translated into Turkish was applied to 221 students for validity and reliability analyses.

2.3. Data Analysis

Data were analyzed using confirmatory factor analysis (CFA) using IBM SPSS AMOS software (version 21.0). CFA was used for validity testing, and Cronbach alpha coefficients, which calculate internal consistency coefficients, were used for reliability testing. Confirmatory factor analysis during scale adaptation is a statistical method that is used to test the adapted scale and is sufficient as long as no new items are added to the scale or items are removed from the scale as a result of adaptation (Büyüköztürk et al., 2017; Tabachnick et al., 2013). Therefore, it was not deemed necessary to perform exploratory factor analysis (EFA) during the Turkish adaptation process of SPS. In addition, the original version of the scale was developed by Kizilcec et al. (2015) and its factor structure was previously evaluated within the scope of validity and reliability analyses. CFA is accepted as a sufficient and appropriate statistical method in the adaptation process to another language (Büyüköztürk et al., 2017; Tabachnick et al., 2013).

Before data analysis, the assumptions required for CFA were tested with IBM SPSS software. The first assumption required for the application of CFA is sufficient sample size. There are different approaches to sample size in the literature. While Guilford (1954) states that sufficient sample size should be more than 200, Hair et al. (2010) state that at least 5 participants are required for each item. In addition, MacCallaum et al. (1999) emphasize that at least 10 participants are sufficient for each item. Since SPS contains a total of 5 items, sufficient sample sizes should be 200, 25 and 50, respectively, according to these approaches. A total of 221 participants' data were analyzed within the scope of the study, and this shows that the sufficient sample size condition was met.

3. Results

The findings obtained according to the data analysis results are explained in order, firstly the findings related to validity, then the findings related to reliability, in line with the purposes of the study.

3.1. Validity

For the validity test, confirmatory factor analysis was performed with IBM SPSS AMOS software 21st version. For the Turkish scale's estimation model, chi-square ($\chi 2$) and the root mean square error of approximation (RMSEA), standardized root mean square error (SRMR), goodness of fit index (GFI), comparative fit index (CFI) and Tucker-Lewis index (TLI) were used. The analysis results obtained are presented in Table 2 in detail.

Table 2.

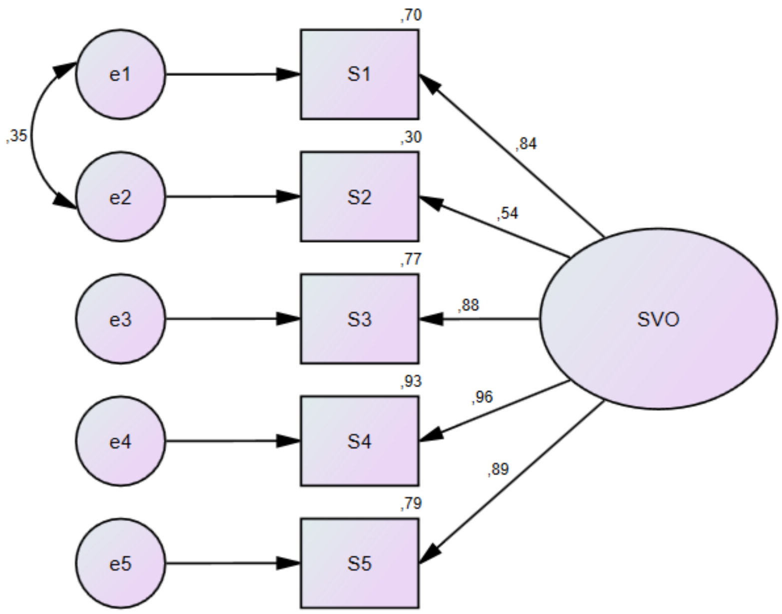
Fit Indices Criteria for CFA and Fit Indices of the Social Presence Scale

Fit Index Values	Excellent Value	Acceptable Value	Adjusted Scale
χ^2/df	≤3	≤5	2.33
RMSEA	≤.05	≤.08	.065
SRMR	≤.05	≤.08	.028
TLI	≥.95	≥.90	.94
CFI	≥.95	≥.90	1.0
GFI	≥.95	≥.90	.99
NFI	≥.95	≥.90	.99

As a result of the adapted SPS's CFA analysis, the $\chi 2$/df value was found to be 2.33, which is below the acceptable limit of 5. The RMSEA value was determined as .065, which is below the acceptable upper limit of .08, and shows that the scale has a good fit. The SRMR value was .028, which is below the perfect value of .05, which indicates that the fit is quite high. When the other fit values of the scale are examined, the TLI value was determined as .94, which is quite close to the acceptable value. The CFI value was calculated as 1.0, which falls into the perfect fit category. The GFI value was .99 and the NFI value was .99; these values reveal that the general structure of the scale has a very strong fit. Therefore, the model and factors obtained in line with the CFA results of the adapted scale were confirmed to be the same as the original scale, and the validity of the adapted scale was ensured (Çokluk et al. 2010; Tabachnick et al., 2013).

Figure 1.

Social Asset Scale CFA Path Diagram



When the item-structure parameters are examined in Figure 1, it is seen that the standardized factor loadings related to the dimension of the relevant model vary between 0.54 and 0.96. It was determined that the factor loadings were statistically significant according to the t-value test (Tabachnick and Fidell, 2001). The item-total correlation values are between 0.30 and 0.93. The value of .30 stated by Büyüköztürk et al. (2020) is accepted as a sufficient criterion for item-total correlation. When this criterion is taken into consideration, it was concluded that the scale items exhibited a strong fit with each other, and the internal consistency of the scale was high. Therefore, the scale was finalized without removing any items and a consistent structure was provided among the items.

3.2. Reliability

For the reliability test of the SPS adapted to Turkish, internal reliability was examined with Cronbach alpha coefficient values. The findings are given in Table 3.

Table 3.

Reliability Values of the Social Presence Scale

Faktoc	**Cronbach's Alpha Coefficient**
Social Presence	0.918

Cronbach alpha coefficient for the entire scale was found to be 0.918. The reliability of the scale adapted to Turkish was ensured. As a result, the Social Presence Scale was found to be valid and reliable, and it can be said that it is an acceptable and appropriate scale.

4. Discussion and Conclusion

The findings obtained during the adaptation of the Social Presence Scale (SPS) into Turkish demonstrate that the scale preserves its original structure and functions as a valid and reliable measurement tool. The confirmatory factor analysis (CFA) supported the one-factor structure of the original scale and yielded acceptable fit indices ($\chi^2/df = 2.33$, RMSEA = 0.065, CFI = 1.0). These values are in line with the psychometric standards recommended in the literature (Hair et al., 2010; Tabachnick et al., 2013). In addition, the high internal consistency coefficient (α = .918) provides further evidence of the scale's reliability. In this respect, it can be concluded that the Turkish version of the SPS is a robust instrument for reliably measuring perceptions of social presence.

One of the major contributions of this study is that it introduces a culturally and linguistically adapted tool for assessing social presence in Turkish online learning environments. In an era when online education is rapidly expanding in Türkiye, especially in higher education, the availability of contextually appropriate instruments has become increasingly critical. The fact that the scale could be adapted without adding or removing any items from its original version also supports the cross-cultural validity of the social presence construct.

Social presence is widely recognized as a core variable influencing the quality of online learning environments. Numerous studies have shown that social presence enhances learners' satisfaction, motivation, and engagement (Richardson & Swan, 2019; Song et al., 2015). More recent studies have also emphasized that social presence not only affects emotional engagement but contributes to learners' cognitive processes, such as sustained attention and focus. For instance, Gu et al. (2024) found that learners with a stronger perception of social presence exhibited greater levels of attentional focus during learning activities. In this context, the measurement of social presence contributes to a more holistic evaluation of both social and cognitive dimensions of online learning.

The visibility of the instructor in online video lectures has emerged as a particularly influential factor in shaping perceptions of social presence. Ng and Przybyłek (2021) reported that the presence of the instructor on screen increased students' motivation and sense of connection, although these improvements did not always translate directly into measurable learning outcomes. Similarly, Kizilcec et al. (2015) emphasized that instructor visibility plays a critical role in enhancing students' feelings of connection with the instructor, while Gu et al. (2024) demonstrated that it improves learners' visual attention. These findings suggest that the SPS can be a particularly useful instrument in experimental studies exploring instructor visibility in online video-based courses.

In the Turkish context, the SPS could be employed in studies comparing synchronous and asynchronous learning environments to examine how social presence varies across different modes of delivery. In addition, it may be used to evaluate the effects of different video design strategies—such as constant, intermittent, or learner-controlled instructor visibility—on learners' perception of social presence. Given the growing interest in user-controlled learning environments, this presents a valuable avenue for future research. Moreover, the SPS can be used in combination with eye-tracking methods to investigate how learners visually respond to social cues and how these responses relate to their social presence perceptions. Such multimodal research approaches could deepen our understanding of the behavioral and cognitive mechanisms underlying learner engagement in online settings.

The scale can also inform the design of socially enriched online learning environments by helping identify which visual and verbal cues (e.g., facial expressions, gestures, instructor feedback) most effectively foster presence and engagement. Furthermore, since social presence is closely linked with satisfaction and motivation, SPS data can support institutional efforts to improve teaching quality by evaluating student perceptions across various course designs. In this way, empirical, data-driven improvements to instructional strategies in Türkiye can be realized.

Ultimately, this study represents not only the adaptation of a measurement tool but also a critical step toward the scientific investigation of social presence in Turkish online learning environments. The Turkish version of the SPS provides both researchers and practitioners with a reliable instrument for designing more socially engaging learning experiences and lays the groundwork for future empirical and applied research in the local context.

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ITALL

Research Article

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The Role of a Brain Game in Eliminating Misconceptions in Geometry and Measurement

Aslı Nur HODANCI *[1], Mihriban HACISALİHOĞLU KARADENİZ [2]

* *Corresponding Author, hodanci75@gmail.com*

[1] *Giresun University, Türkiye*

[2] *Giresun University, Türkiye*

Abstract

The aim of this study is to determine the role of the Tik Tak Bomm intelligence game, adapted to mathematics, in addressing misconceptions related to Geometry and Measurement concepts among prospective elementary mathematics teachers. The research, which utilized the teaching experiment method, was conducted with 31 prospective elementary mathematics teachers (25 females and 6 males) who were in their third year at a university in the Eastern Black Sea region. Data were collected through the Misconception Diagnosis Test 1-c, the Tik Tak Bomm intelligence game application, the Misconception Diagnosis Test 2-c, and unstructured interviews (informal conversations). Initially, Misconception Diagnosis Test 1-c was administered to diagnose the teacher candidates' misconceptions related to mathematical concepts. Subsequently, the Tik Tak Bomm intelligence game, adapted to mathematics, was applied to address the identified misconceptions. Following the game application, Misconception Diagnosis Test 2-c, which was prepared in parallel with the misconception diagnosis tests, was administered to the teacher candidates. Based on the data obtained from this test, the role of the Tik Tak Bomm intelligence game in mitigating misconceptions was determined. The analysis of the misconception diagnosis tests was conducted using the Three-Tier Test's Conceptual Categories within the context of descriptive analysis. The results of the study revealed that the teacher candidates had numerous misconceptions regarding Geometry and Measurement concepts and that these misconceptions could be addressed through the application of the Tik Tak Bomm intelligence game adapted to mathematics.

Keywords: Misconceptions, Correction of misconceptions, Intelligent games, Tik Tak Bomm intelligence game adapted to mathematics, Prospective elementary mathematics teachers

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Geometri ve Ölçmedeki Kavram Yanılgılarının Giderilmesinde Bir Zekâ Oyununun Rolü

Özet

Bu araştırmanın amacı, ilköğretim matematik öğretmeni adaylarının Geometri ve Ölçme kavramlarına ilişkin kavram yanılgılarının giderilmesinde, matematiğe uyarlanan Tik Tak Bomm zekâ oyununun rolünü belirlemektir. Öğretim deneyi yönteminin kullanıldığı araştırma, Doğu Karadeniz'deki bir üniversitenin 3. sınıfında öğrenim görmekte olan 25 kız, 6 erkek toplam 31 ilköğretim matematik öğretmeni adayı ile gerçekleştirilmiştir. Veriler, Kavram Yanılgıları Teşhis Testi 1-c, Tik Tak Bomm zekâ oyunu uygulaması, Kavram Yanılgıları Teşhis Testi 2-c ve yapılandırılmamış görüşme (ayaküstü görüşme) kullanılarak toplanmıştır. Araştırmada ilk olarak öğretmen adaylarının matematik kavramlarına ilişkin kavram yanılgılarını teşhis etmek amacıyla Kavram Yanılgıları Teşhis Testi 1-c uygulanmıştır. Sonrasında teşhis testinde tespit edilen kavram yanılgılarının giderilmesine yönelik olarak belirlenen Tik Tak Bomm zekâ oyunu matematiğe uyarlanmış ve öğretmen adaylarına uygulanmıştır. Zekâ oyunu uygulamasının ardından kavram yanılgısını teşhis testlerine paralel bir biçimde hazırlanan Kavram Yanılgıları Teşhis Testi 2-c öğretmen adaylarına uygulanmıştır. Bu testten elde edilen verilere göre, Tik Tak Bomm zekâ oyununun kavram yanılgılarını gidermedeki rolü belirlenmiştir. Kavram yanılgıları teşhis testlerinin analizi, betimsel analiz yöntemi bağlamında Üç Aşamalı Testin Kavramsal Kategorileri ile gerçekleştirilmiştir. Araştırma sonucunda, öğretmen adaylarının Geometri ve Ölçme kavramlarına dair birçok kavram yanılgısına sahip oldukları ve matematiğe uyarlanan Tik Tak Bomm zekâ oyunu uygulamaları ile bu yanılgıların giderilebildiği belirlenmiştir.

Anahtar Kelimeler: Kavram yanılgıları, Kavram yanılgılarının giderilmesi, Zekâ oyunları, Matematiğe uyarlanan Tik Tak Bomm zekâ oyunu, İlköğretim matematik öğretmeni adayları

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1. Introduction

Concepts are cognitive structures that enable learning to be easily understood and the basis of learning to be formed by associating what is learned with previously formed concepts in the mind. (Senemoğlu, 2018). If we liken conceptual knowledge to a chain, each link contains a piece of information. As related pieces of information increase, the chain expands, and each link becomes more meaningful, thus adding significance to the concepts that form the chain. Therefore, the expansion of conceptual knowledge can be achieved by strengthening the structural connections between pieces of information (Hiebert & Lefevre, 1986). When we consider this analogy in the context of mathematical concepts, it is evident that mathematics has a spiral structure, where understanding certain topics and concepts often requires the comprehension of related concepts. Teaching mathematical concepts is essential for students to grasp mathematics, as well as to determine what types of knowledge and techniques they utilize in problem-solving; this necessitates an explanation of conceptual mathematics learning (Baki & Kartal, 2004). At this point, conceptual knowledge involves not only knowing the name and definition of a concept but also understanding the relationships between concepts. The existence of relationships between concepts indicates that individual concepts do not convey meaning in isolation. As in all disciplines, prior knowledge in mathematics forms a foundation for new learning. Skemp (1971) stated that understanding a concept can only occur when complete prior knowledge is properly connected with new information. On the other hand, Van de Walle (2013) stated that doing mathematics is different from the traditional addition, subtraction, multiplication, and division, so it is not a pile of operations. In the same study, it was highlighted that doing mathematics involves understanding it, making assumptions, hypothesizing, and explaining reasoning through logical thinking, and that students often struggle with this concept, leading to difficulties in mathematics. These difficulties escalate, and misconceptions formed from incorrect learning eventually become problematic for students, leading to the development of misconceptions (MC).

Misconceptions (MC), defined as "student understanding that systematically produces errors" (Smith, Disessa, & Roschelle, 1994), arise due to various factors such as deficiencies in prior knowledge, incorrect and incomplete use of scientific language, and inability to relate concepts to each other and to everyday life (Chi, 1992). According to Akkaya and Durmuş (2006), MC emerge subjectively as a result of incomplete and incorrect learning, and due to their weak foundations, they occur in a way that contradicts conceptual learning. A review of the literature reveals that students, prospective teachers, and even in-service teachers possess numerous MC. The fact that prospective teachers and, subsequently, in-service teachers hold MC about the concepts they teach indicates that it is inevitable for students to develop MC as well. Therefore, it is essential to focus on how to correct MC to support, develop, improve, and strengthen the concept teaching process. The assertion that MC negatively affect students' learning (Hewson & Hewson, 1984) supports this idea. According to Eryılmaz and Sürmeli (2002), for a student's or prospective teacher's thought to be considered a MC, it must meet three consecutive criteria: First, the student's thought must be scientifically incorrect; second, the student must provide justifications to defend this incorrect thought; and third, the student must be confident in their responses and explanations. The crucial point here is that mistakes and MC are distinct phenomena. A mistake is explained as the incorrect use of mathematical expressions, or errors in operations or calculations (Erbaş et al., 2010). While incorrect student responses sometimes indicate a mistake, they may also reveal a MC. The reasons behind the student's mistake-whether they are confident in their answer, whether it stems from carelessness, etc.-can determine whether the student holds a MC. In conclusion, students may frequently make mistakes in problem-solving; however, when students rationalize their mistakes and confidently explain them as correct, it indicates the presence of a MC (Altan, 2023). MC are resistant to change and correction because students replace scientific facts with the incorrect or incomplete knowledge they have learned for various reasons. To enable students to abandon incorrect and incomplete knowledge and acquire accurate information, MC must first be identified and then targeted for elimination. The first step in this process is to detect the gaps in knowledge and MC (Ryan & Williams, 2007). Subsequently, appropriate methods and techniques are developed to address these gaps and MC. Finally, through the application of these methods and techniques, efforts are made to correct the MC.

A review of the literature reveals that various instructional methods and techniques have been employed to address MC. Some of these include conceptual change teaching (Cankoy, 1998), activity-based instruction (Akkaya, 2006; Anıl, 2007; Erdem, 2017; İşçi, 2019), game-based activities (Akkaya, 2018), and concept cartoons (Kaplan, Altaylı & Öztürk, 2014; Sancar, 2019; Yürekli, 2020). More specifically, Cankoy (1998), in his study with prospective elementary school teachers, showed that conceptual change instruction was effective in terms of eliminating the MC that the candidates had in interpreting and applying decimal representations of a number. It was stated that activity-based instruction used in eliminating MC had a positive effect on sixth-grade (Akkaya, 2006) and seventh-grade (Erdem, 2017) students' CK in the Algebra learning domain, tenth-grade students' MC in the concept of absolute value (Anıl, 2007), and eighth-grade students' MC in the concept of linear equations (İşçi, 2019). In addition, Akkaya (2018) found that as a result of five-week game-based concept teaching to fourth-grade elementary school students, game-based teaching had a positive effect on eliminating the MCs of students. Kaplan, Altaylı, and Öztürk (2014), who conducted a study to determine the misconceptions of eighth-grade students about square root expressions and to compare concept cartoon and traditional teaching in eliminating these misconceptions, determined that concept cartoon and traditional teaching were effective in eliminating misconceptions and that concept cartoon was more effective in eliminating misconceptions. Sancar (2019), in his study on the elimination of fifth grade students' misconceptions about triangles and quadrilaterals, revealed that concept cartoons can be used to eliminate students' misconceptions and positively affect their attitudes towards mathematics. Finally, Yürekli (2020) found that seventh-grade students had MCs about operations with integers in subtracting a positive integer from a negative integer, subtracting two negative integers from each other, multiplication of integers, and division of integers by 0. In the same study, it was concluded that these MSs could be partially eliminated with concept cartoons. The critical aspect here is that the chosen method or technique must be appropriate for the concept, prepared in a way that supports learning, and capable of replacing MC, which are often resistant to change, with scientific knowledge. It is believed that intelligence games, which aid in the development of various skills, including mathematical process skills such as reasoning, correlation, problem-solving, and communication, can be used as a means to achieve this goal. The Middle School and Imam Hatip Middle School Intelligence Games Course Curriculum highlights that intelligence games can be effectively used to enhance students' mental capacities and skills through various games and activities (Ministry of National Education [MoNE], 2013). In this study, a selected intelligence game was adapted to mathematical concepts based on the belief that intelligence games help develop critical thinking, quick and accurate decision-making, reasoning, correlation, and problem-solving skills. However, it was found that no studies have addressed the use of intelligence games to eliminate MC, and more specifically, no studies have used an intelligence game adapted to mathematics. Elucidating the relationship between addressing MC and the use of intelligence games adapted to mathematics will provide important insights into the development of these skills and the correction of incorrect or incomplete concept instruction. Therefore, research demonstrating the potential of intelligence games adapted to mathematics to correct MC held by prospective elementary mathematics teachers is of particular significance. On the other hand, it has been observed that prospective teachers hold MC in topics such as statistics (Sevimli, 2010), functions (Özkaya & İşleyen, 2012), irrational numbers (Adıgüzel, 2013), and probability (İlgün, 2013). Additionally, topics like symmetry (Hacısalihoğlu Karadeniz, Baran-Kaya & Bozkuş, 2017), angles (Demirci, 2022), variables (Dinçer, 2022), and triangles (Şimşek-Altıparmak, 2022) are other areas where prospective teachers exhibit MC. In this context, it can be stated that while the majority of studies in the literature focus on identifying MC, there is a lack of research aimed at correcting them. Consequently, this study was motivated by the desire to address the MC that prospective teachers hold regarding concepts by implementing an intelligence game adapted to mathematics, and to explore the role it may play. Hence, the research question of the current study was formulated as follows: "What is the role of the Tik Tak Bomm intelligence game adapted to mathematics in addressing the MC that prospective teachers have regarding Geometry and Measurement concepts?"

1. What are the MCs that prospective elementary mathematics teachers hold regarding concepts in Geometry and Measurement?

2. What is the role of the Tik Tak Bomm intelligence game, adapted to mathematics, in addressing the MCs held by prospective teachers?

2. Method

2.1. Research Model

Qualitative research is defined as a research process that uses propositions, perspectives and theoretical approaches as much as possible, focusing on social or individual problems and the groups associated with them (Creswell, 2007). Additionally, Patton (1990) explains qualitative research as providing detailed and rich information to the researcher despite working with a small group. Therefore, this study was conducted in accordance with qualitative research methods, as it aims to reveal the process that prospective teachers undergo in their own environment in alignment with the research objectives. In this context, the teaching experiment method was chosen because the study aims to examine students' mental processes and involves new classroom applications. The teaching experiment is an instructional-based approach in which students closely experience what their mathematical knowledge is during the mathematics teaching process and how this knowledge changes in the designed instructional process (Czarnocha & Maj, 2008). Within the context of mathematics education, the teaching experiment is defined as a dynamic method designed to elicit and understand participants' mathematical activities in order to directly experience their mathematical learning (Steffe & Thompson, 2000). Through this method, the instructional phases identified, new approaches, or techniques can be implemented in a natural setting, allowing for an in-depth examination of the situations affecting participants' cognitive, affective, and conceptual development, as well as how these aspects evolve, change, or take shape, and actively engaging in the participants' mental processes (Steffe & Thompson, 2000; Engelhardt et al., 2004). The stages followed during the teaching experiment process of this research are detailed below:

- Studies in the literature were reviewed in the context of the MCs that prospective teachers hold regarding the relevant concepts. Considering these MC and potential MCs that may emerge differently, the Misconception Diagnostic Test 1-c (MDT1-c) and its parallel, Misconception Diagnostic Test 2-c (MDT2-c), were developed to identify participants' MCs.
- Based on the analysis of MDT1-c administered to the participants, the instructional process, content, and materials of the Tik Tak Bomm intelligence game, adapted to mathematics, were planned.
- The Tik Tak Bomm intelligence game was implemented, MDT2-c was administered at the end of the process, and the data were collected.
- Following the implementation process, inferences were made and evaluated regarding the MCs that emerged among the prospective teachers. Consequently, the role of the Tik Tak Bomm intelligence game adapted to mathematics in addressing MCs was determined.

2.2. Participants

The participants of the study consist of 31 prospective elementary mathematics teachers (25 female and 6 male) enrolled in the third year at a university in the Eastern Black Sea region. Purposive sampling, a non-probability sampling method, was used to select the participants. In purposive sampling, the aim is to collect in-depth information in a way that serves the specific purpose of the study concerning the individuals, events, or situations constituting the research topic (Maxwell, 1996). When selecting the participants for the study, it was considered that they had prior knowledge of the mathematical concepts being addressed and were familiar with games adapted to mathematics. Consequently, the participants are prospective teachers who have taken the course "Mathematics Teaching through Games," which includes traditional children's games adapted to mathematics. For ethical reasons, the participants' names are kept confidential and are coded as P_1, P_2, …, P_{31}.

2.3. Data Collection Tools

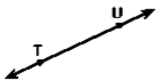
The data for this study were collected using the Misconception Diagnostic Test 1-c (MDT1-c), the Tik Tak Bomm intelligence game adapted to mathematics, the Misconception Diagnostic Test 2-c (MDT2-c), and informal interviews (brief interviews). The use of multiple data collection tools in the study aims to obtain more in-depth data.

2.3.1. The Misconception Diagnostic Test 1-c (MDT1-c)

The Misconception Diagnostic Test 1-c (MDT1-c) was prepared using relevant questions selected from the sources provided in Table 1 and questions created by the researcher. It was then reviewed by an expert faculty member in the field. Based on the expert's feedback, one question was removed from the diagnostic test before its application. This diagnostic test covers the concepts of Basic Geometric Concepts, Circles and Discs, and Triangles and Polygons. Table 1 provides information on the content of each question in MDT1-c, including the knowledge and cognitive process dimensions, as well as the misconceptions intended to be measured by each question.

Table 1

Content of MDT1-c questions

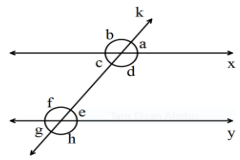
<table>
<tr><th>Questions and Misconception Measured by the Question</th><th>Questions and Misconception Measured by the Question</th><th>Questions and Misconception Measured by the Question</th><th>Questions and Misconception Measured by the Question</th><th>Questions and Misconception Measured by the Question</th></tr>
<tr>
<td>Q1. Write the name and symbolic representations of the model below. Please explain your answer.


....
Created by the researcher.
A) Sure B) Not Sure

Q2. Write the name and symbolic representations of the model below. Please explain your answer.


....
Created by the researcher.
A) Sure B) Not Sure

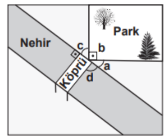
Q3. Write the name and symbolic representations of the model below. Please explain your answer.</td>
<td>Q4. Chess is a strategy game played with pieces of different characteristics, such as pawns, knights, bishops, and rooks. In this game, each piece has different movement properties.

For example, the movement of the knight is in an L-shape.
Specifically:
1.One unit to the right or left and two units up
2.One unit to the right or left and two units down
3.One unit up and two units to the right or left
4.One unit down and two units to the right or left
Based on this information, list all the squares where the knight can move, given its position on the board. Please explain your answer.
<table><tr><td>Current Position</td><td>Possible Moves</td></tr></table></td>
<td>Q8.


x // y
Line k intersects the lines x and y at two different points. Determine the types of angles listed below. Please explain your answer.
Corresponding Angles:
EBA Study Booklet (URL-1)
A) Sure B) Not Sure

Q9. Vertical Angles:
Please explain your answer.
EBA Study Booklet (URL-2)
A) Sure B) Not Sure

Q10. Interior Alternate Angles:
Please explain your answer.
EBA Study Booklet (URL-2)
A) Sure B) Not Sure

S11.Alternate Exterior Angles
Please explain your answer.
EBA Study Booklet (URL-2)</td>
<td>Q15. According to the given diagram, which angles are supplementary?
Explain your answer.


SBS (URL-3)
A) Sure B) Not Sure

Q15, The focus in S15 was on determining the participants' misconceptions regarding the concept of supplementary angles by measuring their understanding of angles whose measures sum up to 90º according to the given model. The selection of this question was guided by the anticipation that participants might confuse supplementary angles with angles that measure 90°, and that they might encounter difficulties distinguishing between these concepts.</td>
<td>Q19. Bangle
Circle/Disk
Explain your answer.
Created by the researcher.
A) Sure B) Not Sure

Q20. Bagel
Disk/Circle
Explain your answer
Created by the researcher.
A) Sure B) Not Sure

Q21. Plate
Disk/Circle
Explain your answer
Created by the researcher.
A) Sure B) Not Sure

Q22. Ring
Disk/Circle
Explain your answer
Created by the researcher.
A) Sure B) Not Sure

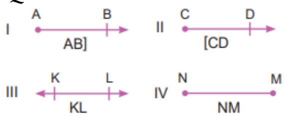
Q23. Hula hoop
Disk/Circle
Explain your answer
Created by the researcher.</td>
</tr>
</table>

……………………………

Created by the researcher.

A) Sure B) Not Sure

Q7.



Which of the above symbols are correct? Please explain your answer.

EBA Study Booklet (URL-1)

A) Sure B) Not Sure

In Q1, Q2, Q3, and Q7, it was intended to determine whether participants have misconceptions related to understanding and identifying the symbols and names of lines, line segments, and rays. This is based on the idea that the concepts of line and line segment might be used interchangeably, indicating potential gaps in participants' prior knowledge.

of the Piece	
c3	

EBA Study Booklet (URL-1)

A) Sure B) Not Sure

Q5. Explain your answer.

Current Position of the Piece	Possible Moves
d4	

EBA Study Booklet (URL-1)

A) Sure B) Not Sure

Q6. Explain youur answer.

Current Position of the Piece	Possible Moves
d7	

EBA Study Booklet (URL-1)

A) Sure B) Not Sure

In Q4, Q5 and Q6, the focus is on the general knowledge regarding the position of one point relative to another. The aim is to identify any gaps or misconceptions in the participants' understanding in this area, thereby revealing any conceptual errors. The selection of these questions was influenced by the expectation that participants might struggle with correctly

A) Sure B) Not Sure

Q12. Interior Angles:

Explain your answer.

EBA Study Booklet (URL-2)

A) Sure B) Not Sure

Q13. Exterior Angles:

Explain your answer.

EBA Study Booklet (URL-2)

A) Sure B) Not Sure

Q14. Adjacent Angles:

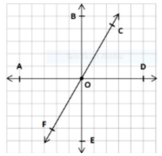
Explain your answer.

EBA Study Booklet (URL-2)

A) Sure B) Not Sure

Q8, Q9, Q10, Q11, Q12, Q13, and Q14 focus on the participants' knowledge of angle classifications and aim to identify their KY. In this context, it was anticipated that vertical angles might be confused with interior alternate and exterior alternate angles. Additionally, systematic errors were expected to arise from misunderstandings related to interior alternate angles being confused with interior angles, and exterior alternate angles being confused with exterior angles.

Q16.



In the figure, the lines AD, BE, and CF intersect at point O. Based on the given information, list three acute angles, three right angles, and three obtuse angles. Provide your answers with explanations.

EBA Study Booklet (URL-1)

A) Sure B) Not Sure

Q17. Right Angles

Explain your answer.

EBA Study Booklet (URL-1)

A) Sure B) Not Sure

Q18. Acute Angles:

Explain your answer.

EBA Study Booklet (URL-1)

A) Sure B) Not Sure

In Q16, Q17, and Q18, the aim was to identify the participants' misconceptions regarding the classification of angles. The selection of these questions

A) Sure B) Not Sure

Q24. Wheel

Disk/Circle

Explain your answer

Created by the researcher.

A) Sure B) Not Sure

Q25. Button

Disk/Circle

Explain your answer

Created by the researcher.

A) Sure B) Not Sure

Q26. Coin

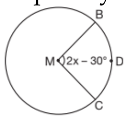
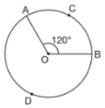
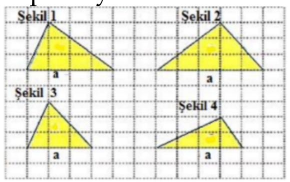
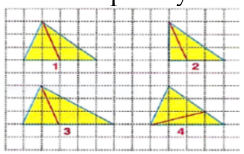
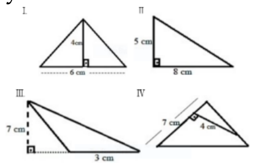
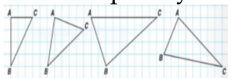
Disk/Circle

Explain your answer

Created by the researcher.

A) Sure B) Not Sure

In Q19, Q20, …, Q26, the aim is to identify MCs related to participants' examples of the concepts of circle and disk in everyday life situations.

	identifying reference points or making errors in direction and unit counting or calculation.		considered that participants might confuse the concepts of acute angle and obtuse angle as having the same meaning and might face difficulties in identifying the types of angles within a given coordinate system.	
Q27. The diameter of a circle with a radius of 6 cm is 12 cm. T/F Explain your answer Created by the researcher. A) Sure B) Not Sure Q28. The diameter of a circle is half the length of its radius. T/F Explain your answer Created by the researcher. A) Sure B) Not Sure Q29. The distance from the center of a circle with a diameter of 12 cm to the circumference is 12 cm. T/F Explain your answer Created by the researcher. A) Sure B) Not Sure Q30. The center of a circle is equidistant from every point on the circle. T/F Explain your answer Created by the researcher. A) Sure B) Not Sure	Q34. In the following circle centered at m $(\widehat{BMC})$ = 2x-30º ve m(BDC) = x+35º ise m(BDC)? Explain your answer.  The mathematics textbook approved by the Board of Education A) Sure B) Not Sure Q35. In the following O centered circle, if m(AOB)=120∘ and |ACB|=20 cm calculate the circumference of the circle. Please explain your answer.  The mathematics textbook approved by the Board of Education A) Sure B) Not Sure	Q38. Which of the triangles placed on the unit squares of the floor has a different length for the height corresponding to side aaa compared to the others? Please explain your answer.  Kaya (2018) A) Sure B) Not Sure Q39. Which of the triangles placed on the grid of unit squares has a median drawn to one of its sides? Please explain your answer.  Kaya (2018) A) Sure B) Not Sure	Q41. Which of the triangles given below cannot have its area calculated using the provided information on the figure? Explain your answer.  Altıparmak (2022) A) Sure B) Not Sure Q42. Which of the following shapes represents a right triangle? Please explain your answer.  Altıparmak (2022) A) Sure B) Not Sure In Q41 and Q42, the aim was to investigate whether participants have KY regarding the relationship between the area of a triangle and the correct drawing of its height, as well as their ability	Q47. d. A pentagon has six vertices. Please explain your answer. Created by the researcher. A) Sure B) Not Sure Q48. e. A diagonal of a polygon is drawn by connecting two non-adjacent vertices. Please explain your answer. Created by the researcher. A) Sure B) Not Sure Q49. f. The line segments that form a polygon are called vertices. Please explain your answer. Created by the researcher. A) Sure B) Not Sure In Q44, Q45, Q46, Q47, Q48, and Q49, participants' ability to evaluate a given statement, integrate their knowledge with various pieces of information, and

Q31. In a circle, the radius is denoted by “r” and the diameter by “R”. T/F
Explain your answer
Created by the researcher.
A) Sure B) Not Sure

Q32. The shape formed together with the interior region of the circle is called a circle. T/F
Explain your answer
Created by the researcher.
A) Sure B) Not Sure

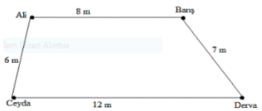
Q33. A shape formed by points that are equidistant from a fixed point on a plane is called a circle. T/F
Explain your answer
Created by the researcher.
A) Sure B) Not Sure

In Q27, Q28, ..., Q33, it was aimed to determine whether participants have misconceptions by examining how the concepts of circle and circumference and their components, such as diameter, radius, and center, are related. Specifically, it was considered that issues such as misunderstanding the relationship between radius

Q36. If the area of a circle with center M is 75 cm², what is the length of the diameter (assuming M=3)?
Please explain your answer.
The mathematics textbook approved by the Board of Education
A) Sure B) Not Sure

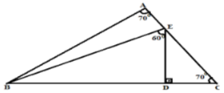
In Q34, Q35, and Q36, the circumference (length) of a circle, the arc length on a circle, and the area of a circle are addressed to reveal any misconceptions the participants might have. In this context, it was anticipated that participants might face difficulties in calculating the circumference and area of a circle, as well as in calculating the arc length on the circle and distinguishing between the area of the circle and the area of the circumference.

Q37.



Ali, Barış, Ceyda, and Derya are standing in the schoolyard as shown in the diagram above. What is the smallest possible

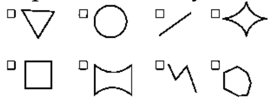
Q40.



Which of the statements given below are correct for the ABC triangle above? Please explain your answer.
[BE] is the angle bisector of $\hat{B}$'
[ED] is the perpendicular bisector of |BC|
[BE] is the perpendicular bisector of |AC|
IV. The ABC triangle is an isosceles triangle.
Kaya (2018)
A) Sure B) Not Sure

In Q38, Q39, and Q40, the aim was to identify KY related to the auxiliary elements of triangles among teacher candidates. Specifically, it was anticipated that misconceptions might arise regarding the determination of altitude, such as overlooking that the altitude is a perpendicular line segment drawn from a vertex to the opposite side and considering a non-perpendicular line segment from the vertex as a possible altitude. Additionally, errors in counting units and confusion

to apply the rules for identifying a right triangle based on given drawings on grid paper.
Q43. For the given shapes below, place a “✓”next to those that are polygons and an "X" next to those that are not. Provide an explanation for your answers.



A mathematics textbook approved by the Board of Education and Discipline
A) Sure B) Not Sure

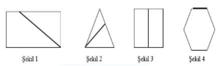
In Q43, participants' knowledge about polygons was examined, and their ability to draw conclusions about the polygon concept from the given diagrams was focused on. The goal was to identify conceptual misunderstandings based on the missing or incorrect answers. The selection of the question was based on the expectation that participants might indicate that shapes made up of both straight and curved lines are also polygons, without considering the definitions related to polygons.

either confirm or refute the statement with their reasoning has been examined. The goal was to identify any concept misconceptions related to the fundamental elements of polygons. The statements were selected to reveal difficulties such as confusing the concepts of vertex and diagonal in polygons and misunderstanding the meaning of a diagonal.

Q50. Determine which of the following quadrilaterals “Square, Rectangle, Parallelogram, Rhombus, and Trapezium” each of the given basic elements belongs to. Explain your answer.
a. Opposite sides are of equal length.
Created by the researcher.
A) Sure B) Not Sure

Q51.
b. Each of the interior angles is a right angle. Explain your answer.
Created by the researcher.
A) Sure B) Not Sure

Q52.

and diameter, confusing the concepts of circle and circumference, and making incorrect statements about the center of the circle could be revealed through these questions.	integer value for the distance between Ali and Derya in meters? Please explain your answer. Kaya (2018) A) Sure B) Not Sure In Q37, the consideration of triangle inequality and the possibility of the drawn angle being an obtuse angle involves putting together the parts of the whole. The aim was to identify participants' misconceptions related to this relationship. It was anticipated that the problem might be solved by creating two different inequalities, potentially overlooking the need to consider the obtuse angle.	between the concepts of median and altitude, leading to their interchangeability, were expected to be revealed.	Q44. Are there any errors in the statements provided below? If there is an error, correct each one individually. Explain your answer. a. Polygons have at least two sides. Created by the researcher. A) Sure B) Not Sure Q45. b. A triangle has three diagonals. Explain your answer. Created by the researcher. A) Sure B) Not Sure Q46. c. A quadrilateral has four interior angles. Please explain your answer. Created by the researcher. A) Sure B) Not Sure	c. The diagonals are of equal length. Please explain your answer. Created by the researcher. A) Sure B) Not Sure Q53. d. The opposite sides are parallel. Please explain your answer. Created by the researcher. A) Sure B) Not Sure Q54. e. The diagonals intersect each other at their midpoints. Please explain your answer. Created by the researcher. A) Sure B) Not Sure Q55. f. All sides are of equal length. Please explain your answer. Created by the researcher. A) Sure B) Not Sure
Q56. g. Diagonals intersect each other perpendicularly, bisecting each other. Please explain your answer. Created by the researcher. A) Sure B) Not Sure Q57. h. The measures of opposite interior angles are equal. Please explain your answer. Created by the researcher. A) Sure B) Not Sure	Q58. k. At least one pair of opposite sides is parallel. Please explain your answer. Created by the researcher. A) Sure B) Not Sure	Q59. In the following shapes, which of the line segments drawn from a vertex to a side are diagonals? Please explain your answer.  Created by the researcher. A) Sure B) Not Sure	In Q50, Q51, …, Q58, the participants' skills in exemplifying and classifying the relevant quadrilaterals according to their basic elements were examined to determine if they had any conceptions errors.	Finally, in Q59, the aim was to reveal the participants' conceptions errors related to interpreting whether the given line segments are diagonals.

2.3.2. Mathematical Adaptation of the Tik Tak Bomm Intelligent Game Practice

2.3.2.1. Original Tik Tak Bomm Game

In the original Tik Tak Bomm ıntelligent game, a card is revealed and the game bomb's button is pressed. Each player then creates a word related to the card and passes the bomb to the next player. The player who gets the bomb when the timer runs out loses their turn and takes the card. The game continues with a new card and new words each time. The player with the fewest cards at the end wins (URL-4).

Fig 1.

Tik Tak Bomm Game Original

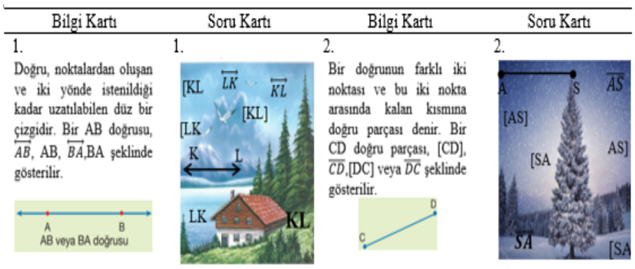
2.3.2.2. Mathematics Concept-Adapted Tik Tak Bomm Game

The Tik Tak Bomm intelligent game, which falls under the category of verbal games, is a game where players utilize not only their logical inferences but also their vocabulary or general knowledge. In the study, the game was played in groups of six (with one group consisting of seven people). All materials for adapting the game to mathematics were prepared separately for each of the five groups by the researcher. When selecting the Tik Tak Bomm intelligent game, the presence of steps for providing information and creating examples related to that information, as well as its suitability for group work, were considered. Additionally, the game is widely known and loved by almost everyone, which played an important role in its selection.

In the first step of adapting the Tik Tak Bomm intelligent game to mathematics, the information to be written on the game cards was determined to address the concept misconceptions related to Fundamental Geometric Concepts, Circle and Disk, Triangles, and Polygons that arise during the game process. It was also considered that participants should encounter incorrect answers given in the MDT1-c. This approach aimed to help participants address their knowledge gaps by reading the game cards during the game process. In the second step of adapting the Tik Tak Bomm intelligent game to mathematics, color prints of the game cards were made, cut, and laminated with acetate sheets to ensure durability. In the game, each information card corresponds to a question card.

Fig 2.

Two examples of game cards adapted to the relevant concepts from the Tik Tak Bomm intelligent game



The goal is to have players in the groups answer these questions collaboratively, implementing peer teaching. More precisely, while planning the game process, it was taken into consideration that the groups should be heterogeneous and therefore, it was considered to increase the interaction by bringing together pre-service teachers with good and deficient knowledge levels and to prepare an environment for peer teaching. For each game card, specific time limits are set beforehand. During the game, an information card is revealed. For example, this information card might state, "Two angles whose measures add up to 90º are called complementary angles. For instance, the complement of a 61º angle is 29º." All players read this information card. Instead of a bomb, small balls are used, and instead of a bomb sound, a stopwatch is used. Once all players have read the information card, the timer for the question card starts. The question card might list angles such as “21°, 73°, 34°, 48°, 59°, 13°.” Each player must state the complement of the angles on the question card and pass the ball to the next player. For instance, the player who selects 21° should explain, “The complement of this angle is 90-21 = 69°.” A player who gives a wrong answer and thus passes the ball loses. If all answers are correct, when the time runs out, the player holding the ball when the stopwatch ends is considered to have "set off the bomb." The information and question cards from that round are given to the losing player. The game continues until all information cards have been read and question cards answered. The player with the most cards at the end loses the game.

2.3.3. Misconceptions Diagnostic Test 2-c (MDT2-c)

The Misconceptions Diagnostic Test 2-c (MDT2-c), identified as the final diagnostic test for conceptual misconception data, was applied to determine the role of the intelligent game application. MDT2-c is not a new test with additional questions. Questions for which all teacher candidates provided correct answers and explanations were removed from MDT2-c, and the resulting MC question numbers and items were identified. Thus, these questions were compiled in MDT2-c. This test was administered to participants after the application of the mathematics-adapted intelligent game. This approach is believed to enhance the validity and reliability of the research.

2.3.4. Unstructured Interview (Informal Interviews)

According to Merriam (2013), interviews can be conducted to learn about individuals' feelings, thoughts, and beliefs about events or phenomena. Patton (2014) states that interviews are used to uncover individuals' experiences, understand how events affect them, and learn about changes in their feelings and thoughts. In this study, informal (brief) interviews were used. Hall and Hord (2006) describe brief interviews conducted between classes, in corridors, or during breakfast or lunch as "informal interviews." They suggest that these short interactions provide significant opportunities for assessing the success of an application. During informal interviews, it is crucial to encourage the interviewee to express their opinions openly and to ask questions that allow them to explain their thoughts.

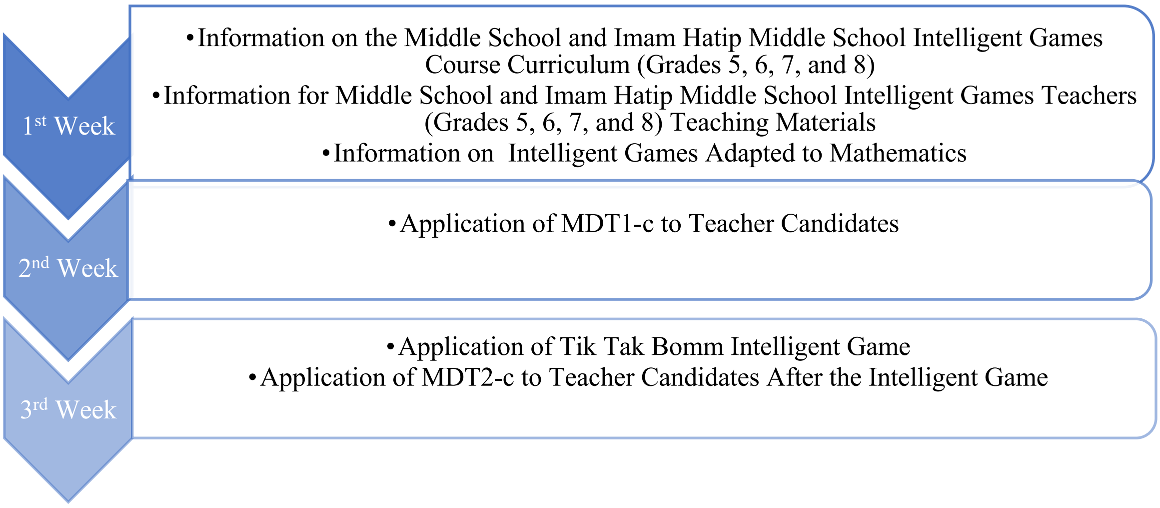
In this research, the goal was to gather participants' opinions about the intelligent game application. These interviews were conducted in a relaxed environment immediately after the game, such as in the cafeteria, corridor, or classroom, in the form of brief conversations lasting five to six minutes. The interviews were not conducted with all participants but were randomly selected. Participants were encouraged to share their thoughts openly and clearly, allowing the researchers to obtain teacher candidates' opinions on the Tik Tak Bomm intelligent game through their discussions. Notes from the conversations were written down by the researcher immediately after the discussions to ensure that the information was not forgotten. This approach was intended to strengthen the research findings.

2.4. Implementation Process

The researcher planned a three-week implementation process, initially preparing a diagnostic test for identifying conceptual misunderstandings (MDT1-c) for the participants. To ensure content validity, the researcher consulted with an expert faculty member in the field. This process led to the final version of the diagnostic test, which was then administered to the teacher candidates. The duration of the diagnostic tests was 79 minutes for both MDT1-c and MDT2-c. Subsequently, the Tik Tak Bomm intelligent game, adapted to mathematics for addressing the identified conceptual misunderstandings, was applied to the teacher candidates. This intelligent game session lasted 75 minutes. Teacher candidates who were unable to participate in the initial implementation were given the opportunity to play the game later. The detailed activities of each week of the planned implementation process are presented in Figure 3.

Fig 3.

Application process



2.5. Data Analysis

2.5.1. Examination of Conceptual Misconceptions Diagnostic Tests

Descriptive Analysis Method was used in the analysis of the Conceptual Misconceptions Diagnostic Tests. Descriptive analysis is a method in which data are interpreted according to themes that align with the conceptual and theoretical framework of the research when this framework is clearly defined beforehand (Corbin & Strauss, 2008). In this context, the responses of the teacher candidates were examined within the framework of the Conceptual Categories of the Three-Stage Test provided in Table 2, by revising the codes of Baran Bulut and colleagues (2021).

Table 2.

Conceptual categories of the three-stage test

Category	Description	Confidence Stage
Scientific Knowledge	Correct Answer- Correct Explanation	Sure
Lack of Confidence	Correct Answer- Correct Explanation	Not Sure
Knowledge Deficiency-Level 1	Correct Answer- Incorrect/Incomplete Explanation	Not Sure
Knowledge Deficiency-Level 2	Incorrect/Incomplete Answer- Partially Correct Explanation	Not Sure
Knowledge Deficiency-Level 3	Incorrect/Incomplete Answer- Correct Explanation	Sure
Knowledge Deficiency-Level 4	Incorrect/Incomplete Answer- Incorrect Explanation	Not Sure
Misconception	Correct Answer- Incorrect/Incomplete Explanation Incorrect/Incomplete Answer- Incorrect/Incomplete Explanation	Sure
Blank	Question Left Blank	Sure

According to Table 2, the responses to the diagnostic tests have been analyzed in terms of correct and incorrect or incomplete answers, as well as correct and incorrect or incomplete explanations, within the contexts of "Sure" and "Not Sure" choices.

2.6. Validity and Reliability of the Research

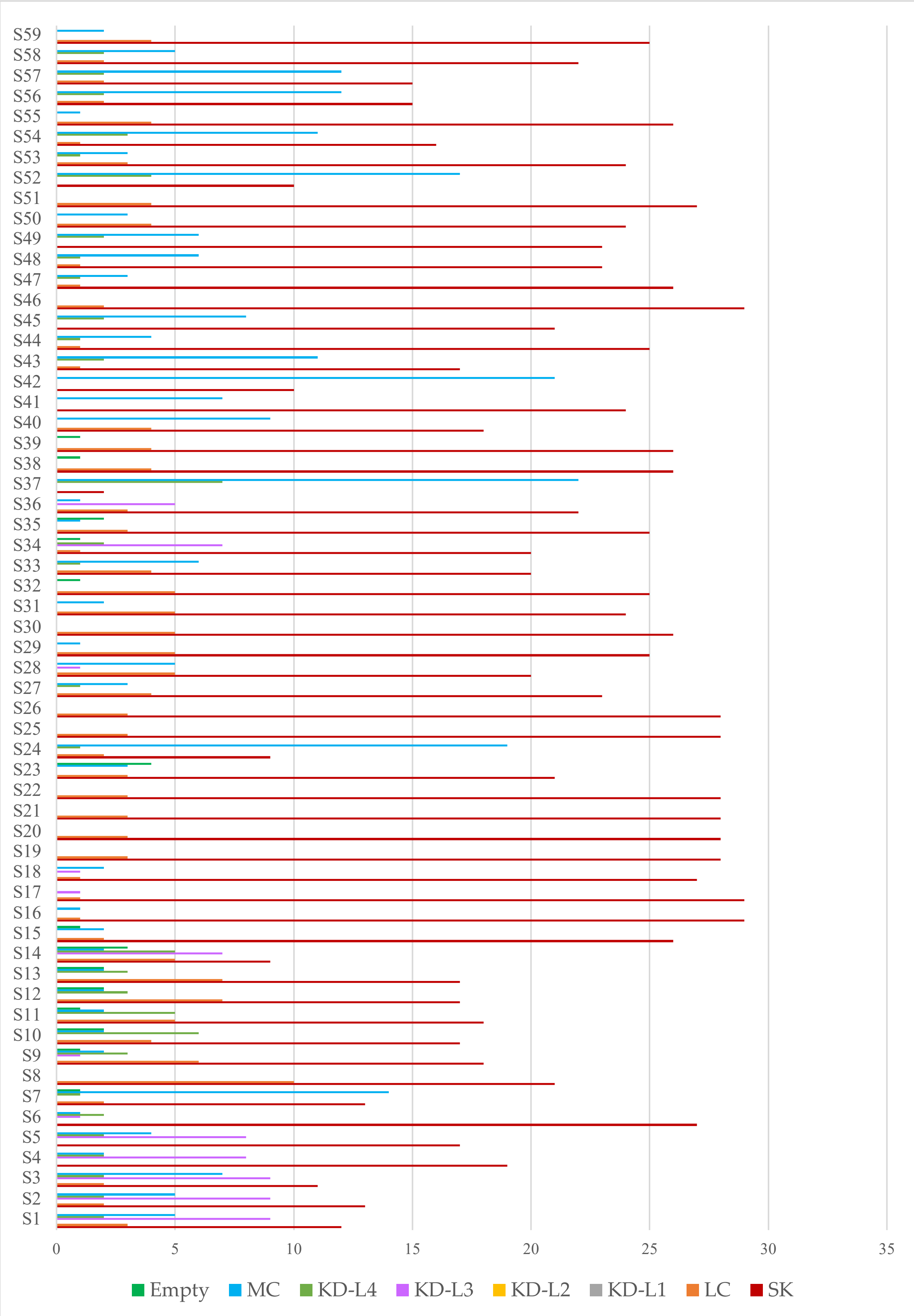
To ensure the quality of a qualitative research study, it must possess attributes of credibility, transferability, dependability, and confirmability (Lincoln & Guba, 1985). In this context, to enhance the credibility of the research, the data collection process has been clearly and transparently described to the reader, and the responses to the MDT1-c from teacher candidates have been presented directly without modification. Additionally, long-term interactions with participants were established, and various data collection methods were employed. Since it is not possible to recreate the exact environment in which the research data were obtained, the research must be transferable (Patton, 2014). To achieve transferability, detailed descriptions of the data are provided and direct quotations are included (Yıldırım & Şimşek, 2018). In the current study, transferability was ensured through detailed descriptions and direct quotations based on the nature of the data. Furthermore, in line with the explanations of the types of MC, the responses and explanations provided by participants were utilized, aiming to increase the validity and reliability of the research findings. Finally, to enhance the confirmability of the research and ensure objectivity, efforts were made to include visuals and explanations of the data whenever possible.

3. Findings

In this section, the responses of teacher candidates to the questions on Basic Geometric Concepts, Circles and Discs, and Triangles and Polygons in the MDT1-c have been classified using the Conceptual Categories of the Three-Tier Test and are presented below in Figure 4.

Fig. 4

Frequency of Participants' Responses to Questions in the Conceptual Misconception Diagnostic Test 1-c



SK: Scientific Knowledge, LC: Lack of Confidence, KD-L1: Knowledge Deficiency Level 1, KD-L2: Knowledge Deficiency Level 2, KD-L3: Knowledge Deficiency Level 3, KD-L4: Knowledge Deficiency Level 4, MC: Misconception

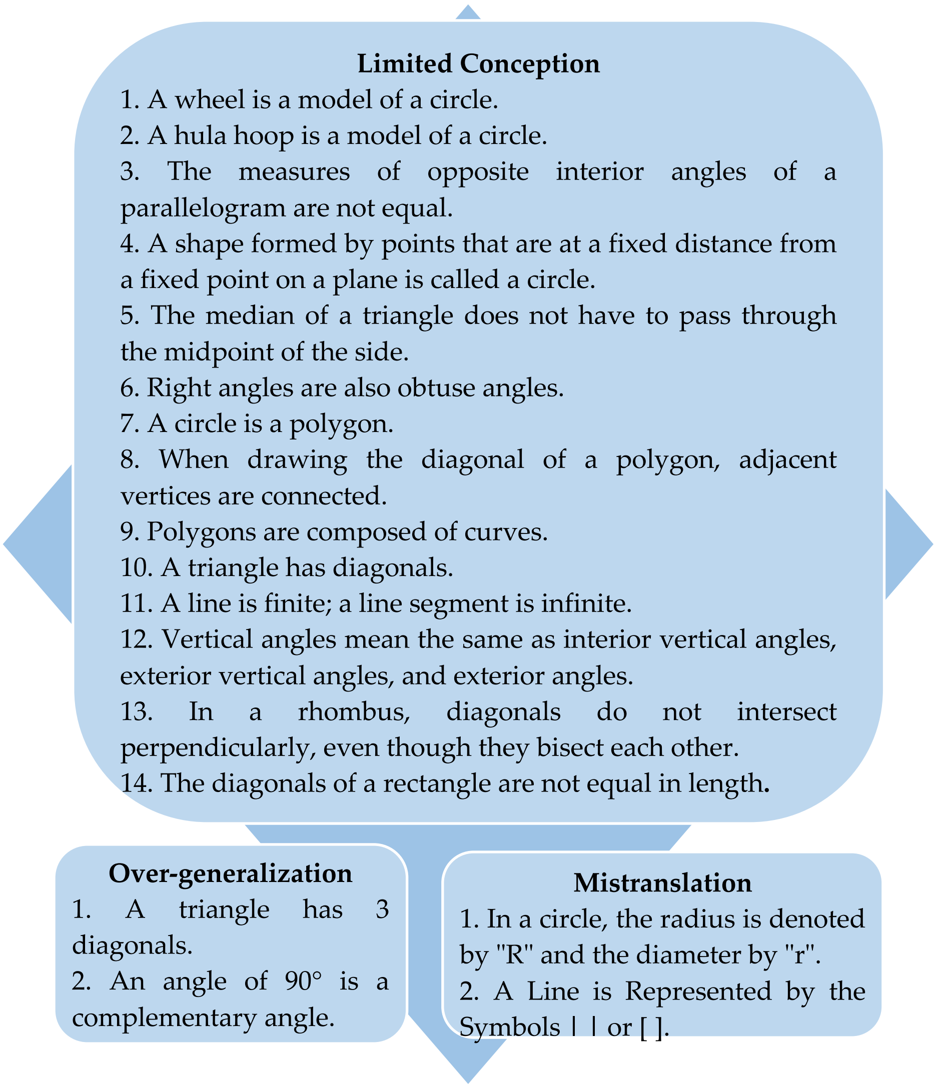
According to Figure 4, it is observed that the majority of the responses given by the teacher candidates fall into the Scientific Knowledge category. This is followed by responses categorized under MC, including categories such as Lack of Confidence, Knowledge Deficiency-Level 3, Knowledge Deficiency-Level 4, and blank responses. Responses that exemplify MC have been addressed, and the teacher candidates' MC have been analyzed according to types such as overgeneralization, limited perception, and incorrect translation.

3.1. Findings on MC in Basic Geometric Concepts, Circles and Arcs, and Triangles and Polygons among Primary School Mathematics Teacher Candidates

In this section, the MC held by teacher candidates in Basic Geometric Concepts, Circles and Arcs, and Triangles and Polygons are examined according to their types and presented in Figure 5.

Fig 5.

MC Identified in the MCDT1-c



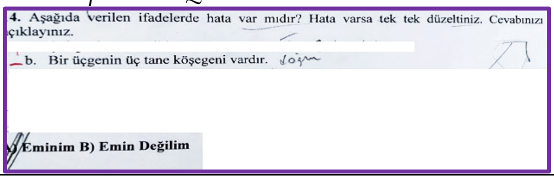
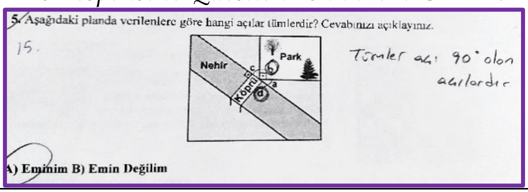
When Figure 5 is examined, it is observed that the majority of misconceptions identified in the MDT1-c are of the "limited perception" type. Following this, misconceptions of the "incorrect translation" type are also noted, with "excessive generalization" misconceptions identified as well. The misconceptions, along with example solutions and explanations, are presented below according to their types.

3.1.1. Findings on KY of the Over-generalization Type

Over-generalization refers to the extension of a rule or concept, which applies to a particular group, to other groups where it may not be applicable (Graeber & Johnson, 1991; cited in Zembat, 2013). The misconceptions of the excessive generalization type identified from the answers provided by the teacher candidates, along with examples and explanations of these misconceptions, are presented below.

Table 3.

Misconceptions of the excessive generalization type

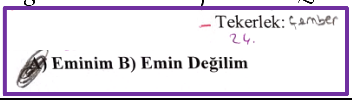
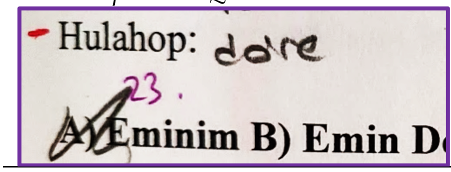
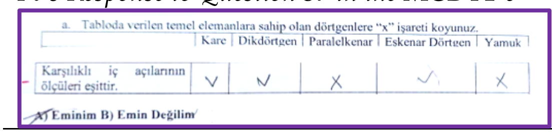
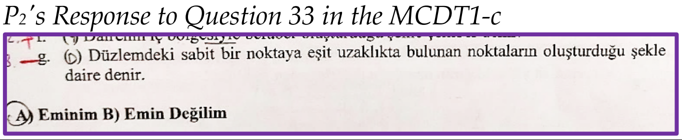
MC: There are 3 diagonals in a triangle	
When analyzing the teacher candidates' responses within the context of the relevant Misconception, it has been observed that P_3, P_7, P_{11}, P_{19}, and P_{22} exhibit this misconception. An example of this can be seen in Figure 6, which shows P_7's response. **Fig 6.** *P_7's Response to Question 45 in the MCDT1-c*  	Upon examining P_7's response, it is evident that they confirm the statement that a triangle has three diagonals. Similarly, this misconception has been identified in the responses of other teacher candidates who have this misunderstanding. They have generalized information about vertices to the concept of diagonals and have not fully grasped these concepts. Therefore, this situation reveals the presence of the misconception of excessive generalization.
MC: An angle of 90° is a complementary angle.	
When examining the answers of the teacher candidates in the context of this MC, it is observed that P_{22} exhibits this misconception. An example of this is provided in Figure 7. **Fig 7.** *P_{22}'s Response to Question 15 in the MCDT1-c*  	When examining P_{22}'s response, it is evident that they have developed a misunderstanding of the concept of complementary angles in solving the problem. P_{22} expresses confidence in their answer by stating, "Complementary angles are angles that measure 90°." This indicates that P_{22} has generalized the concept of complementary angles from the case of a triangle with an internal angle of 90° being a right triangle, resulting in an overgeneralization type of misconceptions.

3.1.2. Findings Related to Limited Conception Type of MC

Limited Perception refers to the construal of a concept in a restricted or weaker (inadequate) manner (Graeber & Johnson, 1991; cited in Zembat, 2013). The misconceptions of teacher candidates related to limited perception identified from their responses to questions, the candidates who have these misconceptions, and examples of solutions and explanations are provided below.

Table 4.

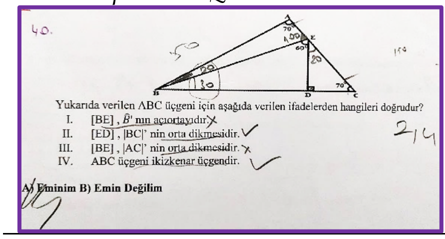
MC of limited conception type

<table>
<tr><th colspan="2">MC: A Wheel is a Model of a Circle.</th></tr>
<tr><td>When analyzing the responses of the teacher candidates in relation to this conceptual misunderstanding, it is observed that P_{2}, P_{3}, P_{4}, P_{6}, P_{8}, P_{9}, P_{11}, P_{14}, P_{15}, P_{16}, P_{17}, P_{18}, P_{19}, P_{20}, P_{22}, P_{25}, P_{29}, P_{30}, and P_{31} exhibit this misconception. An example of this is found in P15's response, as shown in Figure 8.
Fig 8.
Figure 8. P_{15}'s Response to Question 24 in the MCDT1-c

</td><td>When examining P_{15}'s response, it is observed that P_{15} states that a wheel is a circle and is confident about this answer. Therefore, it has been determined that P_{15} and other teacher candidates with this misconception have conceptual deficiencies related to circle and wheel models, indicating a conceptual misunderstanding of the limited conception type.</td></tr>
<tr><th colspan="2">MC: Hula hoop is a model of a circle.</th></tr>
<tr><td>When the teacher candidates' responses were examined in the context of this specific misconception, it was found that P_{15}, P_{25}, and P_{27} held this misconception. An example of this can be seen in P_{27}'s response in Figure 9.
Fig 9.
P_{27}'s Response to Question 23 in the MCDT1-c

</td><td>When examining P_{27}'s response, it is observed that they stated a hula hoop, which is a model of a circle, as being a disk and were confident in their answer. This situation has been interpreted as an indication of P_{27}'s and other teacher candidates' lack of knowledge regarding circle and disk models, revealing a misconception of the limited conception type.</td></tr>
<tr><th colspan="2">MC: The opposite interior angles of a parallelogram are not equal.</th></tr>
<tr><td>When examining the teacher candidates' responses within the context of the relevant misconception, it was found that P_{1}, P_{4}, P_{6}, P_{7}, P_{29}, and P_{30} held this misconception. An example of this situation is present in P_{6}'s response, as shown in Figure 10.
Fig 10.
P_{6}'s Response to Question 57 in the MCDT1-c

</td><td>When examining P_{6}'s response, it is observed that they did not include a parallelogram among quadrilaterals with equal opposite interior angles. Therefore, it was determined that P6 and other teacher candidates with this misconception developed an incomplete understanding by overlooking the fact that a parallelogram's opposite interior angles are equal, resulting in a misconception of the limited conception type.</td></tr>
<tr><th colspan="2">MC: The shape formed by points equidistant from a fixed point in a plane is called a circle.</th></tr>
<tr><td>When the responses of the teacher candidates were examined in the context of this specific misconception, it was observed that P_{2}, P_{3}, P_{4}, P_{7}, P_{27}, and P_{29} exhibited this misconception. An example of this can be seen in P_{2}'s response in Figure 11.
Fig 11.
P_{2}'s Response to Question 33 in the MCDT1-c

</td><td>Upon examining P_{2}'s response, it is observed that they stated the shape formed by points equidistant from a fixed point in a plane, which pertains to the concept of a circle, is a disk. Therefore, it has been determined that P_{2} and other teacher candidates with this misconception have not fully grasped the concepts of a circle and a disk. This situation suggests a misconception of the limited conception type.</td></tr>
<tr><th colspan="2">MC: In a triangle, the median does not need to pass through the midpoint of the side.</th></tr>
</table>

When examining the teacher candidates' responses within the context of the relevant misconceptions, it has been observed that P_2, P_8, P_{14}, P_{19}, P_{21}, P_{22}, P_{27}, P_{29} and P_{30} exhibit this misconception. An example of this situation is presented in P_{27}'s response in Figure 12.

Fig 12.

P_{27}'s Response to Question 40 in the MCDT1-c



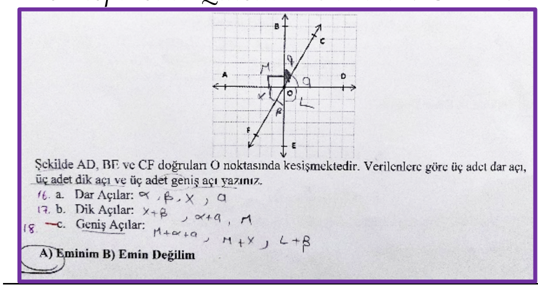
When examining P_{27}'s response, it is seen that they indicated the second statement in the question was correct. P_{27} and other teacher candidates with this error have overlooked that the median in a triangle does not need to be drawn from the midpoint of the side and incorrectly identified [ED] as the median. Therefore, it has been determined that these teacher candidates perceive the concept of the median in a deficient (weaker) manner than required, and they exhibit a misconception of limited conception.

MC: Right angles are also obtuse angles

When examining the teacher candidates' responses within the context of the relevant conceptual misunderstanding, it has been observed that P_3, P_8, and P_{11} exhibit this misconception. An example of this is found in the response of P_3, shown in Figure 13.

Fig 13.

P_3's Response to Question 18 in the MCDT1-c



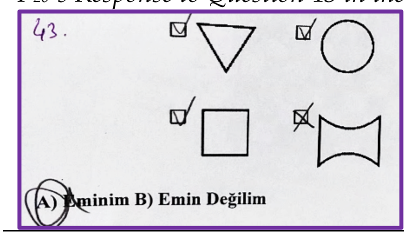
When examining P_3's response, it is observed that the candidate considers the angle AOD, which is a straight angle of 180°, as a wide angle. Based on this, it has been determined that the candidate and others with this misconception have an insufficient conceptual understanding of the difference between straight and wide angles, indicating a limited conception type of conceptual misunderstanding.

MC: A Circle Is a Polygon.

When examining the responses of the teacher candidates in the context of this MC, it was found that P_3, P_{11}, P_{25}, P_{26}, and P_{28} exhibited this misconception. An example of this is shown in Figure 14 with P_{26}'s response.

Fig 14.

P_{26}'s Response to Question 43 in the MCDT1-c



When examining P_{26}'s response, it is observed that the circle model was included in the set of shapes that were to be identified as polygons. This indicates that the requirement for polygons to be composed of straight sides, and consequently that a circle is not a polygon, has been overlooked. As a result, it has been determined that P_{26} and other teacher candidates with this misconception possess a limited conception of the polygon concept, leading to a conceptual misunderstanding of the restricted perception type.

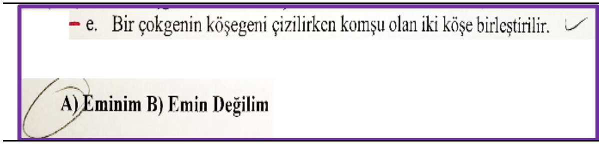
MC: When drawing a diagonal of a polygon, adjacent vertices are connected.

When the responses of the teacher candidates are examined within the context of the related conceptual misunderstanding, it is seen that P_3, P_9, P_{19}, and P_{23} possess this misconception. An example of this is found in P_{19}'s response, as shown in Figure 15.

Fig 15.

P_{19}'s Response to Question 48 in the MCDT1-c

When P_{19}'s response is examined, it is noted that the candidate affirmed the premise that drawing a diagonal in a polygon involves connecting two adjacent vertices and was confident in their answer. It was found that candidates with this misconception have an incomplete understanding of the diagonal concept, as they overlooked the need to connect non-adjacent



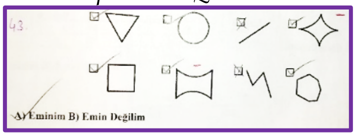
vertices in a polygon. Therefore, this situation reveals a conceptual misunderstanding of the limited conception type.

MC: Polygons Are Composed of Curves.

When examining the answers of the teacher candidates in the context of this conceptual misunderstanding, it is seen that P_5, P_{11}, P_{15}, P_{22}, P_{27}, and P_{30} exhibit this misconception. An example of this is shown in Figure 16, in P_{11}'s response.

Fig 16.

P_{11}'s Response to Question 43 in the MCDT1-c



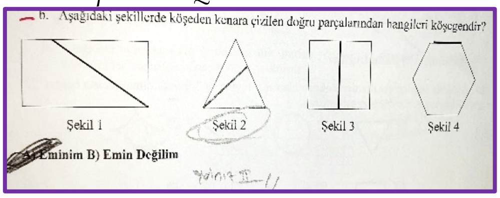
When examining P_{11}'s response, it is observed that in the question where the identification of polygons was required, closed shapes formed by curves were also considered as polygons. This suggests that only closed shapes were taken into account for determining polygons. Consequently, the requirement that polygons should be composed of straight line segments was overlooked by the candidates. As a result, this led to a limited conception of the polygon concept, revealing a conceptual misunderstanding of the restricted perception type.

MC: A Triangle Has a Diagonal.

When examining the answers of the teacher candidates in the context of the relevant conceptual misunderstanding, it has been observed that P_{15} and P_{30} have this misconception. An example of this can be seen in P_{15}'s answer in Figure 17.

Fig 17.

P_{15}'s Response to Question 59 in the MCDT1-c



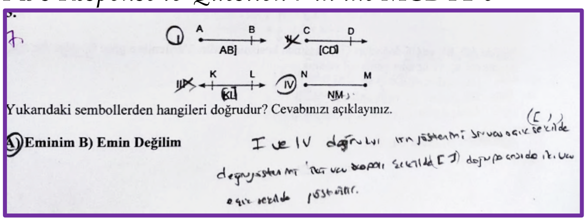
When examining P_{15}'s answer, it is seen that he refers to a line segment drawn from one corner of the triangle to the opposite side as a diagonal. This mistake is also present in P_{15}'s answer. Additionally, it has been determined that these teacher candidates indicated that a triangle has two diagonals in question 45 of the MCDT1-c. These responses reveal that these teacher candidates have misunderstood the concept of a diagonal by neglecting that a triangle does not have diagonals, demonstrating a limited conception and a MC of the restricted perception type.

MC: A line is finite; a line segment, however, is infinite.

When the responses of the teacher candidates are examined in the context of the relevant conceptual misunderstanding, it is observed that P_{13} has this misconception. An example of this situation is provided in Figure 18.

Fig 18.

P_{13}'s Response to Question 7 in the MCDT1-c



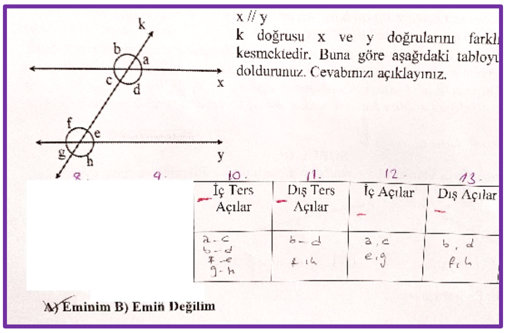
When P_{13}'s response is examined, it is observed that their prior knowledge regarding the representations of lines, line segments, and rays is not at the required level. P_{13} explained their answer as: "I and IV are correct. A ray is represented with one end open; a line is represented with both ends closed; and a line segment is represented with both ends open." In this explanation, it is noted that the concepts of a line as an infinite straight line consisting of points extending infinitely in both directions; a line segment as the finite portion between two different points on a line; and a ray as a straight line extending infinitely in one direction from a starting point are not considered. This limited conception and the failure to properly conceptualize these terms reveal a conceptual misunderstanding of the restricted perception type.

MC: Vertical Angles Are the Same as Interior Vertical Angles, Exterior Vertical Angles, and Exterior Angles.

When the answers of the teacher candidates are examined in the context of this conceptual misunderstanding, it is seen that P_9 and P_{11} possess this misunderstanding. An example of this is found in the answer of P_{11} in Figure 19.

Fig 19.

P_{11}'s Responses to Question 10,11,12 and 13 in the MCDT1-c



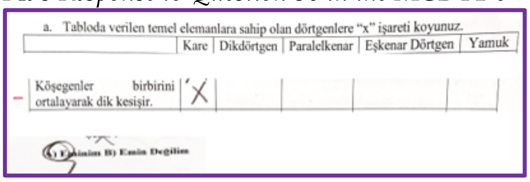
When P_{11}'s answer is examined, it is observed that systematic errors were made in identifying interior opposite angles, exterior opposite angles, interior angles, and exterior angles. For two parallel lines cut by a transversal, the angles between the parallel lines are called "interior angles." Therefore, in the question, "c-d-e-f" are interior angles. The opposite interior angles are called "interior opposite angles." In the question, "d-f" and "c-e" are interior opposite angles. For two parallel lines cut by a transversal, the angles outside the parallel lines are called "exterior angles." In the question, "a-b-g-h" are exterior angles. The opposite exterior angles are called "exterior opposite angles." In the question, "a-g" and "b-h" are exterior opposite angles. However, due to the information deficiencies of the relevant teacher candidates, systematic and continuous errors were made in determining the types of angles given. This situation suggests a conceptual misunderstanding of the restricted perception type.

MC: In a rhombus, the diagonals do not intersect at right angles while bisecting each other.

When examining the responses of the teacher candidates in the context of this conceptual misunderstanding, it has been observed that P_{15}, P_{19}, P_{23}, P_{25}, P_{26}, P_{27}, P_{29} and P_{30} possess this misunderstanding. An example of this is found in the response of P_{26} in Figure 20.

Fig 20.

P_{26}'s Response to Question 56 in the MCDT1-c



When examining P_{26}'s response, it is observed that he did not include the rhombus among the quadrilaterals whose diagonals intersect perpendicularly at their midpoints. Therefore, it has been determined that P_{26} and other teacher candidates with this misunderstanding have developed an incomplete understanding by overlooking the fact that the diagonals of a rhombus intersect perpendicularly at their midpoints. As a result, they have been found to possess a conceptual misunderstanding of the limited conception type.

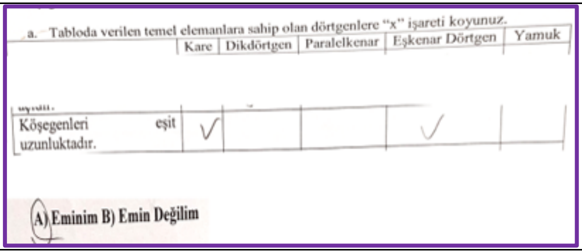
MC: The diagonals of a rectangle are not of equal length.

When examining the responses of the teacher candidates in the context of this misconception, it has been observed that P_{17}, P_{24}, P_{25}, P_{27}, P_{28}, and P_{30} have this misconception. An example of this is found in the response of P_{24} in Figure 21.

Fig 21.

P_{24}'s Response to Question 52 in the MCDT1-c

When examining P_{24}'s response, it is seen that the candidate did not include rectangles among the quadrilaterals with diagonals of equal length. Therefore, it has been determined that P_{24} and other candidates with this misconception have developed a limited understanding by ignoring the fact that the diagonals of a rectangle are equal in length, and thus they exhibit a limited conception type misconception.

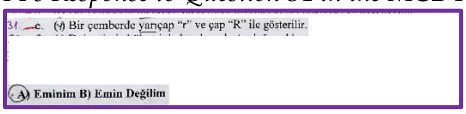
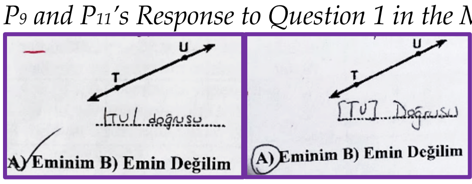


3.1.3. Findings Related to Mistranslation Type of Misconceptions

Mistranslation refers to systematic chains of errors that occur during transitions between different forms such as symbols, formulas, operations, tables, graphs, and sentences (Graeber & Johnson, 1991; cited in Zembat, 2013). The conceptual errors of misinterpretation observed in the answers given by teacher candidates are detailed below, including the candidates with these misconceptions, examples of the misconceptions and their explanations.

Table 5.

Mistranslation Type of MC

MC: In a circle, the radius is denoted by the symbol "R" and the diameter by the symbol "r."	
When the responses of the teacher candidates are examined in the context of this misconception, it is observed that P_2 and P_{14} have this misconception. An example of this is found in P_2's response in Figure 22. **Fig 22.** *P_2's Response to Question 31 in the MCDT1-c*  	When P_2's response is examined, it reveals conceptual deficiencies related to symbolizing the concepts of radius and diameter in a circle. While the radius is denoted by the symbol "r" and the diameter by "R," it is observed that teacher candidates with this misconception overlook this fact, resulting in a chain of systematic errors during transitions to symbolic representations. Thus, they possess a misconception of the type of incorrect translation.
MC: The line is represented by the symbols | | or [ ].	
When examining the answers of teacher candidates within the context of the relevant concept error, it was found that P_9, P_{11}, P_{13}, P_{22} and P_{23} exhibited this error. An example of this is found in the answers of P_9 and P_{11} in Figure 23. **Fig 23.** *P_9 and P_{11}'s Response to Question 1 in the MCDT1-c*  	When examining the answers of P_9 and P_{11}, it was observed that they provided incorrect representations without considering the correct forms such as ilişkin TU, UT, $\overleftrightarrow{TU}$, $\overleftrightarrow{UT}$ for lines. It was found that these teacher candidates imposed specific limits on the representation of lines, neglecting the fact that lines are infinite. Additionally, it was determined that the teacher candidates with this error also made systematic mistakes in the representations of line segments and rays within the same question. Therefore, it was concluded that these teacher candidates created a chain of systematic errors in transitions to symbolic representations, demonstrating a misconceptions of the mistranslation type.

3.2. Findings on Addressing the Conceptual Misconceptions of Elementary Mathematics Teacher Candidates Regarding Basic Geometric Concepts, Circles and Spheres, and Triangles and Polygons

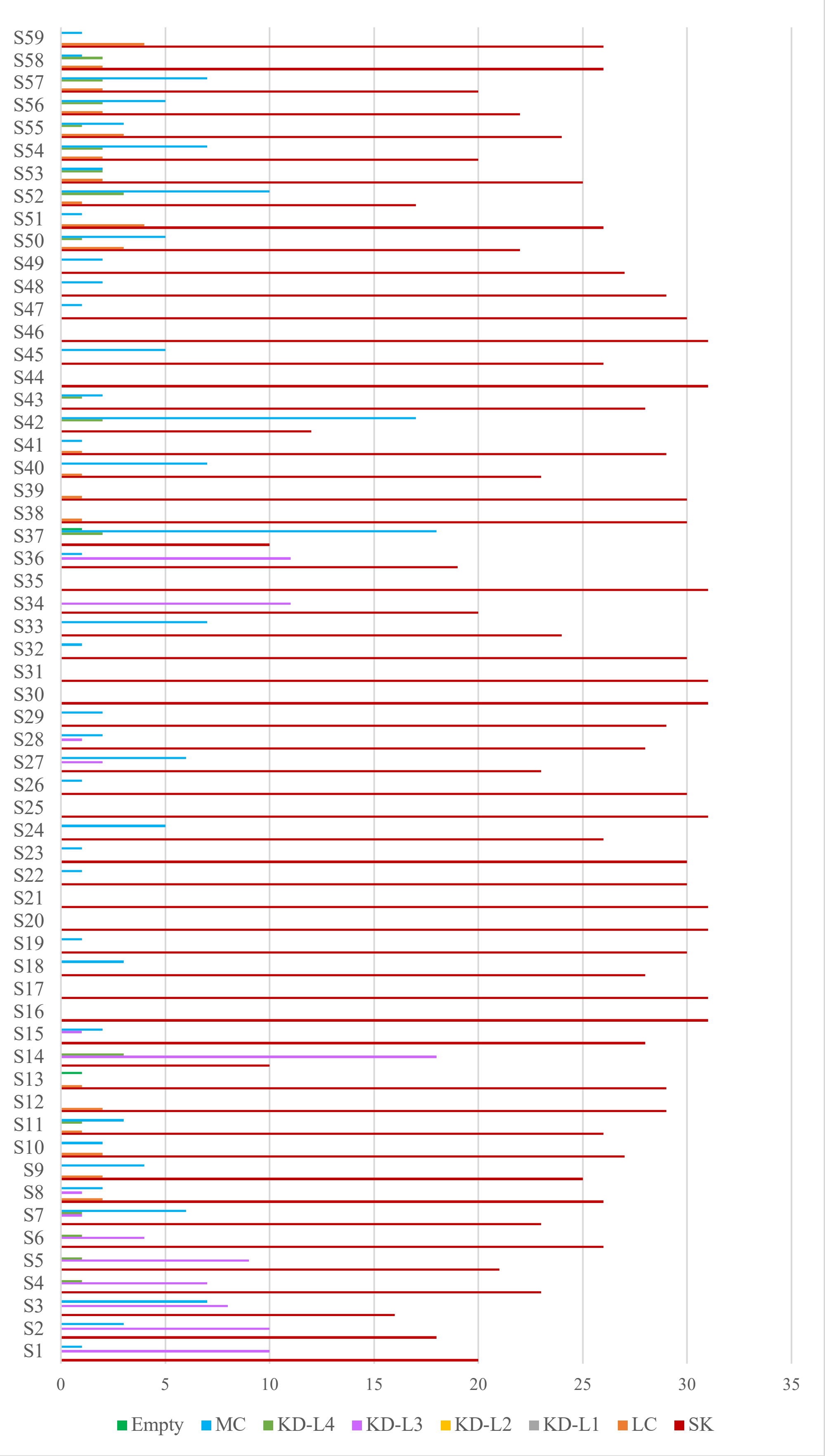
This section presents an evaluation of the teacher candidates' responses to the Misconception Diagnostic Test 2-c within the framework of the Conceptual Categories of the Three-Stage Test, as well as the informal interviews conducted regarding the Tik Tak Bomm game process.

3.2.1. Findings on the Conceptual Misconception Diagnosis Test 2-c

In this section, the responses of pre-service teachers to the MCDT2-c, administered after the intelligence game application, were classified using the conceptual categories of the Three-Step Test. The questions covered Basic Geometric Concepts, Circle and Disk, as well as Triangles and Polygons. The results are presented below in Figure 24.

Figure 24.

Frequency of Responses to Questions in the Conceptual Misconception Diagnosis Test 2-c



SK: Scientific Knowledge, LC: Lack of Confidence, KD-L1: Knowledge Deficiency Level 1, KD-L2: Knowledge Deficiency Level 2, KD-L3: Knowledge Deficiency Level 3, KD-L4: Knowledge Deficiency Level 4, MC: Misconception

Figure 24 shows that the majority of the responses provided by teacher candidates fall into the Scientific Knowledge category. Following this, responses categorized under MC are followed by responses in the Knowledge Deficiency-Level 3, Lack of Confidence, Knowledge Deficiency-Level 4, and blank responses. The analysis of the responses given by primary school mathematics teacher candidates to the questions in MDT1-c and MDT2-c according to the Conceptual Categories of the Three-Stage Test is provided in Table 6.

Table 6.

Frequency and Percentages of Responses Given by Primary School Mathematics Teacher Candidates to the Questions in MDT1-c and MDT2-c

Category	MDT1-c		MDT2-c	
	f	%	f	%
Scientific Knowledge	1242	67,8	1508	82,5
Lack of Confidence	165	9	39	2,1
Knowledge Deficiency-Level 1	-	-	-	-
Knowledge Deficiency-Level 2	-	-	-	-
Knowledge Deficiency-Level 3	67	3,6	93	5,1
Knowledge Deficiency-Level 4	73	4	29	1,6
Misconception	259	14,1	158	8,6
Empty	23	1,5	2	0,1

As seen in Table 6, the percentage of responses categorized as Scientific Knowledge for the questions in MDT1-c is 67.8%, while in MDT2-c, it is 82.5%. Responses classified under the Lack of Confidence category in MDT1-c constitute 9% of the total, compared to 2.1% in MDT2-c. The percentage of responses identified as MC decreased from 14.1% to 8.6%. Overall, this table indicates that the Tik Tak Bomm intelligence game, adapted to mathematics concepts and implemented to address MC, has achieved its goal by effectively reducing the misconceptions among the teacher candidates.

3.3. Findings from Informal Interviews

In this section, findings from informal conversations with 12 teacher candidates about the Tik Tak Bomm game are presented through direct quotes. During the interviews, the teacher candidates expressed their views on the game process as follows:

P_1: "*It made me happy to relate what I knew about vertical, alternate interior, and alternate exterior angles to the information card in the game and explain it to my group member (P_{21}). These are concepts that are often confused. It was important and beneficial to review and reinforce them with the game, and to be able to interpret alternate exterior angles through a sketch example. Additionally, we read the information cards calmly with the group. Identifying and addressing the areas where we were lacking was important and very helpful. I was pleased with my group members. Even those who are usually very quiet actively participated in the game. Through these game processes, I am learning how to adapt intelligent games to mathematics, experiencing how to resolve conceptual misunderstandings, and seeing how I can involve even a very quiet or passive student in the learning process. Thank you very much for this.*"

P_5: "*Until now, I always used the terms edge and face interchangeably. I never paid attention to whether I was using them for geometric shapes or geometric solids. I realized this mistake through the game. I learned that 'edge' is used for shapes, while 'face' is used for solids. I didn't encounter any major problems in the game. My group members were people I normally don't talk to much or am not very close with. But of course, it's not always possible to play with our closest friends in every game. I thought there must be a scientific explanation for this situation. Although I was initially a bit unhappy with the group I was in, I got used to it as we played the game. This also strengthened our communication with those friends. So, we're not just learning information from these games. Thanks to you, we are gaining contributions in many areas. I don't know how you prepare for each application, whether you make the materials alone or not, but I wish you ease and thank you.*"

P_9: "*I realized in this game that I had been confusing the representations of line and line segment, which I thought was a very simple topic that I knew well. Last week, I thought I had written the correct lines on the test, but it turns out I was mistaken. I believe I've learned it well with the example representations in this game, so I won't forget it. Seeing the benefits of these games, I even get up and come to the sessions when I'm sick, and I schedule my doctor appointments on days when the sessions aren't held. I learn a lot and have fun at the same time. I always leave the sessions feeling happy. I want to thank you for that.*"

P13: *"I was very surprised to see even the quietest classmates in the class participate in this game. Normally, people who don't attend any classes or don't actively participate even when they do come, seem to transform into a completely different person during these activities. It seems like playing games brings out the child in us. But I think we also remember the importance of not just playing games but actually learning information. To be honest, at first, I didn't think I could learn anything from these games. But I realized that I even mixed up the representations of lines and line segments, which we see as very simple. So, I can say that I've learned a lot of information and had a lot of fun with these wonderful games."*

P16: "*The games we play are getting better each week. It's hard to predict where we're headed. (Laughs) I'm aware of the effort and trouble that goes into preparing these games for us. Thank you for all your hard work and effort. I'm not sure if we can help you while you're preparing these games, but I'm always ready to assist whenever you need.*"

P18: "*I'm usually not sure about the answers I give in tests, but I'm certain that I shouldn't call a circle an 'annulus' (laughs). Even though I know mathematically what a circle and an annulus are, I struggled to give a real-life example for them. This made me realize that I can't use what I know when needed and that I need to think about why this is happening. I think I'm having trouble relating what I know to other contexts because I've memorized it. This causes me to make mistakes in things that seem very simple. Luckily, we are gradually addressing our gaps. Sometimes I wonder if I would have noticed these gaps if I hadn't been involved in this application process or where I would have noticed them. I probably wouldn't have been able to give a good impression as a teacher to my students without realizing these issues. I'm glad this application is happening with us. Thank you for choosing to work with us.*"

P21: *"I always mix up the terms 'alternate', 'corresponding', 'interior alternate', and 'exterior alternate' angles. Since I used to memorize things when I was younger, I get confused when faced with different questions. I feel very inadequate. The last game we played, Tik Tak Bomm, was not only fantastic but also helped me address my gaps in the concepts I mentioned. The game was very well-prepared. To be more specific, for example, a box of intelligent games is very expensive, around 600-700 TL. This game showed us that we can engage students without buying these games with a box by using just a simple small ball and a stopwatch. I think this is very valuable because we might work in rural areas in the future, where our school won't provide these resources. It will be difficult for us to buy 5-6 of the same game. But with the way we played it, it's both low-cost and, I believe, more fun. Even choosing one of the*

6 small balls you brought at the start of the game excited us. And as we played the game, we absolutely loved it."

P22: "*Developing my own strategies in the game excited me, but it also frustrated my group mates. (Laughs). Although it's a verbal intelligent game, creating strategies is free. (Laughs). In the game, I answered questions, and even though the ball wasn't with me, I kept it in my hand for a while so that it would stay with my friend, thinking it was a good idea. This way, the ball stayed with the person after me, which helped me advance the game successfully for a while. But, of course, only up to a point. When my friends noticed this, they also started using the same strategy, and the ball started staying with them. I fell into the trap I set for myself. (Laughs). What I learned in the game was an added bonus. My incorrect knowledge about complementary angles really got to me. Does every 90° angle count as a complementary angle? I realized this mistake in the game. Another major issue was thinking that polygons are made up of curves and confusing corners with diagonals, claiming that a triangle has 3 diagonals. Even though it seems simple, I couldn't believe that I was wrong about such fundamental mathematical concepts. I'm too embarrassed to discuss this further.*"

P24: "*I thought that an angle of 180° was an obtuse angle. I had completely forgotten the concept of angles. I realized this misconception in the game. Even though I'm embarrassed for not knowing, I'm happy to have learned it now. Thank you for your efforts in the game.*"

P28: "*If I said this was the sweetest game we've played so far, it would be unfair to the others. But they're all wonderful in their own way. It seems that, as you spend more time with us, you choose games that we will enjoy and that help us learn information while playing in groups. While I was curious about what I would learn in the Mathematics Teaching course, I found myself learning to adapt traditional childhood games to mathematics and discovering my misconceptions through the logic game. This makes me happy because I believe the more I learn from a lesson, the better teacher I will become. Even if the applications are after the game lesson and it gets late, I enthusiastically participate in all of them, thanks to you. I've also come to like you very much; you prepare and bring materials for so many groups without hesitation every week. Thank you for your hard work. That's all I have to say, thanks.*"

P29: "*I say this with a lot of embarrassment, but I think I mixed up the concept of diagonals in the test we did last week. I marked the option 'not sure,' but what difference does that make? After all, my knowledge of this concept is lacking at this age. As I mentioned, I was embarrassed, but I'm glad that this game helped me recognize this and many other gaps. I also want to say a few things about the game materials.*

The cards are very nice-their backgrounds and examples provided. I think there were incorrect answers in the cards where we had to give examples. This made us read the information more carefully and try to give more accurate examples. So, this aspect of the game caught my attention. All the preparations were flawless and wonderful. In these games we play every week, we gain a lot. It's also great that different concepts are addressed continuously; it could be boring if it were the same learning area. We are in a process full of surprises, and I think we are very lucky for that."

P31: *"In the game and in the test we solved the other week, I noticed that I say 'ring' where I should say 'circle.' What is a ring? One doesn't realize the incorrectness of what they are saying without scientific feedback. How disappointing. To be good teachers, we must use the language of our field correctly so that our students learn better. I realized how important it is to be careful with this during the application process. I think we will understand the value of this more clearly when we go for our internship next year. On the other hand, the games are all wonderful. In the first week, I didn't realize how beneficial the process would be. We learn many things, from adapting games to identifying and correcting misconceptions. After each game, I eagerly wonder what beautiful game awaits us next. I feel like a primary school student when you come to the classroom with a bunch of bags. Even though you are working on your thesis, I believe we gain more from these applications. I am grateful for that."*

4. Discussion and Conclusion

In this study, the aim was to identify the misconceptions related to Geometry and Measurement concepts held by third-year elementary mathematics teacher candidates at a public university and to address these misconceptions through the implementation of the Tik Tak Bomm intelligence game. The data obtained from the misconception diagnostic tests and the intelligence game application were analyzed and discussed in comparison with the findings in the literature.

4.1. Conclusion and Discussion on the Misconceptions of Elementary Mathematics Teacher Candidates Regarding Fundamental Geometric Concepts, Circle and Disk, and Triangles and Polygons

The findings from the misconception diagnostic test 1-c, prepared on fundamental geometric concepts, circles and disks, and triangles and polygons, revealed that the teacher candidates had several misconceptions. Firstly, it was found that the conceptual knowledge level of teacher candidates regarding the concepts of "line" and "line segment" was not at the desired level.

Many candidates incorrectly stated that a line is finite while a line segment is infinite, a misconception categorized under limited perception. Furthermore, it was determined that the teacher candidates systematically made errors when representing the concept of a line symbolically. This was analyzed as a translation error type of misconception during transitions between different forms. Dane and Başkurt (2012) and Doyuran (2014) also indicated that students perceive a line as a limited segment and thus confuse lines with line segments, which aligns with the findings of this study. Similarly, this misconception was identified in Kiriş's (2008) study with sixth-grade students and in Köken's (2020) research with mathematics teacher candidates, where they associated the representation of a line segment with the symbol for a line. Additionally, this issue was highlighted in the TIMSS 1999 Third International Mathematics and Science Study Report, which noted that Turkish students struggled the most with geometric concepts, including the correct use of fundamental geometry terms like lines, line segments, and rays in problem-solving (MEB, 2003). In the present study, systematic errors related to concepts such as complementary angles, straight angles, and obtuse angles were observed among the fundamental geometric concepts. Furthermore, misconceptions about opposite angles, interior opposite angles, exterior opposite angles, and external angles revealed a limited perception type of misconception. Kılıç, Temel, and Şenol (2015) found that teacher candidates, and Yılmaz (2011) discovered that seventh-grade students, had difficulties expressing the basic elements of complementary, supplementary, interior opposite, and exterior opposite angles due to a lack of knowledge about these concepts. Additionally, sixth and seventh-grade students were found to be unable to accurately identify opposite, interior opposite, exterior opposite, and corresponding angles in given diagrams (Özbellek, 2003). Another noteworthy finding from the study was a teacher candidate's misidentification of 90° angles as complementary angles. This incorrect response was categorized under the misconception type of overgeneralization since the candidate generalized the definition of a right angle (90°) to the concept of complementary angles (angles whose measures sum to 90°). Taylan and Aydın (2018) found that sixth-grade students define complementary angles as "90 degrees" and supplementary angles as "180 degrees," which supports the findings of this study. Unfortunately, the inability of students to correctly understand the concept of an angle and its types, which form the cornerstone of geometry, can lead to entrenched misconceptions that, if not addressed, may persist into their undergraduate years. The fact that a misconception commonly found among sixth and seventh-grade students was also identified in mathematics teacher candidates in this study serves as evidence of this issue.

In this study, the first misconception observed in the concepts of Circle and Disk emerged when examples from daily life were given for these terms. This misconception was followed by the interchangeable use of the concepts of a circle and a disk due to the inability to properly understand their meanings. Additionally, based on the knowledge gaps identified regarding the symbols for diameter and radius in a circle, a misconception was detected where the radius was symbolized by "R" and the diameter by "r". Related to this, it has been noted that students confuse the definitions of a circle and a disk, using them interchangeably, and possess misconceptions about the relationship between diameter and radius (Kaygusuz, 2011; Gerez-Cantimer & Şengül, 2017). In a study examining elementary mathematics teachers' knowledge of the differences between a circle and a disk, it was pointed out that the explanations provided were textbook definitions and consisted of insufficient information. Additionally, it was explained that when teachers mention this prototypical structure during lessons, it leads to incomplete expressions of the concepts of circle and disk among students (Uygun, 2023). On the other hand, in this research, the first misconception identified regarding Triangles was the belief that a triangle has three diagonals. This misconception was followed by an inability to comprehend the concept of diagonals in polygons. Studies by Gutierrez, Pegg, and Lawrie (2004) and Başışık (2010) indicated that students did not consider the definition of a diagonal as a line segment connecting non-adjacent vertices. Furthermore, it was found that seventh-grade students believed in the existence of a diagonal in a triangle and looked for a diagonal within the triangle when questioned (Özkan, 2015). The finding that about one-third of classroom teacher candidates have a correct conceptual image of diagonals, while others perceive them as edges or vertices (Duatepe-Paksu et al., 2013), is consistent with the current study's results. Additionally, misconceptions related to the concept of the perpendicular bisector in triangles revealed a limited perception type of misconception. Teacher candidates with this misconception expressed that the perpendicular bisector does not need to pass through the midpoint of a side. Related to this, it was found that eighth-grade students believed that any line segment perpendicular to a side in a triangle is a perpendicular bisector, indicating that they had not reached an adequate level of conceptual understanding (Kaya, 2018). In the present study, the first misconception identified regarding polygons was the inability to correctly identify the basic elements of quadrilaterals such as parallelograms, rhombuses, and rectangles. Responses suggesting that the diagonals of a rhombus do not intersect perpendicularly were considered indicators of knowledge gaps and misconceptions. Indeed, this can be supported by findings from other studies. Özkan (2015) revealed that seventh-grade students held incorrect beliefs that the diagonals of a rhombus should not intersect perpendicularly. Furthermore, incorrect information regarding the diagonals of a rhombus led to the misconception that the diagonals of a rhombus are not perpendicular (Usiskin, 1982; Duatepe et al., 2013). In the current study, the identified misconception regarding rectangles was that their diagonals cannot be of equal length. Similarly, Ay (2014) stated that due to a lack of knowledge, seventh-grade students believed that the diagonals of a rectangle could be of different lengths, leading to a misconception. Köken (2020) also revealed that mathematics teacher candidates held the misconception that the diagonals of a rectangle are not equal in length. The misconception regarding polygons extended to include the belief that a circle is a polygon and that shapes formed by curves are included in the set of polygons. Related to this, Yılmaz (2019) found that sixth-grade students considered shapes with curves as polygons. As with all the diagnostic tests, the fact that most misconceptions fall under the category of limited perception suggests that teacher candidates have insufficient prior knowledge or explanations related to the geometric concepts discussed. This study demonstrated that these knowledge gaps gradually give way to misconceptions, where scientifically valid information about the concept is completely ignored. However, it can be said that the idea that misconceptions might become entrenched as these candidates enter the teaching profession is concerning. Furthermore, it is evident that a teacher with misconceptions may not be able to identify and correct the students' incomplete or incorrect learning. Related to this, it was found that mathematics teachers, while performing sufficiently or partially sufficiently in predicting student misconceptions, showed lower performance in addressing those misconceptions (Kabadaş, 2022). To prevent this situation, Graeber (1999) suggested that teacher candidates should be presented with different examples of responses containing misconceptions, allowing them to recognize and identify these misconceptions, and that the analysis of student responses should be explored to address and correct these misconceptions. Therefore, it can be said that it is important for teacher candidates to encounter potential misconceptions that students might have about mathematical concepts and to discuss how to assist with these misconceptions through group or individual discussions.

4.2. Results and Discussion on Addressing the Misconceptions of Elementary Mathematics Teacher Candidates Regarding Fundamental Geometric Concepts, Circle and Disk, and Concepts of Triangles and Polygons

In order to address the identified misconceptions of the teacher candidates, the Tik Tak Bomm intelligence game was adapted to mathematics and implemented. While the percentage of responses evaluated under the Scientific Knowledge category in MDT1-c was 67.8%, this percentage increased to 82.5% in MDT2-c. This increase in the level of scientific knowledge led to a decrease in responses evaluated within the context of lack of confidence, lack of knowledge-level 4, and misconceptions. Specifically, in MDT1-c, 9% of the responses fell into the Lack of Confidence category, whereas this figure decreased to 2.1% in MDT2-c. Thus, it was determined that the game process largely succeeded in addressing the candidates' lack of confidence. Additionally, the percentage of responses identified as misconceptions decreased from 14.1% to 8.6%. These results of the study indicate that the Tik Tak Bomm intelligence game, adapted and implemented to address mathematical concepts, successfully achieved its goal by reducing nearly half of the teacher candidates' misconceptions. In addition, the MCs that were very resistant and therefore could not be eliminated were the symbolic representation of the concepts of line, line segment and ray, the concept of diagonal, and the circle and circle models. On the other hand, the improvement and development of pre-service teachers' learning about other concepts addressed in the diagnostic test indicates that other identified MCs can be eliminated through the game process. It can be said that the contributions of the Tik Tak Bomm game to this situation are related to the fact that the game content includes steps of giving information and creating examples about this information and that it enables peer teaching in a way suitable for group work.

Following the game process, informal interviews were conducted with the teacher candidates. They generally expressed that they realized their incomplete understandings of concepts through the game, understood better how an intelligence game could be adapted to mathematics, and grasped the alternative materials that could be used in place of the originals as the process progressed. Additionally, they reported that their communication skills improved positively, everyone participated actively in the game, peer teaching occurred, they had fun and felt happy during the game, and they gained conceptual understanding as the process advanced. In particular, based on the informal interviews, it is thought that the key concept to address is the candidates' awareness of their incomplete, weak, or incorrect understandings and the feelings of shame and embarrassment that arose from this realization. For instance, P_5 mentioned that until the game process, they used the terms "edge" and "side" interchangeably and couldn't grasp the difference and appropriate usage of these concepts. Similarly, P_9 noted that they couldn't distinguish between the representations of a line and a line segment; P_{18} and P_{31} realized they were mistakenly using the word "circle" instead of "ring" when referring to a geometric figure; P_{21} expressed that they learned the concepts of opposite, alternate interior, alternate exterior, and corresponding angles through the Tik Tak Bomm intelligence game. One of the most striking findings of the study is P_{22}'s realization during the game that 90° angles are not complementary angles, that polygons cannot be composed of curves, and that the terms vertex and diagonal are not synonymous. Another important finding is P_{24}'s learning in the game that a 180° angle is not an obtuse angle and gaining an understanding of the straight angle concept. In this context, seeing their misconceptions in the answers on the question cards during the Tik Tak Bomm game process allowed the teacher candidates to evaluate their prior knowledge and focus on scientific knowledge. Therefore, it can be said that this helped them recognize and partially overcome the deficiencies in their readiness levels. A well-qualified and well-trained teacher needs to possess subject matter knowledge, pedagogical content knowledge, and professional knowledge (Baki, 2020). Additionally, teaching competencies, as outlined in the "General Competencies for the Teaching Profession" prepared by the General Directorate of Teacher Training and Development, are grouped into six main competency areas: personal and professional values; understanding students; learning and teaching processes; monitoring and evaluating learning and development; school, family, and community relations; and curriculum and content knowledge (MEB, 2017). Therefore, it is not difficult to foresee that teachers possessing the aforementioned competencies will contribute to students' academic success and increase their interest and motivation in the subject (Darling-Hammond, 2000). Bloom (1995) stated that the adoption and support of these competencies by teachers are dependent on their readiness levels for the teaching profession, and that this level serves as a critical input in the learning-teaching processes (as cited in Akhan, Dolmacı, & Altıntaş, 2019). Readiness includes being prepared cognitively, socially, affectively, and psychomotorically to carry out a learning/teaching activity, which involves the necessary prerequisite behaviors (Yenilmez & Kakmacı, 2008). For teachers, readiness pertains to the extent to which their teacher education has prepared them to cope with the challenges that come with the job (Black, 2003). In this context, the importance of teacher candidates fully developing their professional competencies during their undergraduate education and feeling prepared for the teaching profession, along with having self-efficacy beliefs that they will conduct effective teaching, has been emphasized (Darling-Hammond, Eiler & Marcus, 2002). At this point, the findings of the current study suggest that the Tik Tak Bomm game applied to teacher candidates contributed not only to recognizing their cognitive deficiencies but also to their social and affective development. Thus, based on the teacher candidates' reflections, it can be said that the application of this intelligence game positively influenced their preparation for the teaching profession by helping them recognize and address gaps in their knowledge, strengthening their communication skills in the social domain, fostering happiness and enjoyment in working collaboratively, and learning through play.

4.3. Suggestıons

In this section, depending on the results of the study, recommendations for practice and suggestions for future research are given.

4.3.1. Suggestions for Implementation

It is the teacher's duty to identify misconceptions in students. For this reason, it is thought that the pre-service teachers, who will start to work in the future, should be brought to the desired level of knowledge about the identification and elimination of misconceptions during their undergraduate education. Therefore, the fact that many misconceptions were encountered in this study with pre-service teachers reveals the necessity of eliminating the incomplete learning, lack of knowledge and misconceptions of the candidates about mathematical concepts in the content of the Teaching of Numbers, Teaching Geometry and Measurement, Teaching Algebra, Teaching Probability and Statistics courses taught in the Elementary Mathematics Teacher Education program in the Faculties of Education. In this way, it will be ensured that one of the most important steps to identify misconceptions in the professional life of prospective teachers who graduate with the elimination of weak conceptions will be fulfilled, which is that the teacher himself/herself should know the concepts in a meaningful, complete and accurate way.

In this study, the process of adapting six intelligent teasers to mathematical concepts was explained in detail. More specifically, due to the high cost of the intelligent teasers, alternative methods (stopwatch and small ball) were presented instead of the original materials (time bomb in the game). It was also shown that intelligent teasers can be prepared separately for all play groups at low costs. Moreover, it has been demonstrated that intelligent teasers can be prepared with materials that are easily accessible to everyone and therefore can be prepared with available and waste materials. Therefore, it is seen that intelligence games can be prepared by saving energy and cost even in schools in rural areas where there are difficulties in terms of supplying concrete materials and materials. From this point of view, different intelligent teasers can be adapted to various mathematical concepts by taking these contexts into consideration and can be included in concept teaching processes.

4.3.2.Suggestions for Further Research

In the current study, the role of in teas adapted to mathematics concepts in eliminating pre-service teachers' misconceptions was examined. In this context, the role of traditional children's games adapted to mathematics in eliminating misconceptions can be examined. In addition, the role of traditional children's games adapted to mathematics in determining misconceptions can also be investigated.

In this study conducted with pre-service teachers, misconceptions of pre-service teachers about mathematical concepts were tried to be eliminated with intelligence games adapted to mathematics. Similar studies can be conducted with secondary school students and compared with the results of this study.

This study was conducted with third-year prospective elementary mathematics teachers. Future studies can be conducted with prospective teachers at different undergraduate levels.

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Research Article

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Reducing Mathematics Anxiety: A Systematic Review

Emel TOPBAŞ TAT *[1], Ayşegül TOPBAŞ [2]

* *Corresponding etopbastat@erbakan.edu.tr*
[1]*Necmettin Erbakan University, Türkiye*
[2]*Ministry of National Education, Türkiye*

Abstract

The aim of this study is to examine the graduate theses that aimed to determine the effect of an instructional intervention on mathematics anxiety. For this purpose, graduate theses were reviewed and 22 theses were identified. Descriptive content analysis, which is one of the systematic review methods, was used in the study. Theses were examined according to their years, types, participant groups, instructional interventions used to eliminate or reduce mathematics anxiety, and the effects of the instructional interventions discussed. According to the results of the study, it was seen that most theses on this subject were prepared in 2016 and 2019. It has been determined that the majority of the theses are master thesis. In addition, it was concluded that the theses were carried out with 7th grade students at most. It was also found that the instructional interventions used to overcome mathematics anxiety were different in almost all of the theses examined. Considering the effects of the instructional interventions discussed, it is among the results that in the most of the theses, the instructional intervention did not have a significant effect on reducing mathematics anxiety.

Keywords: Mathematics anxiety, Instructional intervention, Graduate thesis

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Matematik Kaygısının Azaltılması: Bir Sistematik Derleme

Özet

Bu çalışmanın amacı bir öğretimsel müdahalenin matematik kaygısı üzerindeki etkisini belirlemeyi amaçlayan lisansüstü tezleri incelemektir. Bu amaçla lisansüstü tezler taranmış ve 22 adet tez belirlenmiştir. Çalışmada sistematik derleme yöntemlerinden olan betimsel içerik analizi kullanılmıştır. Tezler, yıllarına, türlerine, katılımcı gruplarına, matematik kaygısını gidermek veya azaltmak için kullanılan öğretimsel müdahalelere, ele alınan öğretimsel müdahalelerin etkilerine göre incelenmiştir. Çalışma sonuçlarına göre bu konuda yapılan lisansüstü tezlerin en fazla 2016 ve 2019 yıllarında hazırlandığı görülmüştür. Lisansüstü tezlerin çoğunluğunun yüksek lisans tez çalışması olduğu belirlenmiştir. Ayrıca tezlerin en fazla 7. sınıf öğrencileriyle yürütüldüğü sonucuna ulaşılmıştır. İncelenen tezlerin neredeyse tamamında matematik kaygısının üstesinden gelmek için kullanılan öğretimsel müdahalelerin farklı olduğu da görülmüştür. Ele alınan öğretimsel müdahalelerin etkilerine bakıldığında ise tezlerin çoğunda, öğretimsel müdahalenin matematik kaygısını azaltmada anlamlı bir etkiye sahip olmadığı ulaşılan sonuçlar arasındadır.

Anahtar Kelimeler: Matematik kaygısı, Öğretimsel müdahale, lisansüstü tez

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1. Introduction

Mathematics anxiety is a common condition that many people encounter in their experiences with mathematics. Mathematics anxiety can be defined as "feelings of tension and worry that interfere with the manipulation of numbers and the solution of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972, p. 551). The causes of mathematics anxiety include negative life experiences related to learning mathematics, environmental factors, gender role, genetic factors and neurocognitive effects, social factors, and dyscalculia (Kurnaz et al., 2021). Mathematics anxiety can negatively affect students' experiences with mathematics and prevent them from establishing a positive relationship with mathematics. As the level of anxiety increases, students may avoid mathematics-related activities, studying or completing homework assignments, and may experience fear of failing exams (Alkan, 2010). Mathematics anxiety can negatively affect students' learning in mathematics and prevent them from reaching their full academic potential (Finell et al., 2022; Gabriel et al., 2020). Considering that the principles and techniques of mathematics have become a part of almost all fields of study, it can be said that mathematics anxiety can also result in low performance in these fields of study (Tobias, 1990).

Mathematics anxiety can negatively affect mathematics performance and have a negative impact on cognitive functioning (Ashcraft & Kirk; 2001; Morsanyi et al., 2014). Many studies agree that mathematics anxiety negatively affects mathematics achievement (e.g., Hembree, 1990; Ma, 1999; Wang, 2020). In addition, it is worth noting that the relationship between mathematics anxiety and mathematics performance is bidirectional. Low performance can lead to mathematics anxiety, and mathematics anxiety can reduce mathematics performance. Therefore, it is thought that mathematics anxiety and mathematics performance may affect each other in a vicious circle (Carey et al., 2016).

Coping with mathematics anxiety is important in terms of improving mathematics skills and reducing the negative emotional relationship with mathematics. Effective methods and practices used in classrooms to reduce mathematics anxiety can help students cope with their mathematics anxiety and have a more positive experience of mathematics. This, in turn, can improve students' mathematics performance and self-confidence (Codding et al., 2023). In the literature, various interventions such as relaxation training, breathing exercises, expressive writing activities, class discussions, cooperative learning and reciprocal learning are discussed to prevent or reduce mathematics anxiety (Dilmaç & Bakır, 2022).

The systematic study of mathematics anxiety began in the 1950s with pioneering work of Dreger and Aiken (1957), who introduced the term "number anxiety". The Mathematics Anxiety Rating Scale (MARS) developed by Richardson and Suinn (1972) was a significant milestone in research methodology. There are several types of studies in the mathematics anxiety literature. Some of these are definitional and measurement studies, which include studies that define what mathematics anxiety is and develop tools to measure it (Bindak, 2005; Hunt et al., 2011; Plake & Parker, 1982; Richardson & Suinn, 1972). Some studies investigate the possible causes of mathematics anxiety (Alkan, 2011; Beilock et al., 2010; Maloney et al., 2015; Ramirez et al., 2013), while others focus on the effects of mathematics anxiety in various areas (Ashcraft & Krause, 2007; Beilock & Maloney, 2015). There are also intervention studies investigating strategies to reduce mathematics anxiety (Park et al., 2014; Ramirez & Beilock, 2011; Supekar et al., 2015). Systematic review of the studies on mathematics anxiety plays a crucial role in deepening our understanding of mathematics anxiety and improving educational practices. However, many existing systematic reviews primarily concentrate on its association with mathematics achievement, placing less emphasis on strategies for intervening mathematics anxiety within educational settings (Codding et al., 2023). The strategies aimed at addressing mathematics anxiety hold significant importance owing to their extensive implications on educational outcomes, psychological wellness, and professional opportunities (Zhu et al., 2024). In this direction, the aim of the study was to examine the graduate theses conducted in Türkiye that aimed to determine the effect of an instructional intervention on mathematics anxiety. The sub-problems of the study were determined as follows:

1. What is the distribution of theses by year?
2. What is the distribution of theses by type?
3. What is the distribution of theses by participant group?
4. What are the instructional interventions used in the theses to reduce mathematics anxiety?
5. What are the effects of the instructional interventions used in the theses on reducing mathematics anxiety?

It is believed that the results of this study will provide guidance for future studies by identifying the instructional interventions used in graduate theses to reduce mathematics anxiety and the effects of these interventions.

2. Method

This study used descriptive content analysis, one of the systematic review methods. Studies based on descriptive content analysis provide a summary of the current state of affairs on a particular topic and offers insights for future research to address the shortcomings in the field (Gough et al., 2011, as cited in Bellibaş, 2018). In this study, the aim was to examine the graduate theses that aimed to determine the effect of an instructional intervention implemented in mathematics lessons on mathematics anxiety. The descriptive content analysis method was used because the aim was to determine the current status of these issues by examining the theses according to year, type, participant group, the instructional intervention applied in mathematics lessons to reduce mathematics anxiety, and the effect of the instructional intervention.

2.1. Data Collection

This study examined graduate theses conducted in Türkiye that aimed to determine the effect of an instructional intervention on mathematics anxiety. In the YÖKTEZ database, graduate theses examining the effect of instructional interventions applied in mathematics lessons on mathematics anxiety were searched. The keyword "mathematics anxiety" was used for the search. The theses were searched without any year limitation and the search was carried out in June 2023. The theses were analyzed, and those involving instructional interventions were identified. The theses to be included in the study were limited by the fact that the instructional intervention was applied in mathematics lessons and that the full text was accessible. In this context, 22 theses prepared between 2008 and 2023 were identified.

2.2. Data Analysis

The theses were examined according to their years, types, participant groups, the instructional interventions used to reduce mathematics anxiety, and the effects of the instructional interventions used. The theses were first coded under these headings and then the findings were transformed into frequency tables. During the data analysis process, the authors first analyzed the data independently and then worked together on the results obtained. The data analysis was finalized by reaching common decisions and conclusions.

3. Result

The first sub-problem of the study is "What is the distribution of theses by years?". The distribution of theses that aimed to determine the effect of an instructional intervention applied in mathematics lessons on mathematics anxiety by year is shown in Table 1.

Table 1.

Distribution of Theses by Year

Year	f	%	Year	f	%
2008	2	9.09	2018	3	13.64
2011	1	4.55	2019	4	18.18
2013	1	4.55	2020	1	4.55
2015	1	4.55	2022	3	13.64
2016	4	18.18	2023	1	4.55
2017	1	4.55	Total	22	100

Table 1 shows that most of the graduate theses aiming to determine the effect of an instructional intervention applied in mathematics lessons on mathematics anxiety were prepared in 2016 and 2019 (f=4, 18.18%). These years were followed by 2018 and 2022 with 3 theses (f=3, 13.64%). The years with one thesis (f=1, 4.55%) are 2011, 2013, 2015, 2017, 2020 and 2023. Before 2008 and in 2009, 2010, 2012, 2014 and 2021, no thesis was found on this subject.

The second sub-problem of the study is "What is the distribution of theses by type?". The distribution of theses by type is shown in Table 2.

Table 2.

Distribution of Theses by Type

Type	f	%
Master Thesis	18	81.82
Doctoral Thesis	4	18.18
Total	22	100

Table 2 shows that most of the graduate theses (f=18, 81.82%) were written as master theses. Four doctoral theses (18.18%) were also found on this subject.

The third sub-problem of the study is "What is the distribution of theses by participant group?". The distribution of theses by participant group is shown in Table 3.

Table 3.

Distribution of Theses by Participant Group

Participant Group	f	%	Participant Group	f	%
3rd grade students	1	4.55	8th Grade Students	2	9.09
4th grade students	5	22.73	9th Grade Students	2	9.09
5th grade students	1	4.55	10th Grade Students	1	4.55
6th Grade Students	3	13.64	Undergraduate students	1	4.55
7th Grade Students	8	36.36			

According to Table 3, the most frequently studied participant group in theses aiming to determine the effect of an instructional intervention on reducing mathematics anxiety were 7th grade students (f=8, 36.36%). Five theses were conducted with 4th grade students (22.73%). Three theses were conducted with 6th grade students, while the least frequently studied participant groups were 3rd, 5th and 10th grade students and undergraduate students (f=1, 4.55%). In addition, no theses were found that were conducted with 1st, 2nd, 11th and 12th grade students.

The fourth sub-problem of the study is "What are the instructional interventions used in the theses to reduce mathematics anxiety?". The instructional interventions used in the theses to reduce mathematics anxiety is shown in Table 4.

Table 4.

Distribution of Theses by Instructional Intervention

Instructional Intervention	f
Computer-Assisted Instruction with GeoGebra	2
STEM-Based Education	2
Writing Activities	2
Cognitive Reappraisal Interventions	1
CD Supported Materials	1
Multimedia Applications	1
Teaching Activities Prepared According to the Theory of Multiple Intelligences	1
Teaching with Activities	1
Realistic Mathematics Education Supported Instruction	1
Flipped Classroom Model Practice Focused on Blended Learning	1
Concept Cartoons	1
Team-Assisted Individualization Technique	1
Mathematical Modeling	1
Gamification-Based Activities	1
Instructional Material Use	1
Scenario Based Learning Method of the Historical Developments of the Mathematics Subjects	1
Activities Adapted by Using TESS-INDIA Open Education Resources	1
Web Assisted Instruction	1
Creative Drama	1
Enriched Education Program	1

Table 4 shows that the effects of 20 different instructional interventions on mathematics anxiety were investigated in 22 theses. A single instructional intervention was used in each of the 21 theses, while the effects of two different instructional interventions were analyzed separately in one thesis. There were two theses each investigating the effects of computer-assisted instruction with GeoGebra, STEM-based education and writing activities on mathematics anxiety. The other instructional interventions listed in the Table 4 were used in one thesis each.

The fifth sub-problem of the study is "What are the effects of the instructional interventions used in the theses on reducing mathematics anxiety?". The distribution of the theses according to the effects of the instructional interventions is shown in Table 5.

Table 5.

Distribution of Theses by the Effect of Instructional Intervention

Effect on Reducing Anxiety	f	%
A significant effect	9	40.91
No significant effect	14	63.64

According to Table 5, in the majority of the theses (f=14, 63.64%), the instructional intervention did not have a significant effect on reducing mathematics anxiety. However, 40.91% of the theses found a significant effect of the intervention on reducing mathematics anxiety.

According to the results, both theses investigating the effect of computer-assisted instruction with GeoGebra on students' mathematics anxiety found the same conclusion and concluded that the applied instructional intervention had no significant effect on reducing students' mathematics anxiety. The results also showed that some of the other instructional interventions examined in the theses had no significant effect on reducing students' mathematics anxiety. These interventions included: (a) cognitive reappraisal interventions, (b) CD supported materials, (c) multimedia applications, (d) teaching activities prepared according to the theory of multiple intelligences, (e) teaching with activities, (f) concept cartoons, (g) team-assisted individualization technique, (h) gamification-based activities, (i) scenario based learning method of the historical developments of the mathematics subjects and (j) activities adapted by using TESS-INDIA open education resources. However, it was found that two theses on STEM-based education reached different results. While one thesis found a significant effect of STEM-based education on reducing mathematics anxiety, the other found no significant effect on reducing mathematics anxiety. Similarly, it was found that two theses that used writing activities produced different results in terms of their effect on reducing mathematics anxiety. While one thesis found a significant effect of writing activities on reducing mathematics anxiety, the other found no significant effect on reducing mathematics anxiety. Furthermore, the findings also revealed that various instructional interventions examined in the theses showed significant effects on reducing students' mathematics anxiety. These interventions included: (a) realistic mathematics education supported instruction, (b) flipped classroom model practice focused on blended learning, (c) mathematical modeling, (d) instructional material use, (e) web assisted instruction, (f) creative drama and (g) enriched education program.

4. Discussion and Conclusion

In this study, the graduate theses conducted in Türkiye that aimed to determine the effect of an instructional intervention on reducing mathematics anxiety were examined. The analyzed theses were accessed by searching the YÖKTEZ database. As a result of the search data, 22 graduate theses were found.

As a result of the data analysis, it was found that the theses examining the effect of an instructional intervention on reducing mathematics anxiety were prepared between 2008 and 2023. In some years (years before 2008 and years 2009, 2010, 2012, 2014 and 2021), no theses on this subject were found. Considering that mathematics anxiety is common condition that many people encounter in their experiences with mathematics and affects performance in mathematics, it is important to increase the number of theses on this subject.

When the theses were examined according to type, it was found that the majority were master theses. It was seen that there were few doctoral theses on the subject. This finding suggests the need for more in-depth research at doctoral level in this area, which could contribute to a more comprehensive theoretical framework and practical applications in this area.

When the participant groups of the theses were examined, it was found that 7th grade students were the most common participant group in the theses. In terms of participant groups, 7th grade students were followed by 4th grade students. In addition, no theses were found that were conducted with 1st, 2nd, 11th and 12th grade students. According to the results of the study, one thesis was found in which the participant group was undergraduate students. In this thesis, it was found that, despite the instructional intervention applied, no significant change in students' mathematics anxiety level was observed. In later education, avoiding mathematics is connected to previous experiences of high levels of mathematics anxiety and low mathematics achievement during the early stages of learning (Espino et al., 2017). Investigating strategies to address mathematics anxiety from an early age has become a crucial area of research due to significant number of adolescent experiencing symptoms of mathematics anxiety (Luttenberger et al., 2018). In this regard, it is thought that it is necessary and important to conduct studies at all grade levels regarding instructional interventions to reduce mathematics anxiety.

In the 22 theses examined, it was seen that the effects of 20 different instructional interventions on reducing mathematics anxiety were investigated. The effects of only three of these interventions were investigated in more than one thesis. Both theses that investigated the effect of computer-assisted instruction with GeoGebra on students' mathematics anxiety found the same conclusion and concluded that the applied instructional intervention had no significant effect on reducing students' mathematics anxiety. On the other hand, it was found that two theses on STEM-based education reached different results. While one thesis found a significant effect of STEM-based education on reducing mathematics anxiety, the other found no significant effect on reducing mathematics anxiety. Similar results were found in two theses that used writing activities. While one thesis found a significant effect of writing activities on reducing mathematics anxiety, the other found no significant effect on reducing mathematics anxiety. The different results observed across similar interventions may highlight the complex nature of reducing mathematics anxiety. While computer-assisted instruction with GeoGebra consistently showed no significant effect, the varying outcomes in STEM-based education and writing activities suggest that the effectiveness of these interventions may be strongly influenced by implementation factors, contextual variables, and specific student populations rather than the intervention method alone. These findings emphasize the need for more detailed reporting of implementation processes and contextual factors in future research to better understand why similar interventions might produce different results. Additionally, this variation highlights the importance of considering multiple factors beyond the intervention type itself when attempting to reduce mathematics anxiety.

According to the results, 40.91% of the theses reported a significant effect of the intervention on reducing mathematics anxiety. However, it was found that the instructional interventions used in the majority of the theses did not have a significant effect on reducing mathematics anxiety. Similarly, Dowker et al. (2016) reviewed various intervention types including cognitive-behavioral therapy, mindfulness, and classroom-based approaches and found that while some interventions were effective, others showed limited or no significant impact. So, it can be said that addressing math anxiety is a complex process and there is a need for more rigorous research designs (Dowker et al., 2016). So, it can be recommended that future interventions focus not only on the method chosen, but also on ensuring proper implementation conditions, adequate duration, and appropriate support structures. This analysis can provide a starting point for further research. To gain a more comprehensive understanding, the specific methodologies used in the theses, the characteristics of the study participants, and the broader context of mathematics education in which these interventions were implemented can be examined in detail.

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Research Article

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Examination of Research on Developmental Delay, Identification, and Early Intervention: A Bibliometric Analysis

S. Seda BAPOĞLU DÜMENCİ [1], Berna SİCİM SEVİM *[2]

* *Corresponding bernasicim@gmail.com*
[1] *Tarsus University, Türkiye*
[2] *Zonguldak Bülent Ecevit University, Türkiye*

Abstract

Early intervention has been described as a systematic and deliberate effort to encourage development by influencing environmental or experimental factors. These interventions are initiated within the first five years of life. In recent years, there has been a significant increase in studies encompassing early intervention, developmental delay, and diagnosis. However, bibliometric studies on this topic remain limited. This article aims to analyze research on early intervention, developmental delay, and diagnosis published on the Web of Science (WoS). The analysis and visualization of selected documents were conducted using VOS viewer. A bibliometric analysis of 390 academic studies published between 1991 and 2023 was performed, with one study excluded, resulting in the examination of a total of 389 articles. Most of these articles cover areas such as pediatrics, developmental psychology, and related fields. The year 2022 was identified as having the highest number of publications and citations for articles published since 1991. One of the most cited articles focuses on the prevalence of autism spectrum disorder. The country with the highest number of article publications is the United States. Overall, the five most used keywords in the research are 'early intervention, developmental delay, early diagnosis, autism, and screening'.

Keywords: Early intervention, Developmental delay, Identification.

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Gelişimsel Gecikme, Tanılama ve Erken Müdahale Konulu Araştırmaların İncelenmesi: Bibliyometrik Bir Analiz

Özet

Erken müdahale, çevresel veya deneysel faktörleri etkileyerek gelişimi desteklemek için sistematik ve kasıtlı bir çaba olarak tanımlanmıştır. Erken müdahaleler, yaşamın ilk beş yılı içinde başlatılmalıdır. Son yıllarda, erken müdahale, gelişimsel gecikme ve tanımayı kapsayan çalışmalarda önemli bir artış olmuştur. Ancak, bu konudaki bibliyometrik çalışmalar sınırlı kalmaktadır. Bu makale, Web of Science'ta yayımlanan erken müdahale, gelişimsel gecikme ve tanı konularındaki araştırmaları analiz etmeyi amaçlamaktadır. Seçilen belgelerin analizi ve görselleştirilmesi VOS viewer kullanılarak gerçekleştirilmiştir. Bu çalışmada 1991 ile 2023 yılları arasında yayımlanan 390 akademik çalışmanın bibliyometrik analizi yapıldı, bir çalışma hariç tutuldu ve toplamda 389 makale incelendi. Bu makalelerin çoğunluğu pediatri, gelişim psikolojisi ve ilgili alanlar gibi konuları kapsamaktadır. 2022 yılı, 1991'den bu yana yayımlanan makaleler için en yüksek sayıda yayın ve makalenin yayımlandığı yıldan itibaren atıf yapılan yıl olarak belirlendi. En çok atıf yapılan makalelerden birinin otizm spektrum bozukluğunun yaygınlığına odaklandığı bulunmuştur. Makale yayın sayısının en yüksek olduğu ülke Amerika Birleşik Devletleri'dir. Genel olarak, araştırmada en sık kullanılan beş anahtar kelime 'erken müdahale, gelişimsel gecikme, erken teşhis, otizm ve tarama' olarak belirlenmiştir.

Anahtar Kelimeler: Erken müdahale, Gelişimsel gecikme, Tanılama.

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1. Introduction

Developmental delay can occur when a child does not reach normal developmental milestones at the expected age in areas such as motor skills, cognitive development, social-emotional development, or language development (Baker et al., 2010). Infants may be at risk for developmental disorders due to social or biological reasons. Multidisciplinary family health services may be necessary from birth to age five to support child health and minimize developmental delays (Shonkoff & Meisels, 2000).

1.1. Developmental delay

The prevalence of developmental delay varies across countries based on their developmental levels, yet it remains a condition with high incidence worldwide, necessitating intervention (Vitrikas et al., 2017). Developmental delays are pervasive in childhood, affecting 1-3% of preschool children (Bellman et al., 2013). Given the importance of early support, early intervention (EI) is defined as a systematic and planned effort to promote development during the early years of life (0-8 years). This effort encompasses family education to support the child, along with specific interventions and programs aimed at improving access to various support services in the health and social care sectors (McWilliam, 2016; Kaur et al., 2006). In 2014, only 3% of all children had access to public early intervention services by the age of three. Children residing in conditions marked by adversities, such as poverty and malnutrition, face a significantly elevated risk of encountering disabilities (UNICEF, 2013). Detection often occurs during routine check-ups by primary care physicians or when concerns are expressed by parents or preschools. Assessment for developmental delay involves multiple steps. The first step includes growth percentile measurements, hearing and vision tests, initial blood tests when necessary, and a physical examination, where communication with parents and timely intervention are vital (Choo et al., 2019). This is a process in which children with suspected developmental delay should be intervened in a timely manner with early diagnosis, supported by minimizing risk factors, and followed up longitudinally (Raines et al., 2012). Access to early intervention has been identified in the literature as a priority for developmental disability research (Collins et al., 2017). A significant part of children with developmental delays needs early diagnosis but may have difficulties accessing it. These difficulties include lack of access to specialists, waiting times, cultural factors and financial circumstances (Betz et al, 2004). To overcome these challenges, early detection of developmental delays revealed by developmental screening in infants and young children in low- and middle-income countries is of great importance to enable early intervention and rehabilitation (Faruk et al., 2020). The necessity to align growth assessment tools both conceptually and pragmatically led to the convening of an expert group meeting in 2006. The purpose of this meeting was to assess the feasibility of creating a unified international growth reference for school-aged children and adolescents (Rydz et al., 2005; WHO, 2006). In recent years, due to greater awareness of developmental disabilities, improved access to health services, and changes in diagnostic criteria, the identification of children at developmental risk has increased (Olusanya et al., 2018). Greater clarity and guidance are needed regarding the criteria for qualifying children for Early Intervention (EI) services. Emphasizing that infants should be automatically referred for EI based on the likelihood of their Newborn Screening (NBS) results indicating a risk of developmental delay. This approach could expedite referrals for children with developmental delays and enhance access to EI services (Reynolds et al., 2023).

1.2. Early intervention

Research on the effects of early intervention on development has primarily focused on parent-to-parent interactions, the significance of early diagnosis, and the development of infant intervention programs. However, there is a notable gap in long-term studies examining the relationship between early intervention and developmental outcomes (Hadders-Algra, 2011). In summary, the WoS data provides valuable insights into the social and conceptual structure of research in the field by analyzing studies related to developmental delay, identification, and early development. This study conducted a comprehensive literature search of research articles published in the Web of Science using the keywords "developmental delay," "identification," and "early intervention" to perform a thorough scientific evaluation of the literature in these areas. The aim is to observe changes and developments over time and to assess the productivity of the field.

2. Method

2.1. Study Design

In this study, a bibliometric analysis method, which is a subcategory of systematic literature review, was employed. This approach includes measuring both publication and citation metrics while also identifying key themes, patterns, and gaps in the field. Bibliometric analysis encapsulates the bibliometric and intellectual framework of a discipline by examining the social and structural interconnections among various research entities (e.g., authors, countries) (Donthu, et al.,2021). Many areas of early childhood development research that are linked to have already used bibliometric analyses. These areas include motor learning, language development, and neurodevelopmental disorders (Xu, et al.,2022; Guo, 2022, Chen et al., 2023). By incorporating sensemaking into bibliometric analyses, researchers can offer a more detailed view of the literature, enhancing the understanding of the current status, developments, and future directions within the discipline. This method helps to address common critiques of bibliometric studies, particularly those related to data being misinterpreted or insufficiently analyzed.

2.2. Data Sources

The bibliometric analysis was conducted on January 15, 2023. Articles from Dimensions were retrieved and assessed utilizing visualization tool VOS viewer.

2.3. Eligibility Criteria

Citation network analysis was carried out using bibliometric information obtained from the Web of Science. The search strategy employed was "Early intervention" [Topic] and "identification" [Topic] and "developmental delay" [Topic]. The publication limit was determined on a per-article basis, and one article has been exported for analysis. The research process is given in the Table 1 below.

Table 1

Research Process

Stage 1: Study Design	Database Selection	WOS (Web of Science)
	Index selection	Subject – related field indexes
	Document type	Article
	Language selection	English
	Date	1991-2023
	Keywords	"Early intervention" and "Developmental delay" and "Identification*"
	Result	390 academic research
Stage 2: Data Preparation	Data cleaning	Based on the relevant index selection
Stage 3: Data Analysis	Bibliometric analysis	Characteristics of the Studies Distribution of Publication Year Characteristics of the Most Cited Studies Distribution of Authors in Studies Distribution of Countries Involved in Studies Distribution of Research Areas Co-word Analysis Bibliographic coupling analysis

2.4. Data Extraction

One article has been exported due to retracted publication. Retraction typically occurs when there are significant problems related to the research, data, methodology, or ethical considerations associated with a publication. Reasons for retractions can include issues such as data fabrication, plagiarism, ethical misconduct, errors, or other serious flaws that undermine the integrity and reliability of the study.

2.5. Experimental Setup

In the scope of this research, the Web of Science database provided by Clarivate Analytics in 2022 was utilized. Web of Science, with a history dating back to the 1960s, originated from the Science Citation Index developed by Eugene Garfield and is a product of "WOS (Web of Science) Thomson Reuters Institute of Scientific Information (ISI)." This comprehensive and multidisciplinary database encompasses over 20,000 journals and other publications. Researchers can conduct document reviews within the framework of their specified questions, analyzing sources (books, theses, articles, conference papers, etc.) in the Web of Science database in terms of bibliometric parameters (Aghaei Chadegani et al., 2013). Bibliometric analysis provides maps and perspectives that reveal relationships and interactions among scientific elements, such as citation analysis, co-citation analysis, co-authorship analysis, bibliography matching, and co-word analysis (Öztürk & Gürler, 2021).

2.6. Data Analysis

In the study, the dataset of 389 research articles, accessed with the aim of examining research on developmental delay, identification, and early intervention until January 15, 2023, was analyzed in detail using bibliometric analysis techniques. The obtained data were organized based on the subcategories of the study and visualized using the VOS viewer software package through the creation of graphs.

3. Results

3.1 Characteristics of the Studies

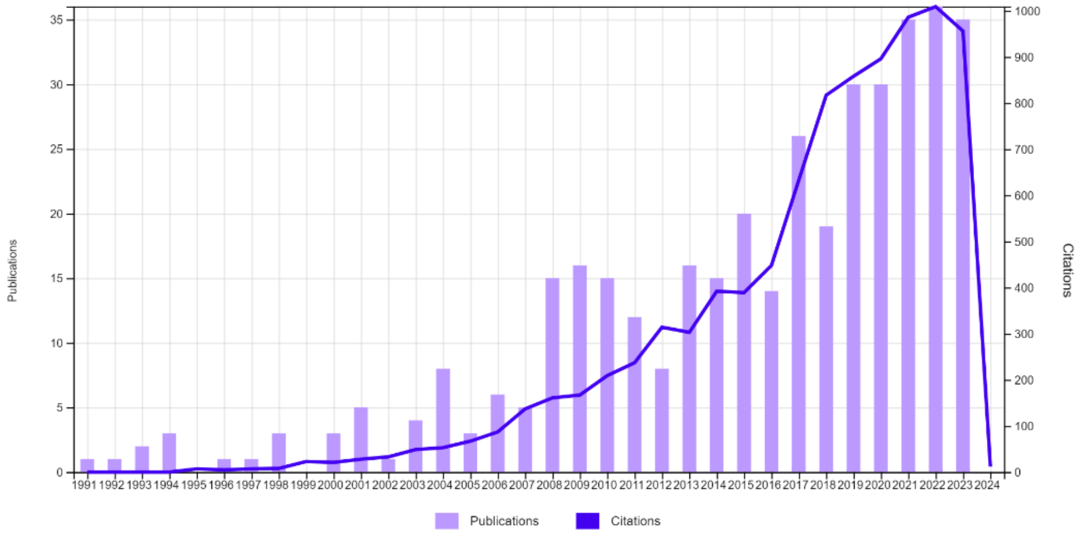
Based on the collected data, a total of 390 articles were identified from 1991 to 2024, published in English (372 articles), German (8 articles), Spanish (6 articles), Korean (2 articles), French (1 article), and Italian (1 article). One retracted publication was excluded from the study group. These articles cover a wide range of research areas, including pediatrics, developmental psychology, rehabilitation, special education, public and environmental health, occupational health, and clinical neurology.

3.2 Distribution of Publication Year

The year 2022 has been identified as the year with the highest number of publications, and no articles were published in research journals in 1995. When considering the citation trend line, there is an upward trend in the number of citations in the articles, reaching its peak in 2022 with 1009 citations. Publication years are shown in Figure 1.

Figure 1

Publication year

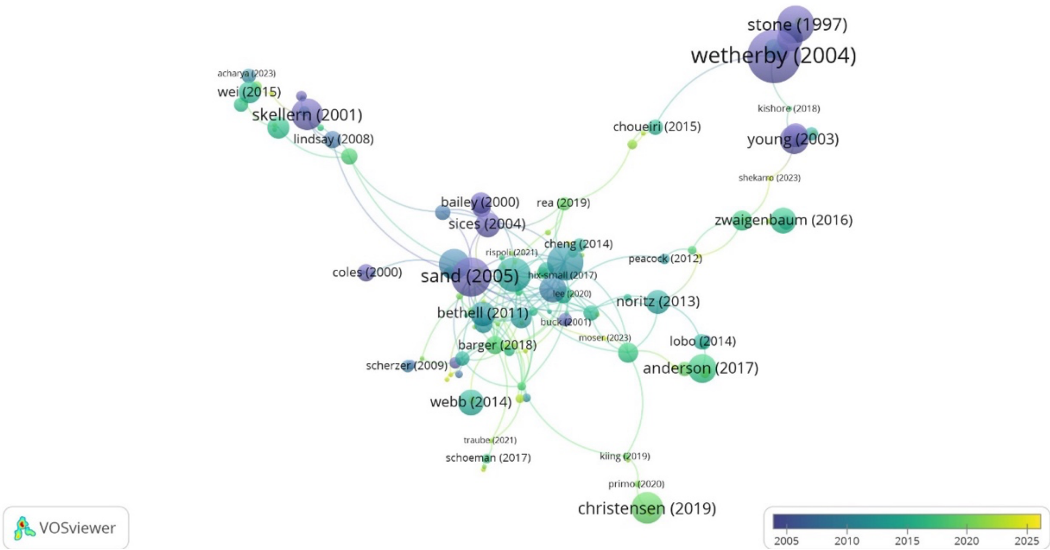


3.3 Characteristics of the Most Cited Studies

When the articles are arranged in descending order based on their frequency, the top three most cited articles have been examined in detail in terms of citations (As can be seen in Figure 2). The three articles with the highest local citations are ranked as follows: "Prevalence and Characteristics of Autism Spectrum Disorder Among Children Aged 8 Years," published by Christensen and colleagues in 2016 with 757 citations, "Early Indicators of Autism Spectrum Disorders in the Second Year of Life," published by Wetherby and colleagues in 2004 with 366 citations, and "The Changing Purpose of Prader-Willi Syndrome Clinical Diagnostic Criteria and Proposed Revised Criteria," published by Günay Aygün and colleagues in 2001 with 313 citations.

Figure 2

Most cited studies



3.4 Distribution of Authors in Studies

The top three authors with the highest number of published articles are Von Suchodoletz and Wetherby with 6 articles each, and Barger with 5 articles. The research topics of all three authors are centered around language development disorders/delays and early identification.

3.5 Distribution of Countries Involved in Studies

Most studies have been published by three countries: the USA (n = 210), Australia (n = 29), and Canada (n = 27). As can be seen in table 2, the top three countries with the highest citation count for studies on the USA, Australia, and Canada are, respectively, the United States (n = 6850), the United Kingdom (n = 1026), and Canada (n = 801).

Table 2

Country-wise publication and total citation counts

Country	Publication counts	Total citation counts
USA	210	6850
Australia	29	631
Canada	27	801
India	19	144
England	16	1026
Germany	15	135
China	13	83
Taiwan	13	139
South Africa	11	108
Brazil	9	142
Austria	7	70
Italy	7	98

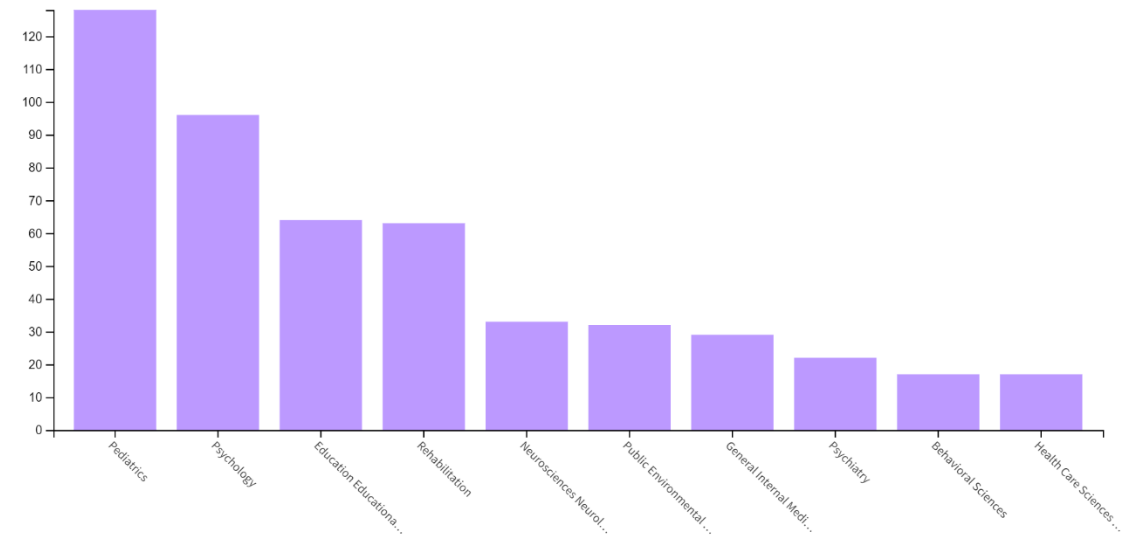
Country	Publication counts	Total citation counts
Israel	5	75
France	5	54
Sweden	5	15

3.6 Distribution of Research Areas

The top three significant sources are as follows: 128 articles in pediatrics, 72 articles in developmental psychology, and 62 articles in rehabilitation (as illustrated in Figure 3). The most cited article in the field of pediatrics is "The changing purpose of Prader-Willi syndrome clinical diagnostic criteria and proposed revised criteria" published by Gunay-Aygun and colleagues in 2001 with 128 citations. In the field of developmental psychology, the most cited article is "Early indicators of autism spectrum disorders in the second year of life" published by Wetherby and colleagues in 2004 with 72 citations. In the field of rehabilitation, the most cited article is "Sex differences in the evaluation and diagnosis of autism spectrum disorders among children" published by Giarelli and colleagues in 2010 with 62 citations.

Figure 3

Research areas

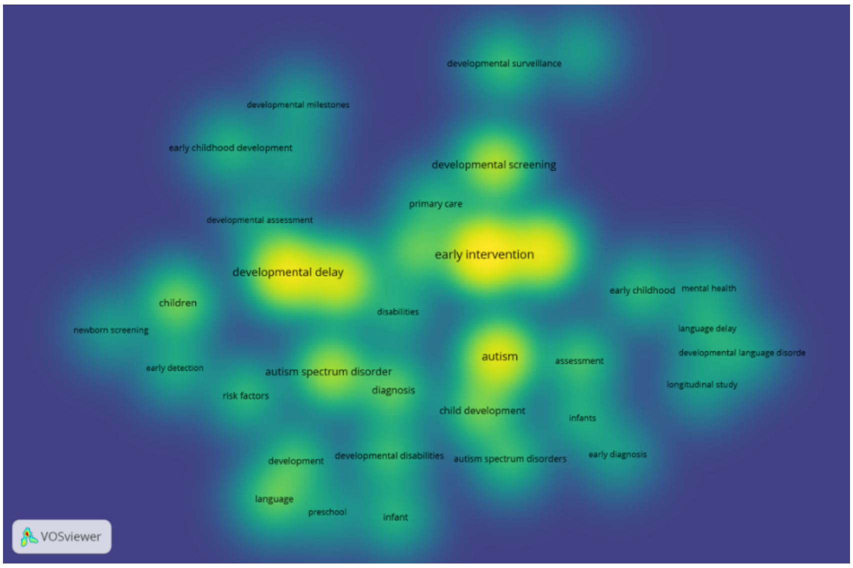


3.7. Co-word Analysis

In the visual representation of the co-keyword analysis density, when the threshold value for the least-used keyword is set to 5, chosen by the program, it is observed that out of 942 keywords, 36 have been used 5 or more times. In the density visualization, colors are arranged as follows: green represents the lowest density, yellow represents medium density, and red represents the highest density. Overall, the top five most frequently used keywords in the research are "early intervention, developmental delay, early identification, autism, and screening," appearing 54, 41, 38, 36, and 32 times, respectively (as shown in Figure 4).

Figure 4

Co word analysis

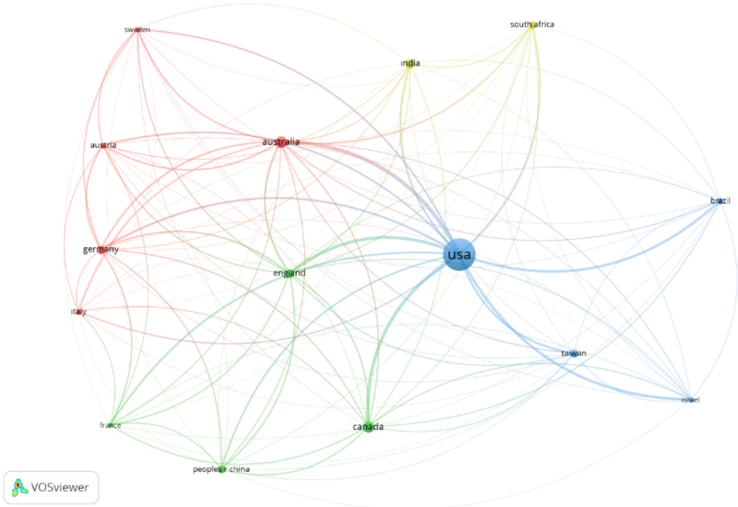


3.8. Bibliographic coupling analysis

Bibliographic coupling analysis involves systematically processing information and allows for the in-depth exploration of scientific data through the use of computer algorithms (Merigo et al., 2016). When using the same references, the similarity between articles can be assessed through bibliographic coupling (as seen in Figure 5). This analysis enables the revelation of the intellectual structure of emerging literature, facilitating a better understanding of current developments in the literature and deepening connections in the field (Kajikawa et al., 2007). Furthermore, it aids in monitoring and classifying current trends, while also offering insights into the network of relationships among authors, institutions, and countries that reference the same studies (García-Orozco et al., 2020).

Figure 5

Bibliographic coupling analysis from a country perspective



Based on the bibliographic coupling analysis illustrated in the figure, the United States (US) stands out as the leading country where authors collaborating on research pertaining to developmental delay, diagnosis, and early identification have published the most articles. The US not only has the highest volume of publications but also plays a crucial role in advancing the field. Following the US, Australia, Canada, and India are also significant contributors.

4. Discussion and Conclusion

Bibliometric research has gained momentum in recent years, facilitating the identification of significant trends and gaps in research topics through bibliometric analysis (Donthu et al., 2021). A comprehensive literature review was performed using the keywords "early intervention," "developmental delay," and "identification" to examine the characteristics of published research in these areas. Understanding the features of these studies offers several advantages, including insights into current trends, the identification of future research directions, and information about the relationships among the most frequently studied topics and concepts (Bağış, 2021). Researchers have increasingly focused on the detection, intervention, and early identification of developmental delay. In recent years, there has been a consistent rise in the number of articles related to this topic. This research aims to comprehensively outline studies in the areas of early intervention, developmental delay, and diagnosis, incorporating bibliographic coupling analysis and co-word analysis.

The primary objective of research on early intervention, developmental delay, and identification is to explore strategies to address the fundamental issue of developmental delay.

Investigating the causal factors contributing to the observed delays in children is essential. Identifying a specific underlying etiology has significant implications for ongoing management, including estimating the risk of relapse, determining accurate prognoses, establishing mechanisms for medical follow-up, and, in rare cases, guiding specific therapeutic interventions (Shevell et al., 2001). Publications on this subject have demonstrated an upward trend from 1991 to the present, with a notable peak in the last two years. Notably, a screening study on the prevalence of autism spectrum disorder stands out among the most cited works (Christensen et al., 2016).

When looking at research output by country, the USA (n = 210), Australia (n = 29), and Canada (n = 27) stand out as leading contributors. There remains a lack of agreement on the most effective screening tools for identifying developmental disorders across various contexts. Although substantial strides have been made in developing, validating, and implementing screening tools for low- and middle-income countries, the majority of these tools were originally created in North America or Europe and are now applied in different cultural settings. While a shortage of validated tools for detecting autism in low- and middle-income countries persists (Soto et al., 2015). Various organizations, mostly in the United States, advocate for the screening of Autism Spectrum Disorders (ASDs), and the adaptation of screening instruments is on the rise. Research on childhood disability remains insufficient, particularly in low- and middle-income countries, despite its significant impact on child development, family dynamics, and economic factors (Maulik & Darmstadt, 2007). Besides, within-culture factors can restrict the validity of a tool, including differences in education levels, socioeconomic status, literacy, awareness of autism spectrum disorder and prejudgment (Soto, et al., 2015).

When examining the areas of research, it is evident that the majority of articles have been published in the field of pediatrics. This underscores the interdisciplinary nature of the investigation and intervention required in this field. The traditional categorization of young children may lead to premature labeling, mis categorization, and the under identification of children with delays who do not fit into conventional eligibility categories (Division for Early Childhood of the Council for Exceptional Children, 2001). This effect has been observed in past studies as well. Instead of simply associating with birth weight, it is feasible for primary healthcare providers to regularly conduct observations and developmental screenings (Poon et al., 2010). The labeling of young children requiring early intervention services has been a subject of ongoing debate among parents, advocates, service providers, researchers, and policymakers for several years (Hadadian & Koch, 2013). The evaluation process of early childhood development is influenced by various risk factors. Additional risk factors that can arise in a school or community context include a strict curriculum, less opportunities for children to engage with one another, social isolation, and frequent exposure to violence (Hadadian & Koch, 2013).

4.1. Implications of Research

Key characteristics of modern education emphasize that it is more effective and cost-efficient when delivered at an early age compared to early intervention programs for children with general developmental delays (Singh & Anekar, 2018). In co-word analysis, in addition to the keywords "early intervention," "developmental delay," and "early intervention," the terms "autism" and "screening" stand out. This highlights the significance of research on autism in the context of early intervention. The presence of the keyword "screening" also indicates that screening results are crucial assessment elements in early intervention. Hence, various studies have been conducted to detect developmental delays in early childhood (Wallace et al., 2012; Goldfeld & Yousafzai, 2018).

4.2. Limitations and Suggestion

The primary aim of this study is to elucidate the intellectual structure of research on developmental delay, diagnosis, and early intervention and provide information about the research areas. Firstly, our analysis is solely based on the Web of Science database. While there is no limitation in terms of the starting point of the analysis in this study, the latest studies have been restricted to those available until January 15, 2023, which is the date of the last systematic literature review. For future studies, this time frame can be restructured by including publications from 2024 onwards. In this study, searches were conducted in the topic fields for the keywords "early intervention," "developmental delay," and "identification."

Addressing developmental delay is of the most importance for both families and society. However, there is a notable deficiency in high-quality studies examining the benefits of screening and the long-term effectiveness of treatment. Urgent research is imperative to identify optimal treatments for diagnosed developmental delay, leveraging promising findings as a foundation. Additionally, valuable studies should evaluate effective strategies for developmental milestone surveillance and case identification. Primary healthcare providers play a crucial role in this context and should remain vigilant in monitoring a child's development during every clinical encounter, emphasizing developmental surveillance. Their focus should be on confirming the diagnosis of developmental delay among children who are suspected to be at risk, ensuring timely and appropriate interventions for improved outcomes.

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Research Article

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A STEM Activity Focused on Chemistry: Smart Food Packaging

Çiğdem KARAKAYA [1], Nusret KAVAK *[2]

* *Corresponding nkavak@gazi.edu.tr*
[1,2]*Gazi University, Türkiye*

Abstract

The aim of this study is to introduce a STEM activity in accordance with the problem-based teaching method focused on chemistry course prepared to develop 10th grade students' entrepreneurship and scientific process skills. The activity consists of seven stages. In the first stage, a problem that students may encounter in daily life was presented and they were asked to produce a solution to this problem. The problem is related to smart packaging, which is widely used abroad. In the STEM activity, which was initiated with a story, students were asked to design a smart packaging that is harmless to human health with the cheap and easily accessible materials given to them, to make a prototype and to carry out the promotion and marketing of the product they created. The activity was applied to 25 high school students. Students' opinions about the activity were collected through the activity evaluation form. The students who participated in the activity described the activity as interesting.

Keywords: STEM activity, Problem based learning, Entrepreneurship, Scientific process skills

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Kimya Dersi Odaklı Bir STEM Etkinliği: Akıllı Gıda Ambalajı

Özet

Bu araştırmanın amacı 10. sınıf öğrencilerinin girişimcilik ve bilimsel süreç becerilerini geliştirmek amacıyla hazırlanan kimya dersi odaklı probleme dayalı öğretim yöntemine uygun bir STEM etkinliğini tanıtmaktır. Etkinlik yedi aşamadan oluşmaktadır. İlk aşamada öğrencilerin günlük yaşamda kaşılaşabilecekleri bir problem sunulmuş ve onlardan bu probleme çözüm üretmeleri istenmiştir. Problem, yurt dışında yaygın olarak kullanılan akıllı ambalajlarla ilgilidir. Bir hikâye ile başlatılan STEM etkinliğinde öğrencilerden kendilerine verilen ucuz ve kolay ulaşılabilir malzemelerle insan sağlığına zararsız bir akıllı ambalaj tasarlamaları, prototipini yapmaları ve oluşturdukları ürünün tanıtım ve pazarlama çalışmasını yürütmeleri istenmiştir. Etkinlik 25 lise öğrencisine uygulanmıştır. Öğrencilerin etkinliğe ilişkin görüşleri etkinlik değerlendirme formu aracılığıyla toplanmıştır. Etkinliğe katılan öğrenciler etkinliği ilgi çekici olarak nitelendirmiştir.

Anahtar Kelimeler: STEM etkinliği, Probleme dayalı öğrenme, Girişimcilik, Bilimsel süreç becerileri

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1. Introduction

It is important for countries aiming for economic development to invest in human capital. In the twentieth century, which is also called the "Age of Human Capital," the level of education has become the most important indicator of the productivity of individuals and the level of development of nations. The increase in the level of education of individuals increases not only their own productivity but also the productivity of others with whom they interact; thus, as the average level of education increases, the level of productivity in society also increases (Card, 2001). Many studies in economics have emphasized that education generates economic returns (Öztürk, 2008). Education is like a lever: It enables countries to catch up with or lead the era.

During the transition from the Neolithic age to the information age, many transformations have taken place in education due to the changing needs of society. This transformation process is analyzed in four periods: Education 1.0, Education 2.0, Education 3.0 and Education 4.0. Education 1.0 is the era in which the people needed by the economy based on agricultural production were trained, and education in this era was based on teacher-centered understandings in which knowledge and experience were transferred from master to apprentice. Education 2.0, which started with the Industrial Revolution, aims to train individuals for the industrial sector. With this understanding of education, individuals who work in harmony with their colleagues in the production line were trained. Education 3.0 is a period in which students are in the position of producing information, not just receiving it, and schools aim to raise individuals with diplomas in accordance with social expectations. Education 4.0 aims to raise individuals who can adapt to changes such as rapid transformation, artificial intelligence, robotics, and automation and who can cooperate with robots, and according to this approach, it is accepted that only diplomas and certificates are not enough (Zengin, 2022). In addition to the diplomas that individuals have, being competent in the field they work in, being open to continuous learning, being productive in the digital change processes in the world in a global context, being a designer, being able to produce solutions, being able to adapt quickly to technological changes, and having flexible skills are reported as necessary criteria for them to be preferred in the business world (Zengin, 2022). In this context, the adaptation of STEM education to the education system is important.

STEM is an acronym derived from the English words science, technology, engineering, and mathematics. Although the acronym STEM commonly refers to certain disciplines (Science, Mathematics) and professions (Engineering, Technology), there is still debate about what exactly these disciplines and professions are (Gonzalez & Kuenzi, 2012). Individuals with STEM knowledge and equipment solve problems using the information they have learned and develop critical thinking and higher-order thinking skills (Morrison, 2006). This approach encourages students, enables them to reach their aspirations, and provides them with the opportunity to apply what they have learned. It is stated that STEM education practices contribute to students' creativity, increase their self-confidence, and better understand and express the nature of technological developments through engineering studies using their knowledge and skills (Morrison, 2006). It is thought that the skills that students acquire in STEM education are related to 21st-century skills (Li & Schoenfeld, 2019).

Economic competition and environmental issues in the global market have made STEM education important. STEM education has also changed the education systems and curricula of countries in the economic race. Global problems have increased the demand for labor requiring STEM education.

STEM education approach practices vary considerably according to the level of education. At the primary school level, the focus is more on increasing performance and participation in science and mathematics curricula that are required for everyone. As the level of education increases, the content of the curricula includes more specific information about the relevant field of science and the sciences referred to by the acronym STEM can be specialized into sub-disciplines. For example, at the primary school level, science courses are based on a curriculum for daily life that is necessary for everyone, while at the high school level, science specializes in sub-disciplines of physics, chemistry, and biology. In addition to teaching daily life skills, students are also taught higher-level skills specific to the discipline. In this case, it should not be overlooked that STEM education practices are expected to be implemented at the primary school level, and STEM practices at high school, undergraduate, and graduate education levels are not the same; they should be specialized in accordance with the relevant education level. There are scientific studies that suggest a classification of STEM fields at levels other than the primary school level and that the STEM abbreviation should be made in accordance with the level of education in line with this classification (Xie & Killewald, 2012; Xie et. al., 2015).

STEM is easier to implement in primary schools because the subjects of physics, chemistry and biology are gathered in a single program under the name of science. Also, as a result of the fact that students are taught by a single teacher in primary school, teachers can freely develop and implement STEM learning designs (Roberts, A., 2012). The situation is different at the high school level. In addition to the curriculum not being thematic, each course is taught by a different teacher. Therefore, the integration of STEM into the curriculum at the high school level is more challenging. Creating a curriculum structure that integrates STEM elements across disciplines in this existing curriculum requires a long time and in-depth analysis. In countries with STEM-based curricula, this process has taken decades (Dugger, 2010). The best way to implement STEM in high schools is to use the embedded STEM approach. In this approach, an everyday or real-world context is needed as a learning theme. Through these contexts, students can use their cognitive gains to perform context-related activities through problem-solving.

Although different methods have been proposed for the implementation of STEM education, in general, the application starts with the presentation of a problem from daily life to students. Chemistry is a science related to real life. Presenting the subjects in the form of real-life problems enables students to understand the subject better and to be better prepared for similar situations in the future (Savery, 2015). It has been stated that problem-based learning (PBL) applications in chemistry teaching improve students' skills in using information sources, working in cooperation with the group, and contribute to students' high motivation and positive attitude toward chemistry courses (Tüysüz et al., 2010; Tosun & Taşkesenligil, 2012); increase the retention of the subjects taught and provided important advantages such as communication, problem-solving, and self-learning (Tatar et al., 2009). There are many studies showing that PBL applications in chemistry teaching improve students' problem-solving skills (Şenocak, 2005), logical thinking skills (Kumbasar, 2019), scientific process skills, and academic achievement (Tüysüz & Demirel, 2020).

In the traditional approach, students only receive information from the teacher to solve the problems given to them, whereas in PBL, after the problem situation is given, students become aware of what they are learning and why. In this approach, students reach the targeted information while solving the problem and, similar to the work of a scientist, identify the problem situation, collect the necessary information, and try to reach a conclusion (Tosun & Taşkesenligil, 2012). PBL is a method of learning in groups and individually that encourages students to conduct research to solve real-world problems, rather than teachers delivering lessons in the form of presentations and students trying to learn topics from textbooks (Sönmez & Lee, 2003). In PBL environments, the teacher coaches students in collaborative work and product design processes (Black & Wiliam, 1998; Hattie & Timperley, 2007).

The Chemistry Curriculum, published by the Ministry of National Education in 2024, is structured to shape the undergraduate and graduate studies of students interested in basic sciences (science for science) or engineering (science for society) (MEB, 2024). In the Chemistry Curriculum, the concept of STEM is emphasized explicitly rather than implicitly, unlike previous curricula. For example, the 9th grade chemistry curriculum includes the following statements (MEB, 2024).

> "Students may be asked to come up with designs for cleaning discharge water. For this purpose, students can be made to do an activity where they can apply STEM steps. Students can be asked to identify the waters polluted by domestic, agricultural or industrial wastes in their environment."

In order for chemistry teachers to plan and conduct their lessons in accordance with the Chemistry Curriculum, they need to have knowledge about STEM activities. Therefore, it is important to provide teachers with examples of STEM activities. There are many studies in the literature on STEM applications in chemistry education. Some of these studies are summarized in Table 1.

Table 1.

STEM applications in chemistry education

Researchers	Participant/Sample	Activity
Tarkın-Çelikkıran & Aydın-Günbatar (2017)	13 chemistry teacher candidates	4 activities: Design of cold compress bag, Making indicator, Measurement of CO2 in aquarium, and Preventing browning of apples
Bruce, et. al, (2016)	419 university students	Students build a spectrometer to explore infrared radiation and greenhouse gases in an inquiry-based investigation to introduce climate science in a general chemistry lab course.
Tamburini, et. al (2014)	6 high school students	6 Modules: Paper Pulping and Floatation De-Inking, Enzymatic Digestion, Fermentation, Oligomerization, Lactide Formation, and Polymerization
Marle, et. al. (2014)	33 high school students	It is an application made in summer camp. Students visited the chocolate factory and collected data from the artificially prepared scene. Students also did activities related to methods Chromatography, GIMP Analysis, and Stereomicroscopy
Burrows, et. al. (2014)	106 high school students	A lesson plan has been prepared to be applied in biology and chemistry courses. All of the topics are related to the biodiesel production process.

If the studies in Table 1 are examined in detail, it is seen that most of the activities focus on specific topics. Almost none of these specific topics are in the chemistry curriculum. Chemistry teachers in Turkey may not use these activities very much. Therefore, the number of activities that can be done with simple materials and suitable for the topics in the chemistry curriculum should be increased.

The aim of this study is to introduce a STEM activity in accordance with the problem-based teaching method focused on chemistry course prepared to develop 10th grade students' entrepreneurship and scientific process skills.

2. Implementation Stages of The STEM Activity

The chemistry course-oriented STEM activity designed in accordance with the PBL method was carried out by taking engineering design steps into consideration. After obtaining the necessary permissions, the activity was applied to twenty-five 10th-grade students. The students were studying at a school in a good socio-cultural area in the capital of Turkey. The implementation of the activity took 4 class hours of 40 minutes each. The materials used in the activity are listed in Table 2.

Table 2.

Equipment and the materials used in the activity

Solutions	Other Materials
0.1 M Hydrochloric acid (HCl)	pH meter
0.1 M Sodium hydroxide (NaOH)	Erlenmayer
1 M Acetic acid (CH3 COOH)	Beherglas
Concentrated ammonia	Test tubes
Lemon juice	Tube Holder
Bleach	Graduated cylinder
Detergent water	Glass pipette
Pure water	Glass rod
Red cabbage juice	Pet bottle
	Duct tape
	Scissors
	Colored cardboard

The activity starts with a picture, followed by a brief explanation about the importance of food poisoning and smart packaging labels used abroad that provide direct information about the freshness of food. Then, the short story of a family who had to leave home for a long time for vacation was given. Upon returning from vacation, the family was unsure about the freshness of perishable foods such as meat and milk in their fridges. Although the expiry date has not expired, the family suspects that during the time they were away, they were exposed to an adverse condition, such as a power outage, which could have caused the food to spoil unobservably.

2.1. Defining Problem

This is the stage where students brainstorm after reading the short information and the story in the activity introduction to find out what the problem is under the guidance of the teacher. At this stage, the question "How could there be a packaking that would allow us to understand whether meat and dairy products are spoiled or not?" was asked to students and their answers were written on the board without criticism. Then, each answer written on the board was discussed and the logical ones were determined. This stage, which was carried out to determine the boundaries of the problem and to ensure that students internalize the problem, lasted approximately 10 minutes.

2.2. Analyzing the Problem

At this stage, students were first asked how they could tell whether meat and dairy products were spoiled or not. Then, in order to develop students' scientific observation and classification skills, they were given samples of fresh meat, spoiled meat, fresh milk, and spoiled milk and were asked to examine the samples, describe the characteristics of each of them, and classify them according to the differences in their appearance. Students recorded the results of their observations in the space allocated in the STEM worksheet. Scientific observation is the foundation of scientific process skills. People's need to observe their environment activates their sense of curiosity and triggers their desire to understand the world. Observation is defined as the process of using the senses to obtain information about objects and events in the environment. Observation, which is accepted as an important skill in the scientific process, is considered to be the essence of science as it forms the basis of other scientific process skills (Martin, 2003, pp. 65-66).

Another science process component that students try to develop at the problem analysis stage is prediction based on scientific observation. This skill involves drawing conclusions from observation data to justify their predictions by comparing observational and non-observational examples. In order to develop this skill in students, the following questions were written on the STEM worksheet, and students were asked to answer them.

- With which of your senses can you tell if food is spoiled?
- How do you determine whether meat and dairy products are tainted in a dark environment?
- Imagine that you have temporarily lost your sense of smell due to illness. What observations would you make to guess whether meat and dairy products were spoiled? Which observations would lead you to conclude that the meat and dairy products were spoiled?

Another science process skill focused on at this stage is operational definition. In order to help students acquire this skill, which is also known as transforming concepts into variables, an activity to determine whether various substances are acids or bases with a cabbage juice indicator was conducted in class. In this activity, students were asked to add hydrochloric acid, sodium hydroxide, acetic acid, concentrated ammonia, lemon juice, vinegar, bleach, detergent water, and distilled water to the flasks in which they put equal amounts of cabbage juice and observe the color changes in the solutions. Students used the observation data to classify the solutions as acidic, neutral, or basic and tried to estimate the pH values of the solutions as less than 7, 7, or greater than 7.

After the activity was completed, the class was informed that meat and dairy products produce acidic and basic gases when they are spoiled. They also discussed how to understand whether meat and dairy products are spoiled without opening their packages. This phase lasted approximately 30 minutes.

2.3. Explaining the Problem

This is the stage where students write a testable problem statement from the inferences they make and the data they obtain. In order to write a good problem statement, it is necessary to know what is known, what is expected, and what is available. For this, first of all, it should be determined how the topic has been examined before and what new studies are needed. For this reason, the students decided what they would investigate by discussing what they knew about the topic in the group and what they had learned from their observations and experiments. Students investigated the reactions that take place when food spoils and the gases that are produced as a result of these reactions and collected information about packaging technologies that show whether food spoils or not, depending on the pH change.

After the literature review was completed, students were asked to read the criteria and limitations in the STEM worksheet (Table 3). Finally, the students who had reviewed sufficient resources and, read the criteria and limitations discussed in the group and wrote the problem statements on the STEM worksheets. This application took about 15 minutes.

Table 3.

Criteria and limitations are written in the worksheet about the STEM activity

Criteria	Limitations
At least 100 mL of liquid should be placed in the container you will design	Only the following materials can be used when designing the container.
The container you design should be able to hold both meat and milk	500 mL Pet water bottle Strainer paper
The container you will design should not leak solid, liquid, or gas	Red cabbage juice Duct tape and decoration materials
The container you design must be aesthetic	The time allocated for the design of the container is 30 minutes.

2.4. Solutions

The scientific process skills focused on at this stage were hypothesizing and identifying variables. In order to help students acquire these skills, a demonstration experiment was first conducted with a pH meter. In this demonstration experiment, equal volumes of water with the same temperature were placed in two beakers, and the pH values of the waters were measured using an identical pH meter. Then, 5 mL of 0.1 M HCl solution was added to one of the beakers, and 10 mL of 0.1 M HCl was added to the other beaker, and the pH values were measured again. Finally, the results of the measurements were written in the table drawn on the board, and the dependent, independent, and control variables were discussed in the class.

After the demonstration experiment, students were asked to think of possible solutions to the problem they had identified. They wrote their solutions as hypotheses on their STEM worksheets. They were also asked to identify the dependent, independent, and control variables in their hypotheses. This phase took approximately 10 minutes.

2.5. Consider Alternative Solutions

At this stage, each student explained their solution proposals for the problem they had chosen, their hypothesis, and the variables in their hypothesis to their groupmates. The groups decided on the best solution proposal by considering the criteria, limitations, and variables. This phase took approximately 5 minutes.

2.6. Modeling the Prototype

This is the stage in which the students think about and model the prototype using the materials given to them. Students drew the model of the prototype they designed at this stage on their STEM worksheets. This phase took approximately 10 minutes.

2.7. Preparing the Prototype

The groups were divided into small groups to prepare their prototypes. Some students in the groups prepared their indicator papers. For this, they first cut the filter papers into different shapes according to their designs. Then, they soaked the cut papers in red cabbage juice and dried them.

The other members of the groups prepared the plastic water bottles. They made small holes in the plastic water bottle according to their designs. The indicator paper prepared by the first group was placed on the hole and wrapped well with duct tape. In this way, it was tried to prevent the substance to be put into the plastic bottle from leaking out. Finally, the groups finalized their designs by decorating the containers they prepared with decoration materials. This stage took approximately 15 minutes.

2.8. Testing the Prototype

The science process skill focused on at this stage was experimentation. Students were asked to design an experiment to determine whether the prototype they prepared was fit for purpose. They were told that food would take a long time to spoil and that it would not be possible to observe this during class time, and they were told to think of alternative materials they could use in the experiment. Through teacher-led class discussions, it was decided that acetic acid and concentrated ammonia vapor could represent the acidic and basic gases produced by spoiled foods and that acetic acid and concentrated ammonia solutions could be used in the experiments. The teacher then gave the students containers of solutions that they did not know what was in them. The students conducted experiments using their prototypes to determine whether the substances given to them were acids or bases. The students poured the given solutions into their prototypes, closed the cap of the bottle, and started the stopwatch. As soon as they observed a color change in the indicator (Figure 1), they stopped the stopwatch and recorded the time in a table, as in Table 4. Before each trial, the filter paper impregnated with the indicator that had changed color on the prototype was removed and replaced with a new one. When some groups tested their prototypes, they could not observe the color change clearly because there was gas leakage where they glued the filter paper impregnated with the indicator. This stage took approximately 15 minutes.

Figure 1.

Color change on indicator-impregnated filter paper in one group's prototype

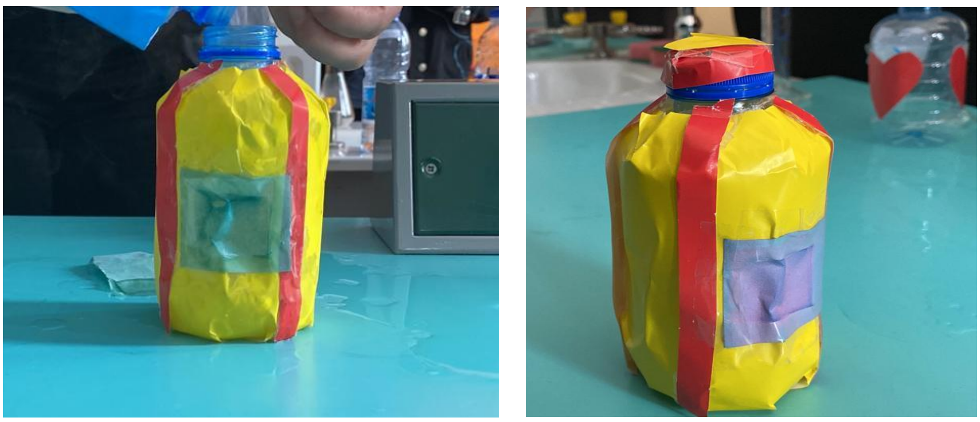

Table 4.

Example of a table in the STEM worksheet where groups record the results of the experiment

Experiment No	Independent Variable	Dependent Variable (Indicator color change time)	Observed Change

2.9. Test-Improve

This stage is the stage where the designs are reviewed, and necessary improvements are made in light of the data obtained from the experiments. The time allocated for this stage of the proposed activity is 10 minutes. Students discussed within the group and decided what kind of changes they would make in their designs. For example, some groups observed that a single layer of filter paper was punctured and used two layers of filter paper in their new designs. This phase took approximately 10 minutes.

2.10. Marketing the Prototype

At this stage, students were asked to promote and market their products in order to develop their entrepreneurial skills. For this, students first answered the following questions as a group.

- Think about what distinguishes your product from similar products. What are the advantages of your product?
- What is your advertising message?
- Explain your advertising strategy.

The students then prepared a poster for the promotion and marketing of their smart packaging and presented it to their classmates. This stage took approximately 20 minutes.

2.11. Evaluation

The students evaluated the smart packaging prototypes. In order for the evaluations to be objective, first of all, a measurable and observable scoring key given in Table 5 was prepared with the students for each criterion listed in Table 5.

Table 5.

The scoring table was created with the students to evaluate the prototypes

Criterion	2 Points	1 Point	0 Points
The volume of the container	Even if the container lies on its side, 100 mL of liquid can be poured into the container without leaking.	100 mL of liquid can barely be poured into the container without lying	The container cannot hold 100 mL of liquid.
Substances that can be placed	The container can hold both meat and milk.	Only milk or meat is put in the container.	No milk or meat can be put in the container.
Robustness	The container does not leak solid, liquid, or gas.	The container does not leak solids or liquids.	The container leaks solid, liquid, or gas
Aesthetics	At least two different colors are used in the decoration	A single color used for decoration	No decoration

Students presented their prototypes with their group in front of other groups. Students scored the prototype of the presenting group using the prepared scoring key. The scores of the groups were written on the board. Each member of the group with the highest score was given a chocolate bar as a reward. This phase took approximately 20 minutes.

3. Results

Students' opinions about the activity were collected through the activity evaluation form, the items of which are given in Table 6.

Table 6.

Frequencies and percentages of students' opinions about the activity

Item in the activity evaluation form	Student views I agree. f	%	Undecided f	%	Disagree f	%
The activity is engaging.	20	83,4	2	8,3	2	8,3
The activity helped me understand the topic of acids and bases.	20	83,4	1	4,2	3	12,5
I think my entrepreneurship skills have improved by participating in the activity.	8	33,3	14	58,4	2	8,3
In the future, I would like to start a company that sells the products we have designed.	9	37,5	8	33,3	7	29,2
I think my problem-solving skills improved by participating in the activity.	15	62,5	6	25,0	3	12,5
By participating in the activity, I learned about the spoilage process of meat, milk, and its products.	22	91,7	2	8,3	0	0,0
I would like similar activities to be done more often in chemistry lessons.	18	75,0	2	8,3	4	16,7
By participating in the activity, I understood what indicators are for.	21	87,5	1	4,2	2	8,3
By participating in the activity, I learned about some laboratory materials.	15	62,5	5	20,8	4	16,7
Working in a group was more productive than working individually.	16	66,7	5	20,8	3	12,5

Table 6 shows that 83.4% of the students found the activity introduced in this article interesting. According to the Table 6, the majority of the students stated that they understood the acids and bases topic better through the activity and that they had information about the spoilage process of meat, milk, and their products. 75% of the students wanted similar activities to be done more frequently in chemistry lessons. This finding is in line with informal classroom observations. Most of the students tried to do the activities even during breaks, and even students who were generally not interested in the lessons actively participated in the lessons.

According to Table 6, 58.4% of the students are undecided about the development of their entrepreneurial skills. This finding is consistent with the data in the item "I would like to establish a company to sell the product we designed in the future." However, it cannot be said that STEM activities do not develop students' entrepreneurial skills just by looking at this data. This study introduces the activity used in a doctoral dissertation in which the effect of STEM activities on the development of science process and entrepreneurship skills of 10th-grade students was investigated. In the thesis study, students did four different STEM activities. At the end of the activities, the development of students' entrepreneurship and science process skills were measured with standardized measurement tools.

Another important finding in Table 6 is that 62.5% of the students think that their problem-solving skills have improved. As it is known, problem-solving skills and scientific process skills are interrelated. Therefore, students' scientific process skills were also improved thanks to the activity. This finding is supported by the data in the item "Thanks to the activity, I gained knowledge about some laboratory materials" because one of the scientific process skills is to recognize and use the experimental materials correctly

4. Discussion and Conclusion

This study presents an engaging STEM activity that can be used to teach acids and bases to 10th-grade students. The activity was aimed at developing students' science process skills and entrepreneurial skills. During the implementation of the activity, students used various laboratory materials, identified the problem, and developed solutions to the problem with the scenario given to them and the questions and directions directed to them, and used their scientific process skills in design, production, and marketing processes. The presented STEM activity enabled students to acquire scientific process skills by doing and experiencing without realizing it. The results of the study are consistent with the literature. It has been reported that STEM activities applied with problem-based teaching method improve students' scientific process skills (Aprianty et al., 2020; Jewaru, et al., 2022). It was found that students who participated in STEM activities developed for chemistry courses significantly increased their academic achievement and creativity (Ridwan et al., 2017; Tunkham et al., 2016).

In the presented practice, students worked in groups from the beginning to the end of the activity. Students who voluntarily shared tasks within the group in line with the teacher's instructions experienced important skills such as taking responsibility, communicating, and working as a team. In line with the roles that each student has in the group, career development can be contributed to by directing them to conduct research on professions. There are studies showing that STEM education significantly increases students' academic achievement and improves their career interests positively (Çevik, 2018).

In this activity in which the engineering design cycle was used, students realized the deficiencies and mistakes in the design after testing the prototypes they created. These realized deficiencies and errors can be characterized as new sub-problems that emerged as they progressed through the activity steps. For each problem they noticed, the students reinforced their scientific perspective by going through the stages of recognizing the problem, expressing the problem, brainstorming, proposing solutions, problem-solving, reasoning, testing, and developing in a cycle of processes similar to the process they followed from the beginning of the activity. This information is in line with studies showing that STEM activities increase high school students' scientific process and engineering skills (Khamhaengpol et al., 2021). There are also research findings in the literature that STEM activities increase students' awareness about the importance of the engineering profession and engineering skills (Popa & Ciascai, 2017). Teachers can inform students about laboratory materials, methods and techniques, and safety rules during STEM activities. In addition, the implementation of STEM activities in chemistry lessons can provide many advantages, such as enabling students to try cheap materials that are easily available in the design and production stages and to gain skills such as recognizing materials and developing hand skills.

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Research Article

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Implementations of Generative Artificial Intelligence Tools Within the Contexts of English Language Teaching and Learning: A Systematic Review

Narin TUNCER *[1], Sinan HOPCAN[2]

*Corresponding narintuncer10@gmail.com
[1]İstanbul Medeniyet University, Türkiye
[2]İstanbul University - Cerrahpaşa, Türkiye

Abstract

Generative Artificial Intelligence technologies have attracted considerable interest in various fields including language education where their potential to improve learning and teaching has begun to be explored. However, there is a lack of systematic reviews summarizing both the existing knowledge and gaps in this field. In this regard, this systematic review aims to explore the implementation of GAI tools in foreign language education, specifically within the contexts of ESL, EFL, ELL and ELT. Through searching on various data sources and identifying 823 articles, 39 articles were included based on the study's criteria. Aligned with the study objectives, the articles were analyzed in terms of many factors such as publication year, research method, learning place, target audience, utilized GAI tool, its role, data collection tool and method, study duration, sample selection type, data analysis method, main purposes, and results of the studies. The findings suggest that GAI tools, specifically ChatGPT, have the potential to enhance English language education in various contexts. By offering benefits such as providing personalized learning and feedback, ChatGPT enhances overall language proficiency. It develops language skills, particularly writing, boosts motivation and facilitates teaching. Despite presenting benefits for both English language learning and teaching, some concerns, including ethical issues, academic integrity, limiting creativity and misinformation, have been addressed, highlighting the importance of careful implementation to maximize their positive effects on English language education and suggesting that further research is needed.

Keywords: Generative Artificial Intelligence, Language Education, English as a Foreign/Second Language, English Language Teaching

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İngilizce Dil Öğretimi ve Öğrenimi Bağlamında Üretken Yapay Zekâ Araçlarının Uygulamaları: Sistematik İnceleme

Özet

Üretken Yapay Zekâ teknolojileri, dil eğitimi de dahil olmak üzere çeşitli alanlarda büyük ilgi uyandırmış ve bu teknolojilerin öğrenme ve öğretim süreçlerini iyileştirme potansiyeli keşfedilmeye başlanmıştır. Ancak, bu alandaki mevcut bilgiyi ve boşlukları özetleyen sistematik incelemeler konusunda bir eksiklik bulunmaktadır. Bu bağlamda, bu sistematik inceleme, üretken yapay zekâ araçlarının yabancı dil eğitiminde, özellikle İngilizceyi İkinci Dil Olarak Öğrenme, İngilizceyi Yabancı Dil Olarak Öğrenme, İngilizceyi Öğrenen Öğrenciler ve İngilizce Dil Öğretimi bağlamlarında uygulanmasını incelemeyi amaçlamaktadır. Çeşitli veri kaynaklarında yapılan aramalarla 823 makale belirlenmiş ve çalışma kriterlerine dayalı olarak 39 makale dahil edilmiştir. Çalışma hedeflerine paralel olarak, makaleler, yayın yılı, araştırma yöntemi, öğrenme yeri, hedef kitle, kullanılan GAI aracı, rolü, veri toplama aracı ve yöntemi, çalışma süresi, örneklem seçimi türü, veri analizi yöntemi, çalışmaların ana amaçları ve sonuçları gibi pek çok faktör açısından analiz edilmiştir. Bulgular, özellikle ChatGPT'nin, farklı bağlamlarda İngilizce dil eğitimini geliştirme potansiyeline sahip olduğunu göstermektedir. Kişiselleştirilmiş öğrenme ve geri bildirim sunma gibi faydalar sağlayarak, ChatGPT genel dil yeterliliğini artırmaktadır. Ayrıca özellikle yazma becerisi olmak üzere, dil becerilerini geliştirmekte, motivasyonu artırmakta ve öğretimi kolaylaştırmaktadır. Hem İngilizce dil öğrenimi hem de öğretimi için faydalar sunmasına rağmen, etik sorunlar, akademik dürüstlük, yaratıcılığı sınırlama ve yanlış bilgilendirme gibi bazı endişeler dile getirilmiştir. İngilizce dil eğitiminde olumlu etkilerini en üst düzeye çıkarmak için dikkatli bir şekilde uygulanmasının önemi vurgulanmakta ve daha fazla araştırma yapılması gerektiği önerilmektedir.

Anahtar Kelimeler: Üretken Yapay Zekâ, Dil Eğitimi, Yabancı/ İkinci Dil Olarak İngilizce, İngilizce Dil Öğretimi

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1. Introduction

The ever-evolving nature of technology is continuously transforming every aspect of our lives, and artificial intelligence, as a central component of this evolution, is becoming the driving force of this transformation, as well as shaping both the present and the future. Artificial intelligence (AI), as defined by McCarthy (2007), " it is the science and engineering of making intelligent machines, especially intelligent computer programs" (p. 2). A further and more current definition of AI is "computing systems that are able to engage in human-like processes such as learning, adapting, synthesizing, self-correction and the use of data for complex processing tasks" (Popenici et al., 2017, p. 2). It is believed that the history of AI dates back to ancient times. A continuous series of advancements has contributed to the evolution of the development of the computer and what is currently known as AI for more than two centuries (Grzybowski et al.,2024). These technological innovations have led to its effective applications of AI across various fields. Among these fields, education stands out as one of the most significant areas in which AI applications have made a profound impact. Regarding its overall role in education and its impact on key subjects, AI has shown particular promise in language education as well.

Additionally, a discussion of AI would be incomplete without addressing its emerging subfield, Generative Artificial Intelligence (GAI). GAI is a large language model (LLM) which can produce a wide range of content across various formats, including text, audio, images, and video (Nah et al., 2023). The unique capabilities of GAI have drawn considerable attention in various fields, particularly in language education, with growing research interest following the release of ChatGPT in 2022. It has significant potential, especially in English language education, where it can support ESL, EFL, and ELT practices in multiple ways. Thus, examining the implementation of these applications holds great importance and research studies that focus on these issues are crucial. In this context, systematic reviews can also help us better understand the effects of these practices, as they aim to provide a comprehensive and unbiased overview of a specific topic or question by evaluating, summarizing, and synthesizing existing literature. "Systematic reviews answer predefined research questions using explicit, reproducible methods to identify, critically appraise and combine results of primary research studies" (Pollock & Berge, 2018, p. 138). In the literature, when examining systematic reviews, it is observed that there are a limited number of studies on the use of ChatGPT in foreign language education, particularly in the context of ESL, EFL, ELL and ELT. This highlights a gap in research studies regarding the potential implementation of ChatGPT in language education including ESL, EFL, ELL and ELT fields. In light of this gap, recent research has started to explore the potential use of ChatGPT in different language educational contexts.

A systematic review by Balcı (2024) examined ChatGPT's role in EFL teaching and learning. Another review by Chukwuere (2024) evaluated the benefits and drawbacks of applying ChatGPT in higher education context. Likewise, in the systematic literature review by Sharifuddin ad Hashim (2024), it was aimed to explore the implementation, challenges, and impacts of AI in ESL classrooms in various countries. In addition, a systematic review by Lashari and Umrani (2023) investigated the potential benefits and implications of ChatGPT to support second language learning, while Zhang and Tur (2023) examined the utilization of ChatGPT in educational settings from kindergarten to 12th grade (K-12). Moreover, a systematic review by Feng Teng (2024) examined ChatGPT in EFL writing and Lo et al. (2024) explored the use of ChatGPT in ESL/ EFL education in their systematic review. Last, Meniado (2023) performed a rapid literature review to investigate the effects of ChatGPT on English language teaching, learning, and assessment, and Yang and Kyun (2022) carried out a systematic empirical literature review on AI-supported language learning in EFL and in some other languages.

Most of these studies highlight the need for further research to gain a more comprehensive understanding of GAI and AI implementation in English language learning and teaching. Since it serves the same purpose, this systematic review is important and can contribute to the literature. Upon reviewing the related studies in the literature, the present study is similar to those studies in terms of their topics and settings, but it also presents differences in terms of the scope of the topic and the language skills studied. For example, in this systematic review the focus is not limited to EFL, but also includes ESL and ELT studies. Likewise, it addresses studies on not only writing skills, but all language skills in general. Therefore, it is believed that conducting this study will fill a gap in the literature. In this context, the aim of this study is to explore the implementation of GAI tools in foreign language education, specifically within the contexts of ESL, EFL, ELL and ELT.

Taking all of these into consideration, this systematic review can help better understand the implementation of GAI tools in foreign language education. It can also make staying up to date with current research in the literature possible. Based on all this information, this review can be helpful and informative to researchers interested in pursuing work in this field, as well as to educators, students, and administrators, providing valuable insight for those seeking to gain a deeper understanding of this increasingly impactful topic.

1.1. Literature Review

1.1.1. The history of AI

Pirim (2006) quoted the words of Edward Fredkin, director of the MIT Computer Science lab, as follows: "There are three great events in history. The first of them is the formation of the universe. The second is the beginning of life. The third is the emergence of artificial intelligence." (p.2). The emergence of AI has been influenced and shaped by numerous important milestones. In 1950 the British mathematician Alan Turing addressed the question "Can machines think?", and by examining the combination of the terms "machine" and "thinking," Turing established the intellectual foundations of AI (Turing, 1950, p.50). However, the term AI was coined for the first time by John McCarthy in Dartmouth Conference, held by John McCarthy, Marvin Minsky, Nathaniel Rochester, and Claude Shannon (Coskun & Gulleroglu, 2021), which played a key role in establishing AI as a recognized discipline (Bhutani & Sanaria, 2023). Similarly, Benko and Lányi (2009) state that the conference at Dartmouth was the first time when AI was discussed and attracted researchers' attention. AI has gone through various stages of developments from that point onward. For example: In 1965 ELIZA was written as an AI program and is considered the first example of natural language processing programs in AI; 1966 was the year in which Stanford University produced the first animated robot Shakey; the utilization of the Internet began in 1974; and finally, in 1981, the first personal computer was produced by IBM (Mijwel, 2015).

Arslan (2020) explains that the concept of Deep Learning was introduced by John Hopfield and David Rumelhartin in 1980s and in the following period, the 1990s, artificial neural networks, as information-processing structures that are linked in relation to communication but independent in relation to memory, introduced a new dimension to AI by imitating the human brain. The author (2020) also remarks that in 1997, a supercomputer named Deep Blue defeated the world-famous chess player Kasparov.

The developments proceeded as follows: in the early 2000s, a robot named Kismet, which can use gestures and mimicry in communication was introduced; the robot ASIMO was introduced in 2005, as the closest robot to AI and human-like abilities and skills. In the 2010s some programs like Alphago, IBM Watson, personal assistants like Siri, and chatbots were introduced. AlphaGo, a computer program that was created by Google DeepMind in March 2016, defeated Lee Sedol, one of the greatest Go players of all time (Leach, 2022). In 2018, a transformer-based natural language processing model called BERT was released by Google (Aksu, 2024). In 2018, the language model, Generative Pre-trained Transformer (GPT-1) was presented by OpenAI (Radford et al., 2018). In 2019, OpenAI developed GPT-2 by using a larger dataset and adding more parameters to create a stronger language model; GPT-3, generating extended sequences of original text, was started with 175 billion parameters on May 14, 2020, as being 100 times more extensive than GPT-2 (Kumar, 2023). OpenAI later introduced the GPT-3.5 model in 2022, followed by GPT-4, released on March 14, 2023, it is far more than just an ordinary language model with its impressive ability to generate extensive text covering a vast number of words (From GPT-1 to GPT-4: A Look at the Evolution of Generative AI, 2023). From its early days to the present, AI has improved with technological innovations, thus resulting in its effective applications in various areas. AI applications can be classified into seven primary areas: machine learning, deep learning, natural language understanding, expert systems, robotics, computer vision, and speech recognition. They are also considered subsets of AI and the applications of these subsets exist in various fields, including healthcare, finance, manufacturing, retail, transportation, agriculture, human resources, law, marketing, and education.

1.1.2. AI in Language Education

Artificial Intelligence in Education (AIEd) has gained significant popularity, especially during the Covid-19 pandemic, which accelerated the implementation of technology-based educational tools (Pantelimon et al., 2021). AIEd refers to the application of AI technologies to support teaching, learning, and decision-making processes; computer systems with these technologies can provide personalized guidance, feedback, and support to students, as well as helping teachers and policymakers with their decisions, which can create new opportunities for designing more effective learning activities and improving technology-supported learning environments (Hwang et al., 2020). AI has the potential to change the traditional understanding and functioning of education. The implementation of AI in education is revolutionizing how schools, teachers, and students interact (Lesia Viktorivna et al., 2022), leading to new opportunities for more effective learning environments.

AI has shown significant potential in language education as well. The use of AI in language learning offers various essential benefits, including personalized learning experiences (Luckin & Holmes, 2016), providing feedback (Karsenti, 2019), making corrections, assisting with pronunciation and speaking practice, and boosting student engagement and motivation. The implementation of AI in language education is achieved through various AI-based technologies and applications such as natural language processing (NLP), automated writing evaluation (AWE), and chatbots. NLP applications, such as language assessment tools and chatbots, have been integrated into English Language Learning (ELL) environments to facilitate language practice and interaction (Woo & Choi, 2021). The AI-based applications have the potential to support key language skills such as speaking, writing, listening, and reading as well as important language components like vocabulary and grammar, all of which are crucial for effective communication and comprehension. To illustrate, chatbots provide access to learning resources and assist students through engaging them in natural language conversations and offer immediate responses when help is needed (Suta et al., 2020). This can help improve speaking, vocabulary, and pronunciation skills. Furthermore, AWE, as an educational tool, can be used to assess students' writing by providing automatic feedback on aspects such as grammar, spelling, organization, and coherence, and to help learners improve their grammar and writing skills. AWE enables students by providing valuable insights into the types of errors they commonly make (Link et al., 2014).

While AIEd presents numerous benefits in educational contexts, such as improved learning experiences and teaching efficiency, there are also challenges within the scope of both education in general and language education. Regarding education in general, providing sustainable development of AI, inclusion and equity for AI, as well as preparing teachers for AI (Pedro et al., 2019) are some of the identified key challenges. It is emphasized that further research and collaboration between schools, teachers, and policymakers are needed to address these challenges

1.1.3. Generative Artificial Intelligence (GAI)

GAI is a type of AI that uses machine learning and deep learning to create new data such as images, music, and text (Yu & Guo, 2023). GAI, a subset of AI, differs from typical AI. Unlike traditional AI, which analyzes existing data, GAI, creates original content (Zhang et al., 2023). It operates through machine learning techniques, leveraging deep learning to generate artificial artifacts by identifying patterns in training data (Hu, 2023; Jovanović, 2023). GAI has significantly influenced various fields such as computer vision, natural language processing, and the creative arts (Bandi et al., 2023). Two major GAI types include Generative Adversarial Networks (GANs) for image and audio generation and Generative Pre-trained Transformers (GPTs) for language tasks (Baidoo-Anu & Ansah, 2023). Recent advancements, such as ChatGPT, has gained attention in multiple fields covering not only education (Tate et al., 2023; Williams, 2023), but also journalism (Pavlik, 2023), economics and finance (Alshater, 2022; Terwiesch, 2023), engineering (Qadir, 2023) and medicine (Nisar, & Aslam, 2023). Various GAI models exist, including text-to-image, text-to-3D, image-to-text, text-to-video, text-to-audio, text-to-science, text-to-code and text-to-text models (Gozalo-Brizuela & Garrido-Merchan, 2023). Text-to-text models, such as ChatGPT, have gained particular attention in education. Since its launch in November 2022, ChatGPT has sparked discussions about its impact on education, especially in language learning, as it demonstrates remarkable capabilities in handling complex educational tasks, leading to mixed reactions among educators (Baidoo-Anu & Ansah, 2023; Yu & Guo, 2023).

1.1.4. GAI in English language education

The distinctive features of GAI have sparked significant interest across various fields, including language learning and teaching. Likewise, researchers have recently focused on the use of GAI in education, especially following the release of ChatGPT in November 2022, which attracted public interest in the potential impacts of GAI on education (Yu & Guo, 2023). Trained on large amounts of textual data, ChatGPT and its models can "generate human-like text, answer questions, and complete other language-related tasks with high accuracy" (Kasneci et al., 2023, p.1).

Kasneci et al. (2023) further indicate that large language models like ChatGPT have the potential to enhance teaching and learning processes with their wide range of applications through offering valuable opportunities to improve educational experiences across all levels, from primary to professional development. In the same way, Barrot (2024) defines ChatGPT as a groundbreaking tool in the field of language acquisition. In the realm of language learning and teaching, ChatGPT is able to facilitate the development of language skills. For example, a study by Song and Song (2023) found that using ChatGPT in writing resulted in significant improvements in both writing abilities and motivation. Similarly, it was revealed that in terms of providing instant feedback and creating learner-centered experiences, ChatGPT is a valuable tool (Xiao & Zhi, 2023).

Building on these insights, ChatGPT and similar GAI- based tools can also hold significant potential, particularly in the field of English language education, in which it can enhance ESL (English as a Second Language), EFL (English as a Foreign Language), and ELT (English Language Teaching) practices through various ways. As English is currently used as a lingua franca (Baker, 2009) in the world, the number of people learning English is increasing daily. The growing number of English Language Learners (ELLs) has made it essential to find new and effective teaching methods (Diallo, 2014). Within this framework, GAI tools play a vital role as they offer personalized and interactive language practice (Koraishi, 2023). Moreover, these tools support various language skills such as speaking, pronunciation, vocabulary, writing, grammar, and listening. For instance, in the speaking context, ESL and EFL learners can use chatbots to enhance their speaking abilities. Furthermore, it is believed that these chatbots are valuable tools for language learning because they create realistic scenarios and provide authentic learning experiences (Tai & Chen, 2024); they act as stress-free conversation partners to understand and produce language (Jeon et al., 2023; Yang et al., 2022), and offer personalized interactions based on learners' interests and proficiency levels (Dizon et al., 2022). Another language skill where GAI can be applied in ESL/EFL learning is in the development of writing skills. To illustrate, a study on the impact of ChatGPT on ESL students' academic writing skills, Mahapatra (2024) found that ChatGPT had a significantly positive effect on students' writing abilities, and students reported a favorable perception of this impact. GAIdriven tools like ChatGPT are attractive to EFL/ESL learners because they help develop language skills, offer unlimited, on-demand support, and available anytime and anywhere. In addition to the skills mentioned, there are also studies focusing on the improvement of other skills. Vo and Nguyen (2024) indicate that students can enhance vocabulary and grammar by utilizing ChatGPT to explain word forms, meanings, and usage.

Similarly, within the scope of ELT, GAI tools provide valuable opportunities to make both teaching practices and learning outcomes better. From the teaching perspective, GAI in ELT offers various benefits. Designing lesson plans and materials depending on students' needs, creating fun and engaging activities, and improving instructional materials can be achieved with the help of GAI. These tools, like ChatGPT, can be used to provide feedback on students' writing. A survey by Hong (2023) revealed that EFL teachers reported some benefits of using ChatGPT in ELT, such as enhanced student engagement, personalized feedback, and improved language practice. In a similar manner, in their study, Baskara and Mukarto (2023) focused on the use of ChatGPT in higher education ELT, and the results showed improvements in students' vocabulary acquisition and reading comprehension skills.

Despite offering benefits in the context of ESL, EFL, ELL and ELT, AI- based tools, specifically GAI tools, also have some drawbacks and limitations. To illustrate, ChatGPT has several limitations, including the potential for misuse, providing inaccurate information, offering unclear responses, and fostering dependency on technology (Kasneci et al., 2023); additionally, it may pose risks to academic integrity and equal access to education (Yan, 2023), and it can limit creativity and originality, suppress self-expression, and raise ethical concerns (Ningrum, 2023).

It seems that there is growing interest in the use of GAI in language learning. As technology continues to advance, further research and exploration of GAI implementation in English language education have great potential to improve language learning outcomes and enhance educational practices (Liu, 2024). As previously mentioned, this study aims to explore the implementation of GAI tools in foreign language education, specifically within the contexts of ESL, EFL, ELL and ELT. For this purpose, the research questions were as follows:

RQ1: What is the annual distribution of publications and the list of active countries in the selected studies?

RQ2: What journals and conferences are the selected studies published in?

RQ3: What research designs and methods are used in the selected studies?

RQ4: What learning contents, learning domains, learning places, and target audiences are explored in the selected studies?

RQ5: Which GAI tool has been used the most in the selected studies and what are its roles?

RQ6: What data collection tools and methods are employed in the selected studies?

RQ7: What sample sizes, study durations, and sample selection types are applied in the selected studies?

RQ8: What data analysis methods are commonly used in the selected studies?

RQ9: What are the main purposes and results of the selected studies?

2. Method

This study is a systematic review designed to identify and gather all relevant studies on the implementation of GAI tools in foreign language education, specifically within the contexts of ESL, EFL, ELL and ELT. Within this scope, a systematic review collects all available empirical data that fulfil the predefined criteria to address a specific research question (Higgings et al., 2019). Pollock and Berge (2018) state that current and robust systematic reviews are crucial for staying updated on the broad and continuously expanding research evidence. Systematic reviews are also valuable, as they save time for researchers. Mapping the existing published research and gaining awareness of current knowledge of a research topic can help researchers to utilize their time effectively and improve their research process (Yıldız, 2022).

2.1. Data Collection

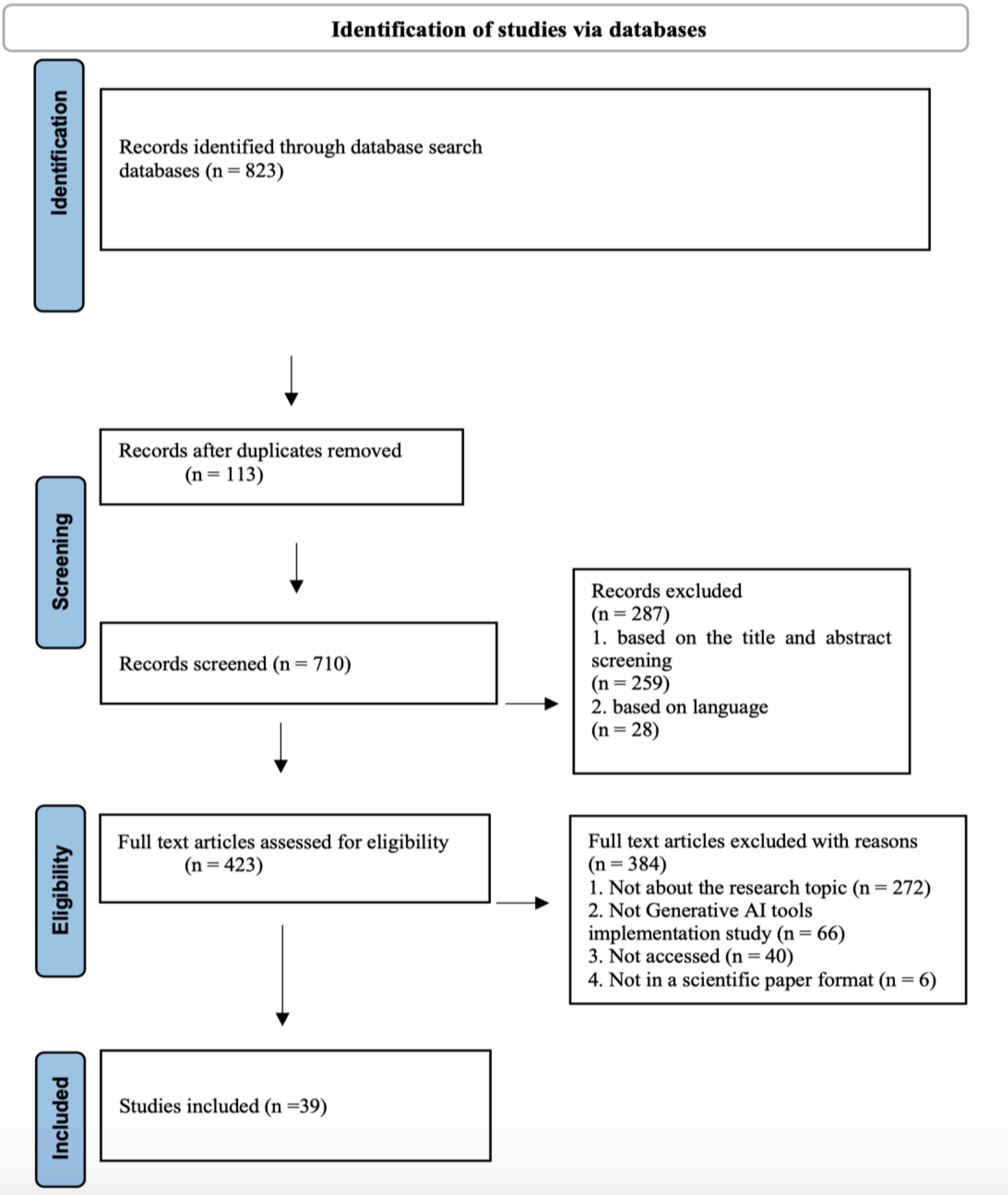
A systematic search was carried out across various databases: Academic Search Ultimate, Biomedical Index, Books at JSTOR, Business Source Ultimate, Complementary Index, DergiPark, Directory of Open Access Journals, eBook Index, ERIC, J-STAGE, JSTOR Journals, Korea Citation Index, MEDLINE, OAIster, OpenAIRE, Sage Knowledge, ScienceDirect, Scopus, Springer Nature Journals, The Belt and Road Initiative Reference Source. The search terms used were "generative artificial intelligence" or "generative ai" or "artificial intelligence" or "ai" or "gpt-3.5" or "gpt-4" or "gpt-4.0" or "chatgpt" or “gemini” AND "esl" or "english as a second language" or "efl" or "english as a foreign language" or "ell" or "english language learning" or "elt" or "english language teaching" or "language acquisition" or "language education" or "language learning" AND "k-12" or "kindergarten" or "primary education" or "secondary education" or "high school" or "university students" or "college students". Moreover, studies published before August 1, 2024 were included in the review.

2.2. Study Selection

Initially, 823 studies were obtained through scanning the databases. A total of 710 studies were defined and chosen for the review after removing duplicated ones. The remaining studies were reviewed again in light of the inclusion and exclusion criteria, and after eliminating those in different languages, 682 studies remained. Another elimination step was carried out by assessing those left for full text quality. There were 423 remaining, 40 of which were removed due to access issues. A further 344 papers were excluded for reasons such as being off topic and irrelevant to the subject of the study, not following the required scientific format, lack of eligibility for the scope of the research. The studies that met the quality criteria were included. Finally, after meticulous examination, a total of 39 articles were identified and considered appropriate for the study by perfectly meeting the eligibility criteria (Fig. 1). The Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) was used to report this systematic review. PRISMA displays various steps in a flow diagram. Identification, screening, eligibility, and inclusion stages are presented to give a clear summary of the number of studies included and excluded at each stage (Siddaway et al., 2019).

Figure 1.

PRISMA publication selection flow chart.



2.3. Inclusion and exclusion criteria

Since some predefined terms and concepts in the review (e.g., ELT, EFL, and ESL) have been the subject of discussion for many years, no specific time frame has been set to select the studies. All relevant studies with participants from elementary level to university level were included. There are only a few studies in which university students are included along with a 45 small number of graduate students. These studies were also included because they involved university students. Only articles, books, book chapters and conference papers were included. Any other kinds of written documents were excluded. The databases provided studies in various languages, but only studies in English were selected for this study. Studies that were outside the focus of the research topic were not involved.

The inclusion and exclusion lists were created based on specific criteria mentioned above. The criteria for including and excluding studies from this systematic literature review are presented below, in Table 1.

Table 1.

Inclusion and Exclusion Criteria

Inclusion	Exclusion
1.Studies must include a GAI tool. 2. The studies should be mainly about ESL, EFL, ELL, or ELT. 3. Selected studies must have been published in English. 4 Included studies must be in a journal, proceeding, or book/ book chapters. 5. Samples ranging from K-16 should have been studied. 6. Studies must be in full text.	1 Studies that fail to meet the inclusion criteria. 2 Studies which do not use a vigorous methodology or are written in an ambiguous way. 3 Studies that fall outside the scope of study. 4 Studies that are not categorized as a research study.

2.4. Data Collection Tools and Coding

In this systematic review an Excel template was created as a data collection tool. This Excel template was generated to work on the chosen studies. The Educational Technology Publication Classification Form (ETPCF) developed by Goktas et al. (2012) was utilized as a guide for the designing of this Excel template. The ETPCF has been used for similar studies as a data collection tool before. (Baydas et al., 2015; Kucuk et al., 2013). The ETPCF has five sections: Publication Information of the Article, Methodology, Data Collection Tools, Sample, and Data Analysis Method. Each section consists of relevant subheadings within itself. For the Excel template, some headings from the ETPCF were selected in alignment with the purpose and scope of the review. Additionally, some headings were also based on those in the study by Hopcan et al. (2023). Throughout the data processing stage in this review, studies were examined under 18 aspects, including title of the article, journal and conference, year of publication, country, purpose of the study, research method, learning content, learning place (for example, in school, out of school, or both, referring to where learning activities take place), learner background, learning domain (for example, writing, speaking, reading and listening are four main language learning domains) data collection tools, type of GAI, study duration, sample size, sample selection types, role of AI technology, data analysis methods, and results of the studies.

The final version of the Excel template was defined, and all relevant data were carefully added to the Excel form. To ensure the effectiveness of the form, feedback was obtained by experts at specific time intervals.

2.5. Data Analysis

At this stage, as it is presented in the selection of studies section, a total of 423 studies were analyzed, and inclusion and exclusion criteria were applied to filter the studies. The remaining 39 articles were reviewed in detail. The data were processed in Excel, and then analyzed through graphs and tables.

Siddaway et al. (2019) emphasize that according to best practice guidelines for systematic reviews, the literature search and screening process should ideally be conducted by two independent reviewers, who must both agree on the studies to include, though this is often not feasible in practice. The authors (2019) further clarify that Cohen's kappa is one of the most suitable statistics for providing a quantitative measure of inter-rater agreement on the studies to be included. In this context, to calculate the Cohen's kappa value to assess interrater reliability, selected articles were separately coded by the researcher, and by an expert with extensive experience in systematic reviews. Two sets of codes were then compared side by side and Cohen's Kappa coefficient value was calculated. Cohen’s Kappa was 0.90. This may be seen as a nearly perfect agreement (0.81–1.00) (McHugh, 2012).

3. Results

RQ1: What is the annual distribution of publications and the list of active countries in the selected studies?

Figure 2.

Distribution of research on the use of GAI in ESL/ EFL/ ELL/ ELT by year (N=39).

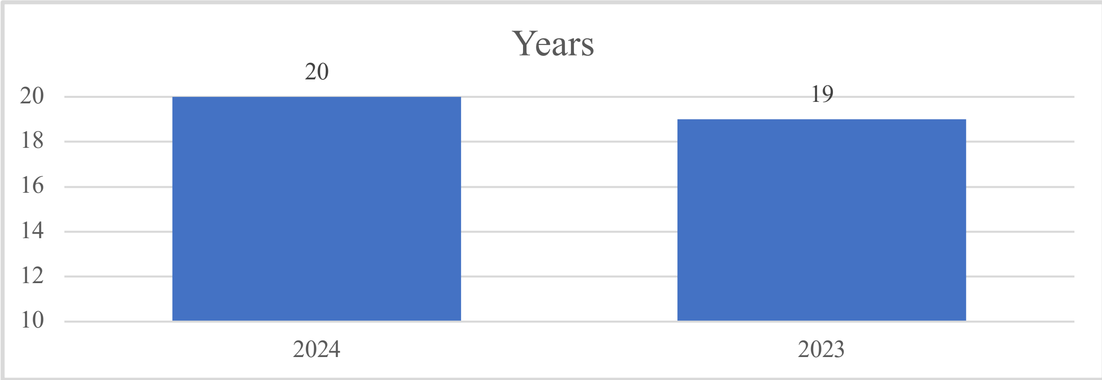


Figure 2 reveals that the number of the articles analysed by year is nearly the same, with a consistent interest in this area of research in recent years. Notably, in 2024, 20 studies were published, demonstrating a slightly higher output compared to 2023, which saw 19 studies being published.

Figure 3.

Countries in which research on the use of GAI in ESL/ EFL/ ELL/ ELT has been conducted.

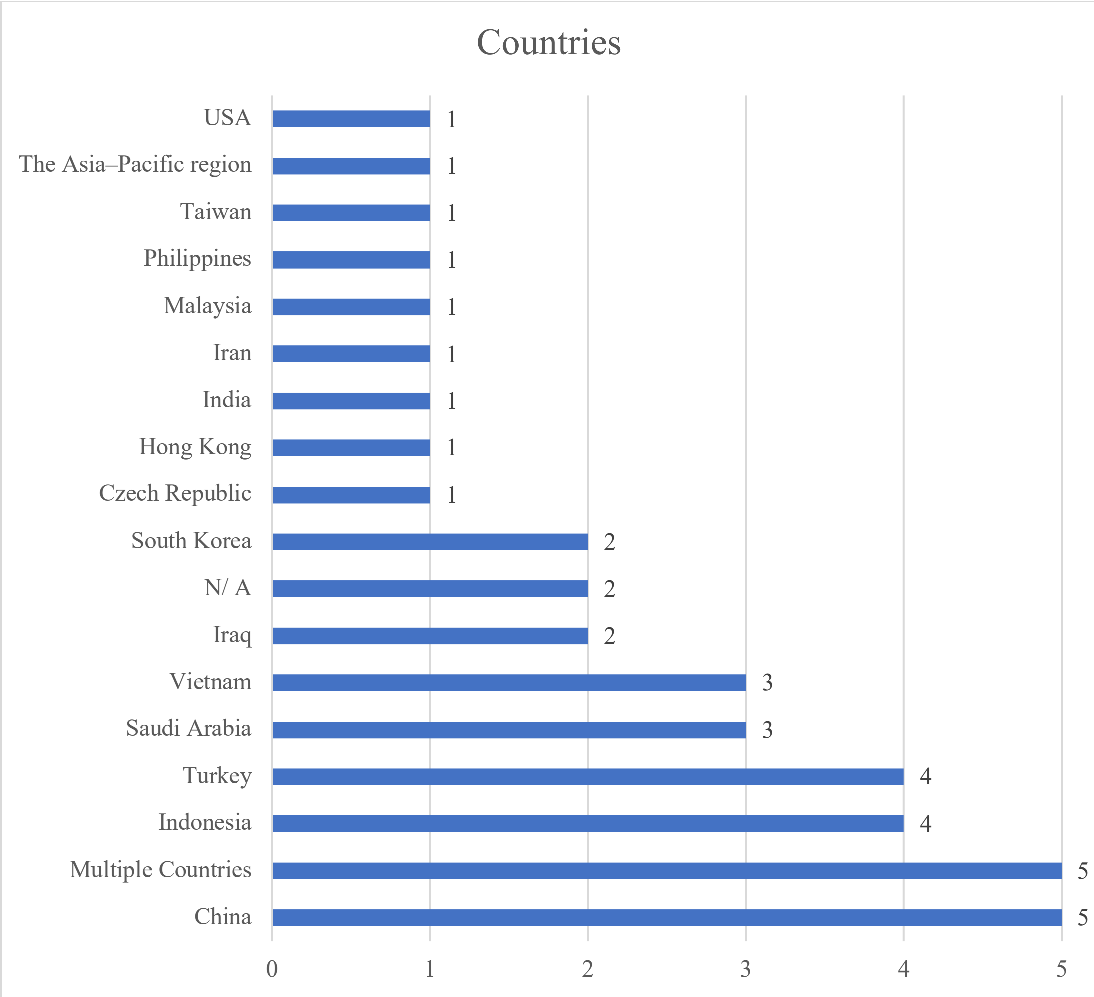
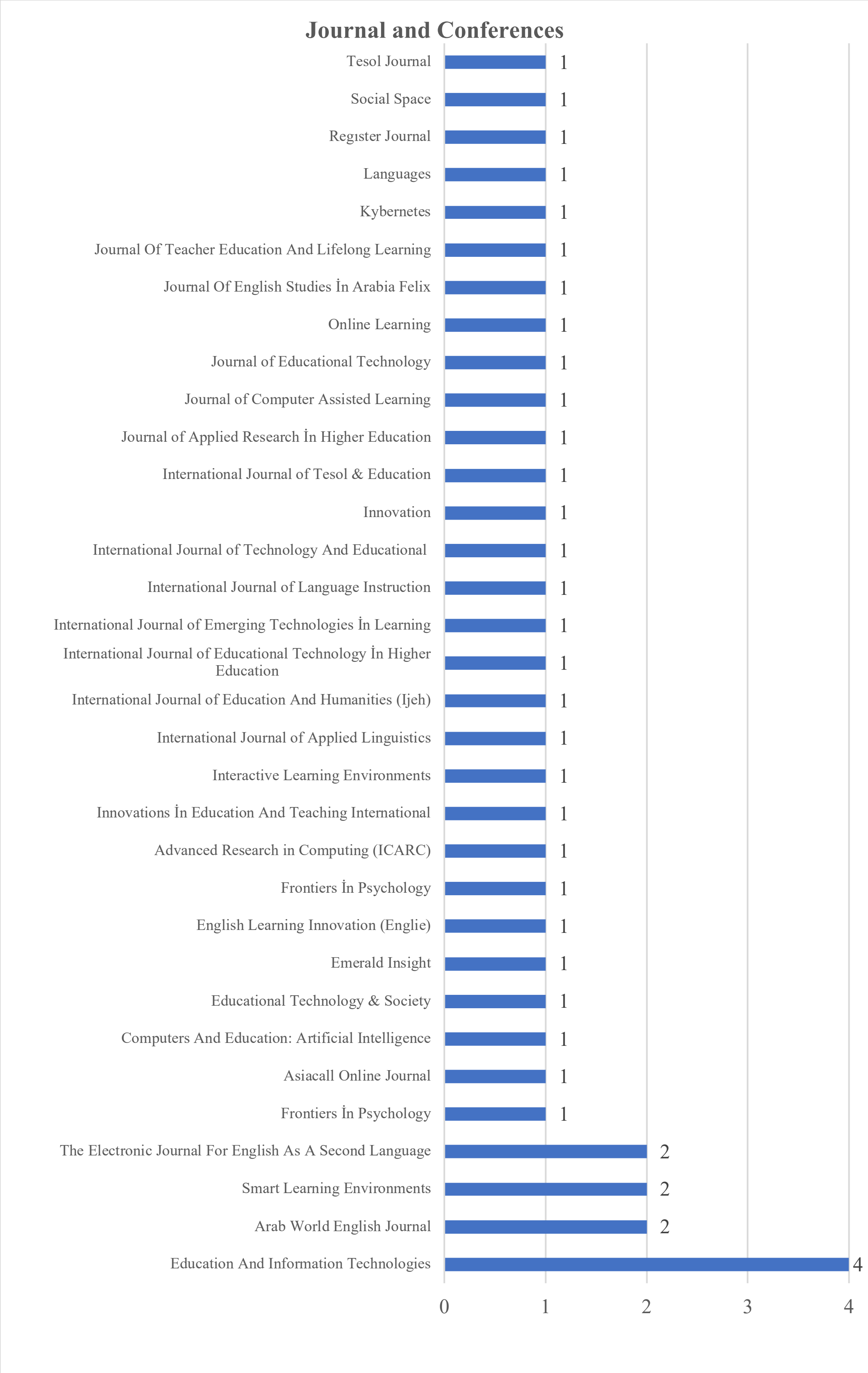


Figure 3 presents the countries in which research on the use of GAI in ESL/ EFL/ ELL/ ELT has been conducted. The highest number (n=5) of the selected studies were conducted in more than one country, in China and multiple countries including Northern and Southern China, Yemen, Saudi Arabia, Jordan, China, Hong Kong, Macao, and Taiwan). Among individual countries, Indonesia and Turkey had the second highest number of studies, with each accounting for four studies. This was followed by Vietnam (n=3) and Saudi Arabia (n=3). Fewer numbers of studies (n=2) were conducted in South Korea, Iraq, and in an unspecified country. The remaining studies were conducted in each of the nine other countries shown, with one study in each.

RQ2: What journals and conferences are the selected studies published in?

Figure 4.

Journals and conferences in the reviewed studies.

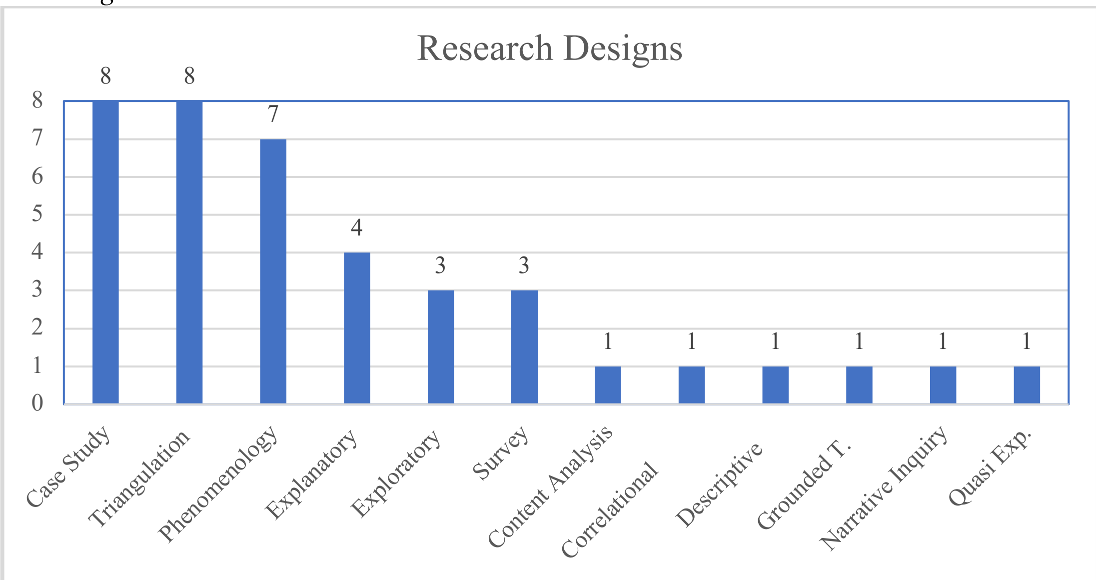


The majority of the research has been published in the Journal Education and Information Technologies (n=4). Additionally, two studies were published in each of the following journals: the Arab World English Journal, Smart Learning Environments, and the Electronic Journal for English as a Second Language. The remaining 29 studies are distributed across a range of other journals. Only one study was published as a conference paper in the study.

RQ3: What research designs and methods are used in the selected studies?

Figure 5.

Research designs used in the reviewed studies.



The figure shows the distribution of research designs employed in the reviewed studies. A total of eleven different designs were identified, with varying frequencies of use. The most frequently employed research designs were case studies and triangulation each used 8 times. The phenomenological method was also widely utilised (n=7). Additionally, explanatory designs were used 4 times, while exploratory and survey methods were each employed 3 times. The least frequently used research designs were the correlational, descriptive, grounded theory, content analysis, narrative inquiry, and quasi-experimental, each used only once.

Figure 6.

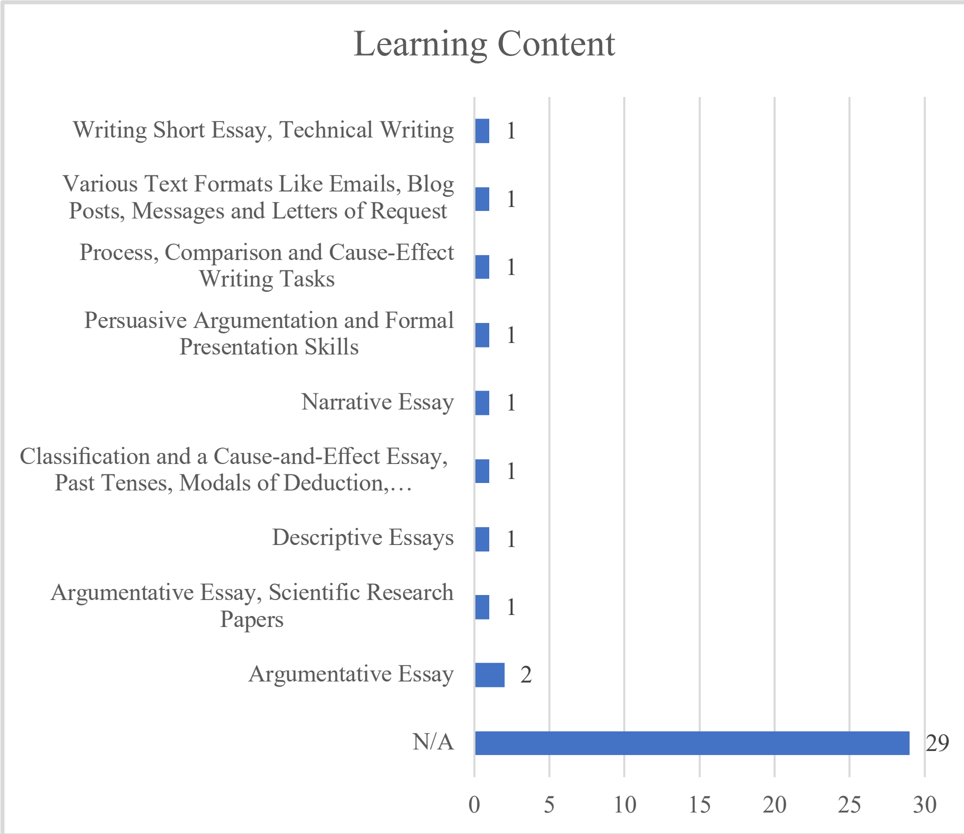
Research methods in the reviewed studies.

Figure 6 illustrates the research methods employed in the analyzed studies. The qualitative research method (n=19) was utilised in approximately half of the studies. The mixed (n=14) method was also preferred in a significant number of studies. In contrast, the quantitative method (n=6) was used the least.

RQ4: What learning contents, learning domains, learning places, and target audiences are explored in the selected studies?

Figure 7.

Learning contents of the reviewed studies.



Upon analysis of the learning contents as illustrated in the figure above, it is determined that most of the studies (n=29) either did not specify their preferred learning content or did not focus on a specific topic. Most frequently mentioned learning content was on argumentative essays (n=2). Following this, the reviewed studies identified various learning contents, each mentioned only once. These include argumentative essays and scientific research papers, descriptive essays, classification and cause-and-effect essays, some grammar-based contents, narrative essays, persuasive argumentation and formal presentation skills, and process, comparison, and cause-effect writing tasks. Additionally, diverse text formats such as emails, blog posts, messages, and letters of request, as well as writing types like short essays and technical writing, were also highlighted as learning contents.

Figure 8.

Learning domains in the reviewed studies.

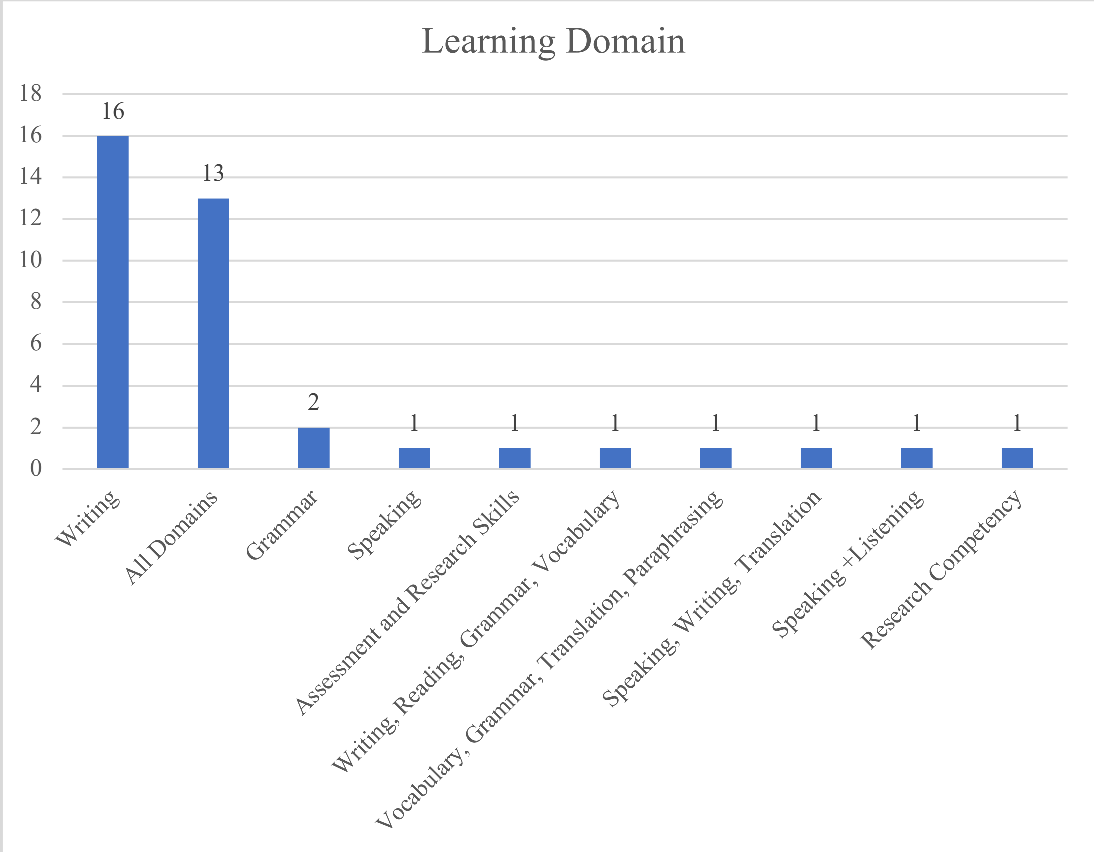
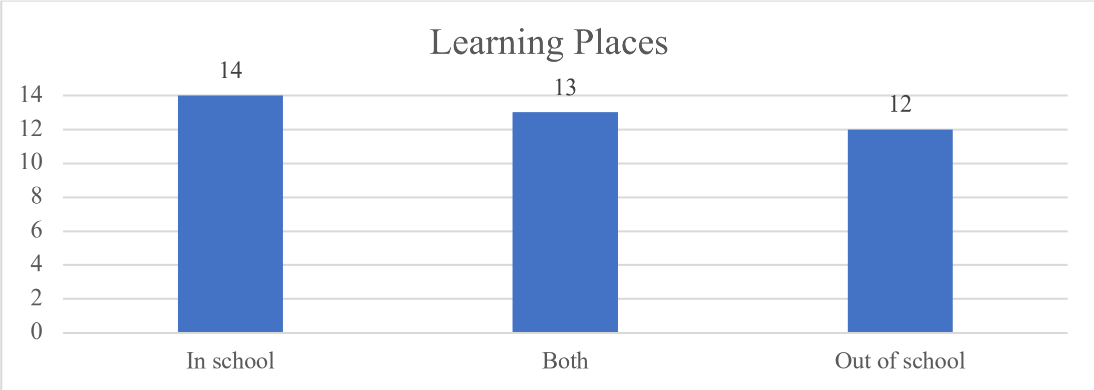


Figure 8 shows that writing (n=16) was the most frequently preferred learning domain in most of the studies. Subsequently, all domains (n=13), referring to language learning in general, without specifying only one language skill, was the second most frequently used learning domain. Among the learning domains that were least frequently focused were grammar, which was mentioned in two studies, speaking, assessment and research skills, and research competency, each appearing in only one study. In addition, some studies combined multiple skills, such as writing, reading, grammar, vocabulary, translation, paraphrasing, and speaking. Another study with a similar combination focuses on both speaking and listening (n= 1).

Figure 9.

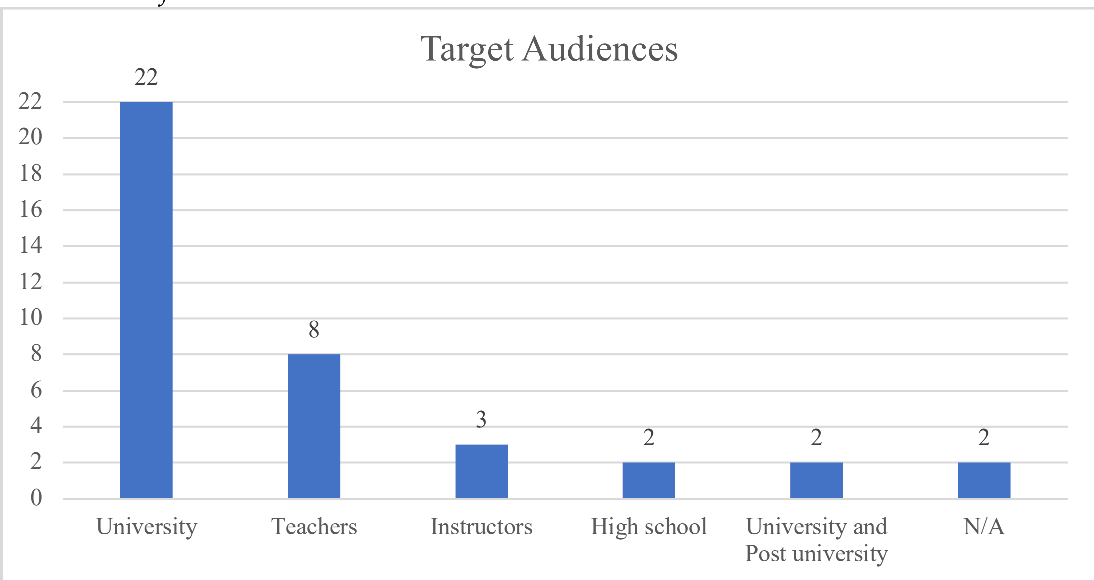
Learning places of the reviewed studies.



The learning places analysed in Figure 9 shows a similar distribution. It is determined that most of the studies were conducted in school settings (n=14), while some were carried out in out-of-school environments (n=12), and others encompass both settings (n=13).

Figure 10.

Target audiences of the reviewed studies.

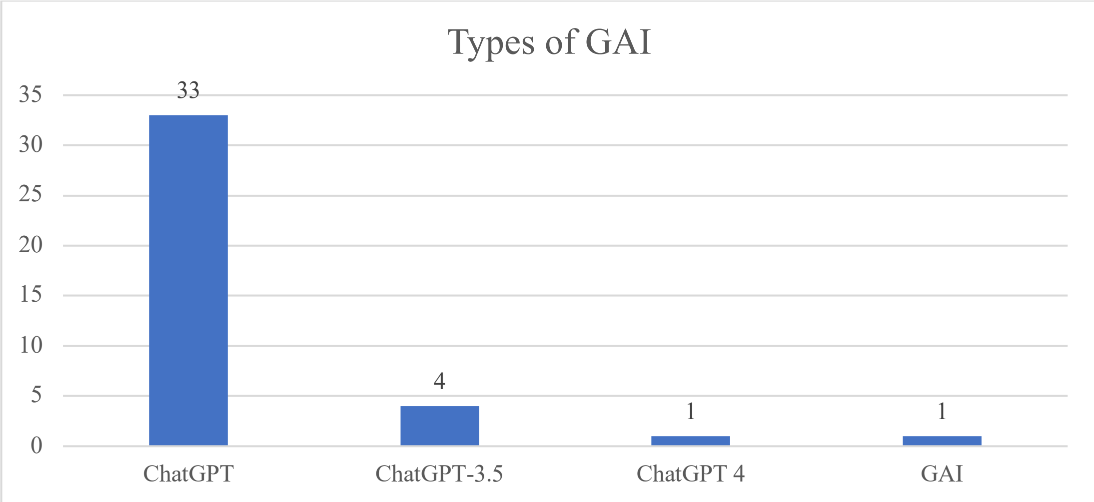


As seen in Figure 10, most of the studies were carried out at the university level (n=22). Teachers were the second-most targeted group, with eight studies involving them as participants. Instructors were also included in three studies. High school students and studies combining university and post-university participants were among the least represented target audiences, each appearing in two studies. Finally, two studies were categorized as N/A, reflecting either unclear or unspecified target audiences.

RQ5: Which GAI tool has been used the most in the selected studies and what are its roles?

Figure 11.

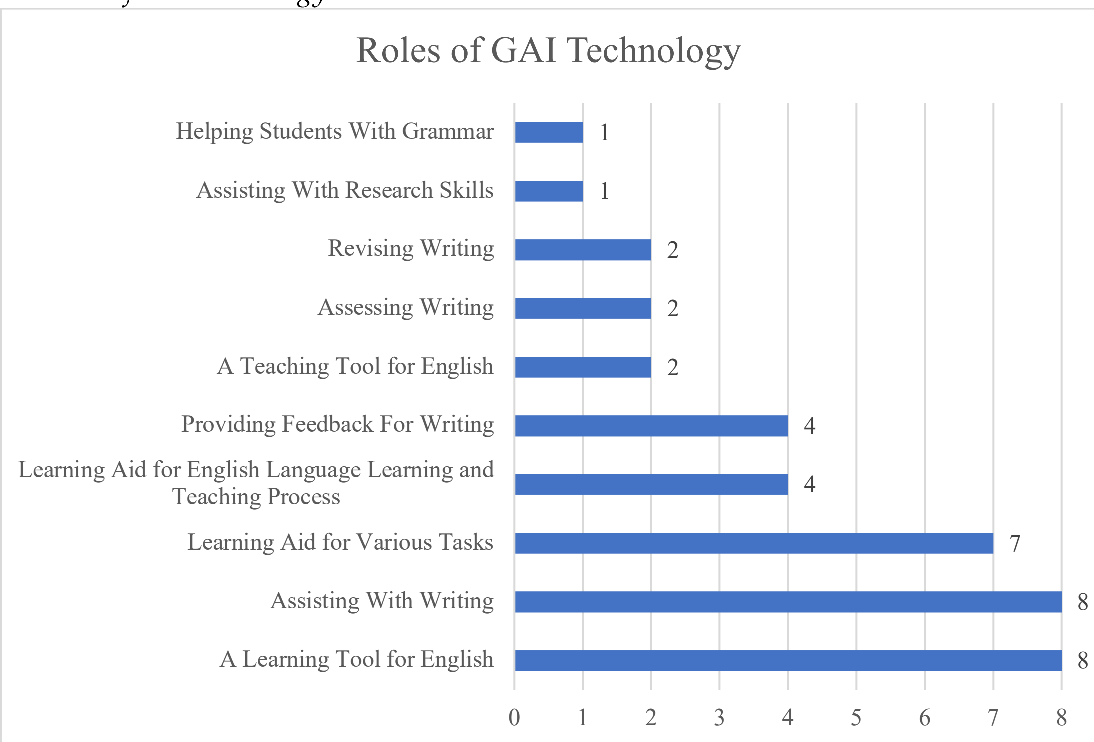
Types of GAI in the reviewed studies.



ChatGPT was used in most of the studies (n=33). ChatGPT-3.5 was the second most frequently used tool, being utilized in 4 studies. On the other hand, ChatGPT-4 and GAI tool, without specific version mentioned, were each used in only one study.

Figure 12.

The roles of GAI technology in the reviewed studies.



In most studies, GAI tools were used as a learning tool for English and writing assistance to enhance learning, with each mentioned in 8 studies. Subsequently, the tools served as a learning aid for various tasks, identified in 7 studies. GAI technologies were also used as a learning aid for English language learning and teaching processes and for providing feedback on writing with each mentioned in 4 studies. Other roles of these tools were revising writing, assessing writing, and serving as a teaching tool, with each mentioned in two studies. GAI technologies were the least frequently utilized for assisting with research skills and for helping students with grammar, each appearing in only one study.

RQ6: What data collection tools and methods are employed in the selected studies?

Table 2.

Data Collection Tools In The Reviewed Studies

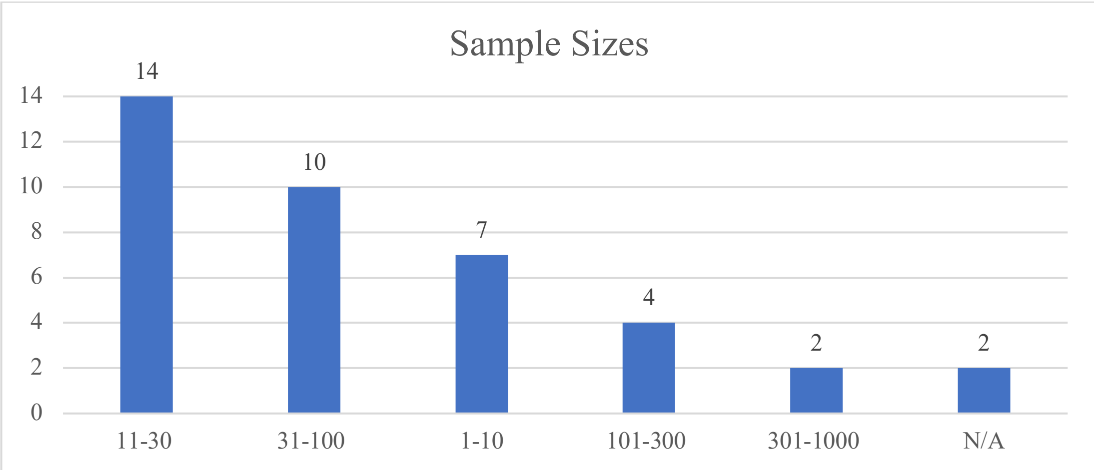
Data Collection Tools	Frequency (f)	Percentage (%)
Interview	23	33%
Questionnaire	13	19%
Observation	7	10%
Achievement Tests	6	9%
Document	6	9%
Others	3	4%
Survey	3	4%
Email interviewing	2	3%
A dataset (RECIPE4U)	1	1%
A paragraph writing task	1	1%
Attitude or perception tests	1	1%
E-Portfolios	1	1%
A writing rubric	1	1%
Two demographic questionnaires	1	1%

The most frequently used data collection tool is the interview, including semi-structured, structured, and unstructured interviews, accounting for 33% of the total. The next most frequently employed data collection tools are the questionnaire which accounts for 19%, including Likert scales, open-ended questions, and multiple-choice items, and participant observation, which makes up 10%. Several other data collection tools, each employed in 6 studies (9% of the total) are achievement tests and documents such as daily learning logs, students' written works, and their reflective writings. The remaining tools, stated as others accounts for 4%, included reflective journals, discussion, and written feedback by teachers and ChatGPT. Among the tools, survey was employed in 4% of the cases, while email interviews were used in 3%. The least used tools were a dataset RECIPE4U, attitude or perception tests; e-portfolios; a paragraph writing task, a writing rubric, and two demographic questionnaires, each accounting for 1%.

RQ7: What sample sizes, study durations, and sample selection types are applied in the selected studies?

Figure 13.

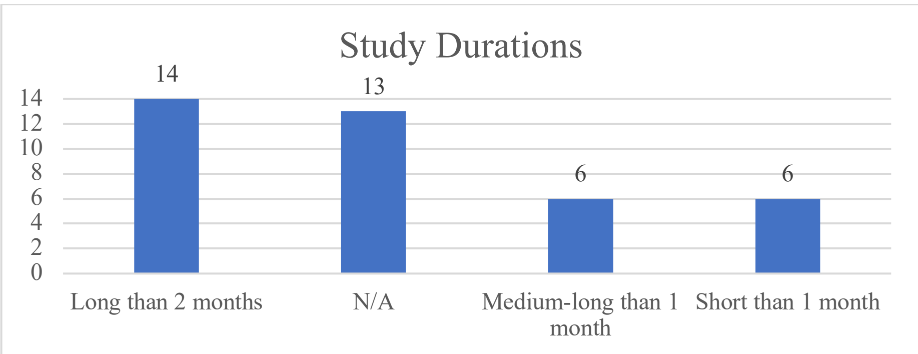
Sample sizes in the reviewed studies.



Most studies were conducted with 11-30 participants (n=14). Almost one in four studies involved a sample size of 31-100 participants (n=10). A smaller subset of studies (n=7) featured sample sizes between 1 and 10 participants. Only a small number of studies (n=4) included larger sample sizes of 101 to 300 participants. Moreover, very few studies (n=2) incorporated even larger sample sizes of 301 to 1000 participants. Finally, two studies did not specify their sample sizes (N/A).

Figure 14.

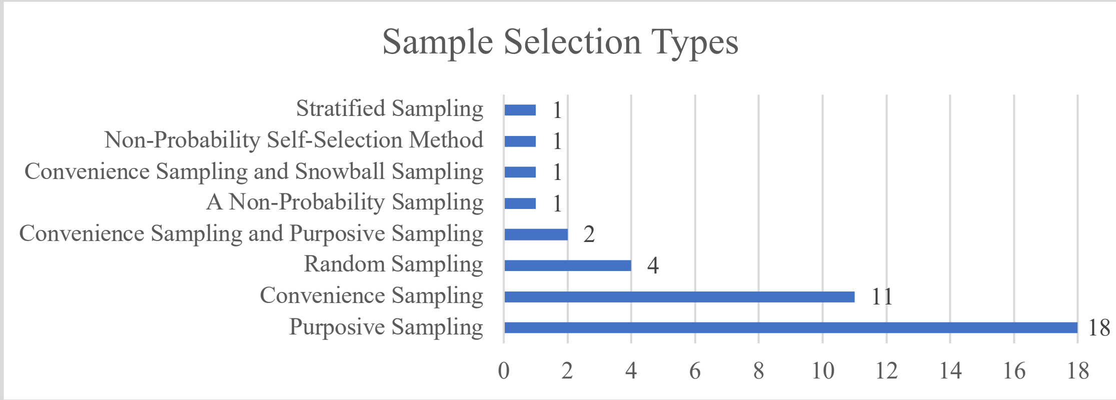
Study durations in the reviewed studies.



The longest study duration was longer than two months, with 14 studies falling into this category. A smaller number of studies (n=6) were conducted over shorter durations, specifically less than one month. Similarly, an additional six studies categorized as medium length, lasting more than one month, were also present. Multiple studies (n=13) did not specify the duration of the study, which was marked as N/A.

Figure 15.

Sample selection types in the reviewed studies.



The most widely used method was purposive sampling, which was employed in 18 studies. The second most utilized method was convenience sampling, with 11 studies. Random sampling was used in 4 studies, representing a smaller group. The least utilised types were non-probability sampling, convenience sampling and snowball sampling, non-probability self-selection method, and stratified sampling, each was used in only one study.

RQ8: What data analysis methods are commonly used in the selected studies?

Table 3.

Data Analysis Methods İn The Reviewed Studies

Data Analysis Methods	Number	Percentage (%)
Thematic Analysis	18	29
Descriptive Analysis	16	25
Content Analysis	8	13
Inductive Coding	4	6
T Test	4	6
Inferential	3	5
ANOVA	2	3
Non-Parametric Test	2	3
ANOVA/ANCOVA	1	2
Comparative Analysis	1	2
Correlation	1	2
Factor Analysis	1	2
RM-ANOVA	1	2
SEM	1	2

The table presents the data analysis methods used in the reviewed studies, showing a variety of approaches used with different frequencies. Thematic analysis was the most frequently employed method, appearing in 18 studies. Subsequently, the descriptive analysis method was employed in 16 studies. Following this, content analysis was utilized in 8 studies. Furthermore, inductive coding and T-Test were each used in four studies, while inferential methods were used in three studies for data analysis. The least utilised data analysis methods were ANOVA, ANOVA/ANCOVA, non-parametric test, comparative analysis, correlation, factor analysis, RM-ANOVA, and SEM, each appearing in only two studies or fewer.

RQ9: What are the main purposes and results of the selected studies?

Table 4

Objectives of the reviewed studies.

No	Objectives
1	To investigate the role of GAI in grading academic writing.
2	To examine the impact of ChatGPT on language learning.
3	To examine the effect of ChatGPT on advancing learners' feedback literacy.
4	To evaluate ChatGPT's impact on EFL grammar instruction.
5	To explore ChatGPT's influence on students in English classes.
6	To examine EFL students' use of ChatGPT for research skills.
7	To determine methods for enhancing ChatGPT use among English learners.
8	To explore ChatGPT's role in English Language Teaching.
9	To examine students' perceptions of ChatGPT in foreign language learning.
10	To examine why teachers implement ChatGPT.
11	To explore how ChatGPT influences writing skills of ESL students.
12	To analyse the implementation of Generative AI in education.
13	To examine factors causing technostress in English teachers using GenAI tools.
14	To explore the effect of using ChatGPT-generated dialogues in language teaching.
15	To investigate the impact of AI tools on English writing skills.
16	To evaluate ChatGPT's ability to provide feedback on EFL students' writing.
17	To examine students' views of ChatGPT in English language learning.
18	To explore EFL students' experiences and perceptions of ChatGPT in language learning.
19	To examine its effectiveness as a self-editing tool for student writing.
20	To examine EFL students' experiences of using ChatGPT in writing.
21	To explore the potential of ChatGPT in EFL teaching.
22	To examine the use of ChatGPT for feedback in L2 writing.
23	To explore the impact of ChatGPT in L2 writing.
24	To investigate the effect of ChatGPT on foreign language learners.
25	To examine EFL teachers' views on ChatGPT's opportunities and challenges in L2 education.
26	To explore EFL special education teachers' views on ChatGPT in language learning.
27	To examine EFL students' experiences of using ChatGPT in writing.
28	To explore EFL learners' intentions to use ChatGPT for English learning.
29	To evaluate the effectiveness of AI-generated feedback on writing.
30	To explore how ChatGPT influences learning English.
31	To examine the effectiveness of the ChatGPT in identifying writing errors.
32	To examine students' views of ChatGPT in language learning.

33	To explore the impact of ChatGPT in EFL writing.
34	To investigate the dimensions of ChatGPT in English language learning.
35	To explore the impact of ChatGPT on student motivation and engagement.
36	To examine students' views of ChatGPT in English language learning.
37	To investigate the efficacy of ChatGPT in language teaching.
38	To examine EFL teachers' views on ChatGPT's in language teaching.
39	To examine teachers' views on ChatGPT's in language teaching.

Table 3 shows the aims of the analysed studies. In general, the implementation of GAI tools like ChatGPT in English language education, in terms of various aspects such as their impact and role in learning and teaching processes, was examined. In addition, some studies aimed to examine opinions, motivation, and perceptions of participants in relation to the role of GAI.

Table 4.

Results of the Reviewed Studies

No	Results
1	Aligns with human scores, helping L2 writing assessment.
2	Enhancing language, linguistic, and social skills; increasing motivation and engagement with repetition.
3	Improving students' feedback literacy and offering a framework for classroom integration
4	Supporting grammar learning and enjoyment but raising concerns about critical thinking.
5	Enhancing language skills, confidence, and collaboration; positive student attitudes.
6	Positively correlating with metacognitive awareness, supporting guidance and idea generation.
7	Aiding L2 interaction practice; teacher-led activities can enhance its use.
8	Mostly positive outcomes: boosting enthusiasm, engagement, and enjoyment, though some drawbacks (technical limitations, shortcuts, and need for human intervention) noted.
9	Seen as valuable for enhancing language learning; requiring careful, ethical integration in teaching.
10	Traditional methods prompted ChatGPT implementation in ELT, offering benefits (language skills, personalised learning, facilitating teaching), but also raising concerns (hinders creative thinking, a new software program, academic integrity, misinformation).
11	Positively impacting academic writing; viewed favourably as a practical, reliable feedback tool.
12	Viewed as humanlike and intelligent, students felt at ease asking it questions they'd avoid with teachers.
13	Rapid AI growth and limited training cause technostress; professional development and gradual implementation ease this and support TPACK.
14	Enhancing academic performance, self-confidence, motivation, and English vocabulary learning.
15	Improving English language learning, particularly writing skills (descriptive).
16	Providing more feedback than teachers, focusing equally on content, language, and organization, whereas teachers prioritized content and language.
17	Effective for ESP vocabulary, translation, grammar, and paraphrasing, but students still value teacher guidance.

18	Valued as a helpful partner for language tasks.
19	Improving formal writing but was seen as less useful for informal and neutral register.
20	Supporting writing with feedback, idea generation, structuring, and critical thinking.
21	Enhancing EFL teaching with immediate feedback but may limit research skills, critical thinking, and risk bias or misinformation.
22	Improving L2 academic writing with an active and strategic use, students' feedback-seeking abilities are shaped by academic background, metacognitive skills.
23	Assisting L2 writing but posing concerns for academic integrity and equitable access.
24	Improving writing, grammar, vocabulary, and student motivation and engagement.
25	Boosting learner autonomy, and reducing teacher workload, but posing risks to creativity, academic integrity, cheating, plagiarism, and misinformation.
26	Valued in special education; female teachers are more eager to use it.
27	Aiding translation, idea generation, and writing, but concerns including misinformation and academic dishonesty.
28	EFL learners' intent to use ChatGPT is driven by social influence, satisfaction, and performance expectancy.
29	No difference in learning outcomes between the group receiving writing feedback from ChatGPT and the group receiving feedback from their human tutor. Study 2: a group receiving feedback from both ChatGPT and human tutor, having slight preference difference; both human and AI feedback offering advantages.
30	Found motivating for reading and writing but students were neutral on its impact for listening and speaking.
31	Catching surface errors; human instructors detecting deeper and pragmatic issues.
32	Helping personalized learning, interaction, and productivity, boosting writing and language skills.
33	Boosting writing skills, motivation, and proficiency in organization, coherence, grammar, and vocabulary.
34	Supporting language development through feedback and acting as a guided practice partner.
35	Enhancing motivation, engagement, and language skills; experienced instructors aid listening motivation.
36	Supporting English learning, independence, and problem-solving; information security is a concern.
37	ChatGPT scores align with teachers' and can help reduce teacher workload in language teaching.
38	EFL instructors are eager to use ChatGPT; training is needed for effective use.
39	First-year teachers recognize GAI's potential, but they lack readiness due to limited knowledge.

Table 4 presents the findings of the analysed studies. In general, it was concluded that the use of ChatGPT in English education facilitated language skill development, (particularly in writing), promoted learning, supported English language learning and teaching processes, and enhanced the motivation of the participants. The necessity of training was indicated for its careful implementation in English language education. In addition, ethical issues, misinformation, and academic dishonesty were expressed among the concerns raised in the studies.

4. Discussion

The first research question in this systematic review aimed to investigate the publication years and countries in which these studies were conducted. The studies were evaluated based on these criteria. One of the findings of this review is that most research studies on GAI in foreign language education in ESL, EFL, ELL and ELT contexts have been conducted in recent years, particularly between 2023 and 2024. The reason for this may be due to the recent emergence of one of the GAI tools, ChatGPT. Since its launch in November 2022, it has raised a mix of excitement and concern among education professionals (Kostka & Toncelli, 2023) and it continues to progress rapidly (Vo, 2024). Teachers and students have also been exploring ways to implement ChatGPT for teaching and learning foreign languages (Vo & Nguyen, 2024), and numerous studies have been carried out to examine the use of ChatGPT in language education (Baskara, 2023; Bin-Hady et al., 2023; Kohnke et al., 2023; Vo & Nguyen, 2024).It can be concluded that the rapid development of GAI in recent years has also influenced the studies conducted in this field. In terms of annual distribution of publications, the results of this study are similar to those of other systematic reviews in the literature. Each of the following studies included studies from 2023: 2023 and 2024 (Balcı, 2024); January 2023 and July 2023 (Chukwuere, 2024); 2023 and 2024 (Feng Teng, 2024), May 15 and August 22, 2023 (Meniado, 2023); all included studies are from 2023 (Zhang & Tur, 2024).

The countries in which the studies were conducted varied when analysing the distribution of active countries in the selected studies. It has been observed that researchers from 18 different countries have conducted studies on similar topics. China had the highest number of studies (n = 5), followed by Indonesia (n=4), Turkey (n= 4), Multiple Countries (n=5), Saudi Arabia (n= 3), Vietnam (n= 3), and Others (n= 15) including 12 different countries. The studies include countries from various continents and regions. Similar to this result, in the related study by Lo et al. (2024) it was reported that nearly half of the included studies (n = 34) were conducted in East Asia, with China accounting for 12 of these studies. The findings of another systematic review by Feng Teng (2024) reveal that researchers in China published more articles (8 out of 20) on the topic of ChatGPT in EFL writing than scholars from other countries. However, in some studies, this distribution of countries may vary. A wide geographical distribution, covering regions in Africa, Europe, the Americas, and Asia are presented in the findings of a systematic review (including 13 studies) by Zhang and Tur (2024). Evidently, the ChatGPT phenomenon is a global area of interest in education and the exploration of the implementation of this GAI tool in educational settings has gained significant importance. Research studies focusing on this phenomenon seem to be supported worldwide.

Regarding research designs and methods, the analysis of the review revealed that over fifty percent of the studies are qualitative (n = 19), with different research designs (phenomenology, case study, content analysis, narrative inquiry, grounded theory and exploratory). This reflects that the use of this method facilitates a deep understanding of the phenomenon, emphasizing participants' experiences and perspectives. Qualitative research is used to gain a detailed understanding of an issue by directly engaging with people and allowing them to share their stories without influence from expectations of findings or what has already been discussed in the literature (Creswell & Poth, 2018). In brief, the deeper understanding of participants' experiences, perceptions, and viewpoints provided by qualitative methods may explain the greater use of qualitative methods in these studies. Similarly, to evaluate the implementation of GAI tools in language education, existing research may rely more on individual experiences and observations rather than analyses based on numerical data. Creswell and Poth (2018) further state that when quantitative measures and statistical analyses are not suitable for addressing the problem, qualitative research can be employed. On the other hand, there are also six quantitative studies, which employed various research designs including correlational, quasi-experimental, pre-experimental, survey, and descriptive designs. Mixed method (n=14) was also widely used, incorporating exploratory, triangulation, and explanatory designs. The widespread use of mixed methods may indicate that combining quantitative and qualitative data can provide a more comprehensive assessment of the use of GAI in language education. Mixed method research creates an opportunity to build new theoretical insights by integrating the strengths of both quantitative and qualitative approaches (Venkatesh et al., 2016). In relation to research designs, it is believed that they are used to explore the phenomenon from multiple angles, validate study findings, and provide detailed explanations. To illustrate, triangulation is a technique to examine a phenomenon by integrating and combining various data sources, research methods, researchers, and theoretical frameworks (Wang & Duffy, 2009). Using multiple methods of data collection and analysis gives a deeper and more complete understanding of the research (Patton, 1999) and it is a process that allows for data validation, used both in quantitative and qualitative research (Noble & Heale, 2019) When examined in the context of similar studies, previous studies by Balcı (2024) and Zhang and Tur (2024) reported that those reviewed studies also adopted various research designs including quantitative, qualitative and mixed methods. However, with some studies, there have been differences in regard to the most commonly used research methods. In the findings of the systematic review by Lo et al. (2024) many of the included studies employed a quantitative method (n= 26), followed by qualitative (n=23) and mixed methods approaches (n= 21). Despite differing in the number of methods used, the diversity of methods available in this systematic review and related systematic reviews may indicate that both empirical data and participants' experiences are important in the exploration of the implementation of GAI tools in language education.

In terms of learning domains, the findings show that writing is the most emphasized learning area in the selected studies. This may be the case because of its importance in language acquisition. One of the hardest skills to master in English learning is writing skills due to the complexity of this ability (Pratama & Hastuti, 2024). In addition to being a means of communication, writing is an important productive skill that improves ESL/EFL students' language learning and development (Jamoom, 2021). Research has been carried out to explore the effectiveness of implementing technology in EFL/ESL writing (Al-Wasy, 2020; Zhao, 2023; Gayed et al., 2022). Similarly, several studies were conducted to explore the potential role of the GAI tool, ChatGPT, in EFL writing (Guo & Wang, 2024; Nugroho et al., 2024). Studies specifically addressing language skills apart from writing are few, such as speaking (n=3), grammar (n=3) and some studies focus on more than one skill at the same time, such as speaking, writing, translation (n=1); grammar, vocabulary, translation, paraphrasing (n=1); and writing, reading, grammar, vocabulary (n=1). Additionally, significant focus was given to all domains, including general English language skills (n=13), which may mean that a more holistic approach is emphasized in use of GAI technology in relation to language skills in the selected studies. This signifies that in these studies, English language education was addressed in general, without focusing specifically on individual skills. However, areas like assessment and research skills, research competency, and vocabulary are given less attention (with only one study for each), which may suggest a potential gap in research. More attention might be given to these specific learning domains in research studies in the future to gain a better understanding of the implementation of their relationship to GAI tools. Likewise, findings of a recent review by Lo et al. (2024) indicate that many selected studies (71) have focused on how students use the tool ChatGPT for writing (n= 29), followed by another primary English language skill, speaking (n= 5). Learning domains were not specified in various studies (n= 28), and the impact of ChatGPT on other language skills has not been sufficiently studied. It has been indicated in the review findings that the lack of studies on reading (n= 2) and listening (n=0) reveals that more research is needed in these areas. In another review by Yang and Kyun (2022), which examines artificial intelligence in language learning in various contexts including EFL (17 studies out of 25), writing skills (n=10) were the most studied aspects of language learning. It is followed by other aspects of language learning, including learning attitudes (n=5), reading (n= 3), two studies for each of the following: vocabulary, speaking, and communication and grammar (n=1). From the results of these systematic reviews, it can be inferred that GAI technologies have been implemented mostly in writing skills, with lesser use for other skills.

In terms of target audiences explored in the selected studies, most of the studies have been conducted at the university level (n=22), while there are two studies conducted at the high school level. Only a few studies (n=2) include both university and a small number of graduate students at the same time, and these studies were also included in the review because they involved university students. Instructors (a term used for those at the university level), and teachers were also included in some studies (n= 11) to explore their experiences for the implementation of GAI tools in language teaching (Moorhouse, 2024; Nguyen Thi Thu, 2023). This study's findings are consistent with previous research by Lo et al. (2024) and Meniado (2023), who also reported higher education as the setting in which most of the studies were conducted. The rapid review results by Chukwuere (2024) highlight that using ChatGPT in higher education offers several benefits. It is true that there has been growing interest in understanding the implementation of GAI tools in English language education across different target audiences, specifically among university students. It may be because university students are more open to independent learning and the integration of technology in education, as well as having easy access to ChatGPT.

When examining which GAI tool is most frequently used in the selected studies and what its role is, many studies used ChatGPT without specifying the model (n= 33). In some studies, ChatGPT-3.5 (n= 4) and ChatGPT 4 (n= 1) were used. In one study, the tool was defined as GAI (n= 1). The widespread use of ChatGPT and its versions as GAI tools in these reviewed studies could be due to the growing interest in ChatGPT since its launch. There has been a parallel increase in research within this field. Many educators have explored the GAI tool ChatGPT for its potential advantages in language teaching and learning (Liu, 2023). The findings of this study align with the literature. Within the scope of related studies, several researchers conducted systematic reviews to specifically examine ChatGPT among GAI tools. They sought to explore its implementation (Lo et al., 2024), impact (Meniado, 2023), and role (Feng Teng, 2024) within the scope of English language education, as well as its advantages and drawbacks (Balcı ,2024, Chukwuere, 2024), its possible benefits and consequences (Lashari & Umrani, 2023), and its strengths, weaknesses, opportunities, and threats (Zhang & Tur, 2024). It can be stated that ChatGPT is one of the most widely used GAI tools in research.

In relation to the roles of GAI tools, the findings showed that ChatGPT and its versions have been used for many purposes. Learners used these tools as an English learning tool (n=8) for various tasks (n=7). They are also used in several studies for writing domainrelated activities, such as assisting with writing (n=8), providing feedback for writing (n=4), revising (n=2) and assessing writing (n=2). The tools were also used to receive assistance with grammar (n=1) as well as for research skills (n=1). Similarly, the tools were used for English language teaching as well (n=4). The results of the study demonstrate similarities with the findings of other related studies. Some of its potential functions have been identified as a lesson planner, teaching assistant and developer of instructional materials (Meniado, 2023), feedback provider, personal tutor, language learning partner (Zhang & Tur, 2024), and facilitator and assistant in EFL writing (Feng Teng, 2024). It can be concluded that ChatGPT is considered a useful tool for many different purposes in language learning and teaching. Its implementation in ELT further indicates its potential not just for learners, but also for educators.

Regarding the data collection tools and methods used, data was mostly collected by interview or focus group (n= 24) through semi structured, structured, and unstructured formats, followed by questionnaires (n=13) including Likert, open-ended, and multiple-choice questions, and observation (n=7). Documents (n=6), such as selfstudy logs, collection of students' interactions on ChatGPT, teacher self-reflection, students’ written work, daily learning logs and reflective writings; achievement tests (n=6); survey (n=3); others (n=3), such as reflective journals, discussion and written feedback were also utilized to obtain data. Email interviews, a dataset, a writing task, attitude, or perception tests, rubric and two demographic questionnaires are among the least used measurement tools (one for each) in the selected studies. Obtaining data through interviews and questionnaires highlights the importance of collecting detailed and direct feedback from participants in these studies. Interviews are useful for understanding participants' thoughts, feelings, attitudes, and experiences regarding certain situations or phenomena (Paradis et al., 2016). Similarly, the systematic review by Balcı (2024), found that similar tools, like interviews and questionnaires, were used in mixed-method studies. The findings of the systematic review by Lo et al. (2024) are also similar to this study, though surveys were reported as the most common data source, followed by interviews. To obtain more reliable results, it is necessary to use a variety of data collection tools (Hopcan et al., 2024).

Examination of the durations of the studies revealed that the longest study durations exceeded two months (n = 14). Additionally, there were studies with durations of less than one month (n = 6) and medium-length studies lasting more than one month (n = 6). Furthermore, the duration was not specified in 13 studies. It can be inferred that these selected studies do not have such long durations in general, which is similar to the findings of the review (Lo et al., 2024). In this respect, the authors further indicate that more longterm studies are needed to gain a deeper understanding of how ongoing interaction with ChatGPT influences students' language acquisition and its lasting impact on their learning behaviour.

Regarding the research question which addresses the main purposes and results of the selected studies, the findings reveal that the objectives of the analysed studies are similar to each other within the context of English language education and can generally be summarized as follows: To examine the impact and/or role of GAI tools, specifically ChatGPT, on EFL/ESL learners' language proficiency, language skills, and language learning (Al-Obaydi et al., 2023; Bin-Hady et al., 2023; Javier & Moorhouse, 2023; Karatas et al., 2024; Kostka & Toncelli, 2023; Kucuk, 2024; Nugroho et al., 2023; Xu & Thien, 2024). The results that align with the stated research aim as follows: Nugroho et al. (2023) reported that ChatGPT facilitates personalized learning, encouraging authentic interactions, productivity, enhances writing and vocabulary acquisition. Similarly, Karataş et al. (2024) reported that ChatGPT positively impacts students' language learning, particularly in the development of writing, grammar, and vocabulary skills and improves motivation and engagement in the learning process, but its impact on speaking was minimal, and there was no effect on listening skills. Regarding language skills, it was also reported by Kucuk (2024) that ChatGPT is beneficial for students to learn grammar and makes learning enjoyable; however, some concerns were raised in relation to its potential to transform students into robots and weaken their critical thinking abilities. Moreover, ChatGPT is reported to support language learning (Al-Obaydi et al., 2023), and increase students' enthusiasm for course material (Kostka & Toncelli, 2023).

Another goal in some studies is to investigate the implementation/role of ChatGPT in EFL/ ESL writing (Al-Garaady & Mahyoob, 2023; Escalante et al., 2023; Geckin et al., 2023; Gozali et al., 2024; Guo & Wang, 2024; Han et al., 2024; Mahapatra, 2024; Nguyen & Tran, 2023; Nugroho et al., 2024; Punar Özçelik & Yangın Ekşi, 2024; Pratama & Hastuti, 2024; Song & Song, 2023; Tseng & Lin, 2024; Yan, 2023; Yan, 2024). With respect to the research objective, the results showed that studies primarily focus on the writing skill. It is reported that ChatGPT had a positive impact on students' academic writing skills (Mahapatra, 2024); and was beneficial for students in writing courses by providing instant feedback, generating ideas, accelerating the writing process, aiding in structuring their thoughts, offering unbiased feedback as an alternative to peer reviews, and encouraging critical thinking (Tseng & Lin, 2024). It also enhanced students' writing skills (Punar Ozcelik & Yangın Eksi, 2024); served as a supporting tool to improve English language learning, particularly writing skills (Pratama & Hastuti, 2024); and, in their engagement with ChatGPT in writing, students felt comfortable asking it questions they might avoid asking teachers (Han et al., 2024). Likewise, Geckin et al. (2023) reported that ChatGPT-3.5 can facilitate writing assessment. Conversely, it was reported by Al-Garaady & Mahyoob (2023) that ChatGPT identifies most surface-level errors, whereas human instructors detect deep structural and pragmatic writing issues; its potential threats to academic integrity and equal access to education were also identified as a threat (Yan, 2023).

Regarding the research aiming to explore students' and/or teachers' perceptions, attitudes, views and experiences of ChatGPT in English language learning and teaching processes (Alenizi et al., 2023; Abdelhalim, 2024; Derakhshan & Ghiasvand, 2024; Klimova et al., 2024; Liu, 2023; Nguyen Thi Thu, 2023; Phuong, 2024; Van Horn, 2024; Xiao & Zhi, 2023), reported results include enhancing multiple language skills, improving confidence, and fostering collaborative learning (Van Horn, 2024); being a supportive tool in providing guidance and stimulating thought (Abdelhalim, 2024); and acting as learning partner and providing feedback (Xiao & Zhi, 2023). Phuong (2024) indicated that students found ChatGPT effective for ESP vocabulary, translation, grammar checking, and paraphrasing, but still expressed a strong need for teacher instruction and the traditional classroom setting. Similarly, Liu (2023) reported that

Chinese university students are in favour of using ChatGPT to learn English outside of school by spending more energy and time to learn to use it in a better way. Despite being considered a useful tool for enhancing language learning, it requires careful consideration of ethical and pedagogical factors in its implementation (Klimova et al., 2024). Similarly, the need for proper training to use ChatGPT effectively (Nguyen Thi Thu, 2023) was identified. Some concerns such as posing risks to creativity, academic integrity, spreading false information, fostering cheating in online exams, and plagiarism (Derakhshan & Ghiasvand, 2024) were also reported.

In relation to the implementation/role of ChatGPT in the context of ELT (Annamalai, 2024; Kohnke et al., 2024; Mohamed, 2024; Moorhouse, 2024; Nguyen & Tran, 2023), the results of the studies showed that ChatGPT can improve language teaching by enhancing classroom activities (Mohamed, 2024), reduces teacher workload (Nguyen & Tran, 2023), and facilitates educators in enhancing their teaching approaches by helping with the development of teaching materials, and generating content (Annamalai, 2024). The author (2024) also highlighted that when planning teaching activities, developing a blended learning strategy is essential to combine ChatGPT with traditional methods. Moorhouse (2024) reported that first-year teachers are generally prepared to implement GAI tools due to early experience and awareness of their potential, whereas beginning teachers, with limited knowledge, are not yet ready to use them in their professional work. However, some concerns, such as its potential to restrict fostering research skills and critical thinking, reinforcing biases, and spreading misinformation (Mohamed, 2024) were reported.

Concerning the results of examining the impact of ChatGPT on student motivation and engagement (Ali et al., 2023; Sotelo Muñoz et al., 2023; Yıldız, 2023), Ali et al. (2023) reported that students found ChatGPT to be a motivating tool for improving reading and writing skills, while having neutral attitudes towards its impact on listening and speaking skills. As a source of intrinsic motivation (Sotelo Muñoz et al., 2023), the implementation of ChatGPT can boost students' academic performance, self-confidence, and motivation, and positively impact vocabulary learning in English (Yıldız, 2023).

Similar to this study, there are some systematic reviews that examine the implementation of GAI tools, such as ChatGPT, in English language education from similar perspectives. Regarding language learning and teaching processes, some results of this study align with the findings of the research by Balcı (2024), reporting that ChatGPT enhanced students' EFL learning experiences and positively influenced teachers' instructional practices. Similarly, in relation to language skills, the review findings showed that ChatGPT improves language proficiency and core language skills, including speaking, listening, reading, grammar, vocabulary, and especially writing, while also boosting student motivation. The results align with those of another systematic review by Feng Teng (2024) that emphasized the opportunities of ChatGPT for EFL writing, like enhancing writing skills and providing instant feedback. Lo et al. (2024) reported that most of the studies examined AI tools within a writing context, which is also in line with this study results. Like this review, the study by Zhang and Tur (2024) also highlighted ChatGPT's potential to aid in designing curriculum, planning lesson, creating materials and enhancing student personalized learning. The findings are consistent with previous research by Meniado (2023) who also found that ChatGPT improves the language learning process inside and outside the classroom. The findings of this systematic review also align with previous systematic reviews in terms of reported concerns. Issues including academic integrity (Zhang & Tur, 2024), its limitations and ethical issues (Balci, 2024), reliance on AI and need for critical thinking skills (Feng Teng, 2024), educational inequality, academic dishonesty, and plagiarism (Meniado, 2023) were in alignment with this study's results. Some studies such as Lashari and Umrani (2023), also highlighted the importance of improving trainings given to students and professors by focusing on promoting academic honesty and originality. In summary, it can be concluded that the results of this study generally align with existing systematic reviews.

Based on the research findings, the studies highlight possible implementation of GAI tools like ChatGPT in various aspects of English language learning and teaching. ChatGPT offers significant benefits in terms of language learning and teaching, such as providing personalized learning and feedback, fostering motivation, as well as enhancing teaching. Despite its positive outcomes for learners, teachers, and instructors, its use requires careful consideration to address potential drawbacks such as hindering creativity, ethical issues, academic integrity, cheating, plagiarism, and misinformation. In addition, implementing these tools properly into the curriculum and trainings are essential for maximizing its positive impact.

5. Conclusion

Relevant research questions were formulated in line with the aim of the study. Regarding the publication years of the selected studies, those selected were conducted in 2023 and 2024 and carried out by researchers from 18 different countries, with China having the highest number of studies, followed by Indonesia and Turkey. Concerning the broad range of journals that published articles, most publications appeared in Education and Information Technologies, and the others were published in different journals. Also, one of the reviewed studies was a conference paper. Examination of research designs and methods revealed that most of the studies employed qualitative methods, followed by mixed-methods studies, and quantitative studies, each using various designs. Having explored the learning contents of the studies, most studies did not focus on a specific learning content, while others focused on writing skills. Similarly, concerning learning domains, the findings indicated that writing is the most emphasized domain compared to other language skills. It was found that learning places showed a similar distribution, with most studies conducted in schools, and the remaining studies taking place outside of school and in both settings. In relation to the target audiences in the selected studies, it was concluded that most of the studies were conducted with participants from the university level. Based on the examination of the most used GAI tool and its roles in English language education, ChatGPT was utilized the most frequently for many purposes. Regarding data collection tools and methods, the studies used a variety of methods including interviews, observations, questionnaires, surveys, documents, and others. Sample sizes in the selected studies are varied, with mostly small to medium sizes. In terms of study duration, most of the studies lasted more than two months while others took shorter time, though in some studies duration of time was not specified. Furthermore, concerning sample selection types, it was found that most studies used purposive sampling and convenience sampling to select the participants, while the others were also used less frequently. Examination of data analysis methods showed that various methods were utilized, with thematic analysis being the most used, followed by descriptive analysis, content analysis, and other less frequently used methods. In relation to research objectives, in general terms it can be stated that studies examined the implementation of GAI tools, specifically ChatGPT, to understand its impact on or role in English language education contexts.

Lastly, with regard to the study results, it was revealed that GAI tools, specifically ChatGPT, have a positive impact on supporting English language learning and teaching. It was not aimed to examine only ChatGPT within the scope of GAI tools but the results of selected studies addressed it. This may be due to its widespread use and growing interest in recent times. It was demonstrated in the studies that these tools were used for various purposes, ranging from enhancing overall language proficiency to improving language skills when examined from learners' perspective. The studies showed that ChatGPT is considered useful to develop language skills, particularly writing and helpful to boost learners' motivation. From the teachers' perspective, it has the potential to enhance EFL teaching with its careful implementation. Despite supporting language education, some concerns related to its implementation were also highlighted in the studies.

The findings of this systematic review are expected to emphasize the changing nature of GAI-based English language learning and teaching practices by highlighting the importance of careful and appropriate implementation to optimize positive outcomes. Through examination of relevant studies on the implementation of GAI based tools like ChatGPT, this study may help gain familiarity with its potential uses and enrich relevant literature by serving as a guide for researchers and future studies in this field. As technological developments continue to shape various aspects of language education, it is important to explore the impact of the implementation of such technologies.

5.1. Implications of Research

Based on the research findings, this study proposes some recommendations for instructors, teachers, learners, educational institutions, policy makers and researchers. Instructors and teachers may benefit from the contribution of this study to support their students in the language learning process by implementing GAI-based tools that aim to enhance their language proficiency, develop their language skills, and encourage students to be active participants in their learning. In this regard, educational institutions and teachers can work together to maximize the careful and effective use of these tools while integrating them into language education, which will enhance their impact on students. Additionally, educational institutions should provide instructors and teachers with the necessary training on this topic, focusing on reducing their workload while ensuring effective guidance. Similarly, by presenting how these tools are implemented, this study may help students have a richer language learning process. By directing researchers to relevant research studies on the implementation of GAI tools, the findings of this study may also enable researchers in their work. This may encourage researchers to conduct more research on this topic which will also contribute to relevant literature. In this regard, this may assist policy makers in revising educational policies, which will also influence the integration of these technologies into educational institutions.

Another important recommendation for researchers might be taking several factors into consideration while conducting research. The findings of this review showed that most studies focused on writing skills in relation to the implementation of these tools. Thus, more studies may be conducted to investigate the impact of GAI tools on other language skills. Likewise, while examining the literature, it was observed that studies on the implementation of these tools in English language are limited in number. Therefore, further research studies, including systematic reviews should be carried out to examine this topic in English language context. An additional recommendation concerns the diversity of GAI tools used in the studies. There is more research on the implementation of ChatGPT among GAI tools, thus, research studies exploring the effects of other GAI tools in language education might be useful. Also, since most of the studies in this review were carried out in university settings, further research should focus on exploring this topic in other educational environments such as high school and postgraduate settings. Similarly, studies should be larger and longer in terms of sample sizes and duration in comparison to the reviewed studies.

In addition, there is a lack of studies on the ethical use of ChatGPT. Therefore, more research on this topic should also be conducted. As implementation of these tools in language education continues to gain increasing interest, further studies could aid in their appropriate application, minimize potential drawbacks, and maximize benefits, thereby providing valuable support to all stakeholders, including teachers, instructors, students, policymakers, and researchers.

5.2. Limitations and Suggestion

This systematic review is limited to studies related to only the implementation of GAI tools in English language learning, excluding other languages, and includes only articles published in English before August 1, 2024.

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Appendix

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Research Article

Research on Early Maladaptive Schemas in Romantic Relationships in Turkey: A Systematic Review Study

Hatice İrem ÖZTEKE KOZAN [1], Zeliha TRAŞ [*2], Neslihan ÖZTÜRK [3]

* *Corresponding Author, zztras@gmail.com*

[1,2] *Necmettin Erbakan University, Türkiye*

[3] *Ministry of National Education, Türkiye*

Abstract

This study aimed to comprehensively review and combine research on "early maladaptive schemas in romantic relationships" carried conducted in Turkey. For this reason, postgraduate theses on early maladaptive schemas in romantic relationships in our nation were thoroughly and methodically reviewed. The results of the studies that met the study group's inclusion and exclusion criteria were then disseminated. Thirteen graduate theses conducted between 2017 and 2023 were found after the YÖKTEZ database was searched between November 2023 and December 2023 to identify the research's study group. Twelve graduate theses were selected to make up the research group for this study based on the inclusion and exclusion criteria. The theses and articles that made up the study group were examined using the "Research Evaluation Form" that the researchers had created. The studies were evaluated based on the variables that were investigated using PRISMA Control items, the types of postgraduate theses, the institutes where they were published, the study groups and sizes, the data collection tools, and the years of publication. Recommendations were made after the research findings were examined in the context of the literature.

Keywords: Early maladaptive schemas, romantic relationships, systematic review

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Türkiye' de Romantik İlişkilerde Erken Dönem Uyumsuz Şemalar İle İlgili Araştırmalar: Bir Sistematik Derleme Çalışması

Özet

Bu araştırmada, Türkiye' de "romantik ilişkilerde erken dönem uyumsuz şemalar" konusunda yapılmış çalışmaları sistematik bir şekilde incelemek ve derlemek amaçlanmıştır. Bu sebeple romantik ilişkilerde erken dönem uyumsuz şemalar konusunda ülkemizde yapılmış lisansüstü tezler kapsamlı ve yapılandırılmış bir şekilde taranmış, çeşitli hariç tutma ve dahil etme kriterleri göz önünde bulundurularak; çalışma grubuna dahil edilen araştırmaların bulguları paylaşılmıştır. Araştırmanın çalışma grubunu belirlemek amacıyla YÖKTEZ veri tabanından Kasım 2023- Aralık 2023 tarihleri arasında taranmış ve 2014-2023 yılları arasında yapılmış 13 lisansüstü teze ulaşılmıştır. Hariç tutma ve dahil etme kriterleri ile; 12 lisansüstü tez ile bu çalışmanın araştırma grubu belirlenmiştir. Çalışma grubunu oluşturan tezlerin incelenmesinde araştırmacılar tarafından oluşturulan "Araştırma Değerlendirme Formu" kullanılmış ve PRİSMA Kontrol maddelerinden de yararlanılarak çalışmalar, yayınlanma yıllarına, lisansüstü tezlerin türlerine, yayınlandıkları enstitülere, çalışma gruplarına ve grup büyüklüklerine, veri toplama araçlarına ve araştırılan değişkenlere göre incelenmiştir. Araştırma sonuçları alınyazın ışığında tartışılarak önerilerde bulunulmuştur.

Anahtar Kelimeler: Erken dönem uyumsuz şemalar, romantik ilişkiler, sistematik derleme

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1. Introduction

In the literature of psychology, the concept of schema has started to be used widely in studies. Schemas are patterns that enable the individual to organize and react to mixed stimuli and experiences coming from the environment (Rafaeli et al., 2020, p. :14). Schemas facilitate the evaluation, interpretation and reorganization of an event experienced by the individual (Yılmaz, 2020, p. :19). Schema therapy is a holistic therapy developed by Young and colleagues for cases where cognitive therapy is insufficient in the treatment of personality disorders. It includes the process of blending cognitive, gestalt therapy with object relations and attachment institutions (Young et al., 2009, p. :23). While schemas guide the individual in his/her life and help him/her to adapt, on the other hand, they may interrupt his/her adaptation process. Those who are in the role of maladaptive schemas are called early maladaptive schemas (Yanık, 2015, p. :6).

Maladaptive schemas start in childhood and adolescence and continue to develop in later periods of life. Although they are functional in childhood and their negative aspects are not obvious, negative side of schemas emerge in adulthood, especially in terms of relationships. It consists of memories, emotions and cognitions of the individual. Schemas show resistance to change. Individuals have difficulty in changing schemas because they are familiar. With the effect of recognition, it is better to stay in the known place and choose it (Young et al., 2009, p. :23).

Rafaeli et al., 2013stated the factors that are effective in the formation of maladaptive schemas. Failure to meet the needs needed in childhood by the caregiver causes maladaptive schemas. Giving these needs too much, not being able to draw healthy boundaries, not supporting the development of autonomy are also the reasons. It is stated that the innate temperament and modelling of important people in the child's life also cause the formation of schemas. Especially in the literature, studies conducted between temperament and schemas (Calvete, 2014; Halvorsen et al., 2009) revealed the effectiveness of temperament. In addition, exposing the child to challenging lives creates maladaptive schemas. In fact, a relationship between stressful life events and schemas was found in the study carried out in our country (Yigit & Erden, 2015, p. 51). Studies by McCarthy & Lumley (2012) and Thimm (2010) also found that parental abuse and neglect had an impact on the separation and rejection schema area (p. 292).

Depending on the unmet needs of individuals, 5 schema areas and 18 schemas develop. Separation and rejection schema develops as a result of unmet needs such as trust, commitment and belonging. There are 5 schemas in this area. In the abandonment schema, the person thinks that he/she will be abandoned by others and left alone. It can occur especially in people who have experienced abandonment by their parents. In the insecurity schema, the idea that others will take advantage of him/her and abuse him/her is dominant. In emotional deprivation, he/she always feels lonely no matter what. He/she can never feel supported and protected. In the defectiveness schema, the person sees himself/herself as deficient and faulty. He/she may avoid establishing close relationships because he/she is afraid of others seeing this aspect of him/her. In social isolation, the individual divides the world into himself and others and does not feel that he belongs anywhere (Young et al., 2009, p. :34).

The schema area of impaired autonomy and failure is formed when needs such as autonomy, autonomy and independent decision-making are not met. There are 4 schemas in this domain. In the dependency schema, the individual has difficulty in doing an independent job alone and needs someone's help. In the vulnerability schema, the person experiences intense anxiety, thinking that he/she will experience a bad event and will not be able to get out of this situation.

In the nesting schema, there is no successful identity development, and the individual cannot do anything without consulting his/her parents. In the failure schema, the individual sees himself/herself as unsuccessful and incompetent. He/she experiences negative internal dialogue about himself/herself. When he compares himself with other people, he sees himself incompetent in every field, especially in talent and communication (Klosko & Young, 2019, pp. :91-121).

The damaged boundaries schema also occurs when the family is too giving, overprotective and healthy boundaries cannot be drawn. There are 2 schemas in this area. In justification schema, the individual sees himself/herself as superior to others and thinks that he/she has privilege. In inadequate self-control, there is a problem in controlling impulses. Tasks that require labour and patience result in failure. The schema area of orientation towards others consists of 3 schemas and develops in situations where it is not possible to express the feelings and thoughts of the individual. In the submissiveness schema, the individual obeys and fulfils the wishes of the other party because he/she is afraid of authority. In the self-sacrifice schema, the needs of the other person are at the center instead of his/her own needs and he/she does this willingly. In the approval seeking schema, the individual does everything in his/her life to get approval from others and his/her self-confidence depends on how they react to him/her (Young et al., 2009, p. :35-36).

In the overstimulation inhibition schema area, the child's natural behavior and the need for play are prevented. There are 4 schemas in this area. In the pessimism schema, the individual always sees the negative sides of life and is anxious and alert. In emotional inhibition, logic is always at the centre and emotions are thought to be unnecessary. In the high standards schema, there is striving and perfectionism until the work is the best. In punishment, when a mistake is made, they think that they and the other person must be punished. It is very difficult to forgive (Rafaeli et al., 2020, p. :37).

The area and degree of schemas in individuals are different for everyone. Schemas ensure their continuation by enabling people to react in accordance with their own areas (Butler et al., 2002, p. :1232). Ways of coping are used in the continuation of schemas. In schema delivery, behaviors and thoughts are created in accordance with the schema. One goes according to the flow of the schema as he/she wants. In schema avoidance, the individual avoids events and objects that will remind him/her of the schema. In schema compensation, the individual tries to behave and think in the opposite way of the schema (Young et al., 2009, p. :33). Although these ways of coping are good for the person in a short time, their damaging effects begin to be seen in the future (Sempértegui et al., 2013, p. :434).

Researchers state that thoughts and attitudes in partner selection are influenced by maladaptive schemas (Hayes & Parsonnet, 2016). In romantic relationships, the quality and satisfaction of the relationship are affected by schemas. Individuals tend to unconsciously find people who trigger their schemas more attractive. Individuals experience the state of going to stimuli that remind old life events or patterns with the effect of familiarity. The triggering of schemas in romantic relationships is expressed as schema chemistry. By choosing individuals who will help to maintain the schemas, the basis of the relationship problems to be experienced is laid (Roediger & Stevens, 2016). Which schemas the partners have and how they use coping responses to the schemas negatively affect the satisfaction to be obtained from romantic relationships. As a matter of fact, studies (Dumitrescu & Rusu, 2012; Yigit & Çelik, 2016) have revealed the existence of a negative relationship between maladaptive schemas and relationship satisfaction. It can be said that maladaptive schemas are associated with most problems in individuals' lives and form the basis of problems such as depression, anxiety, perfectionism and attention seeking (Rafaeli et al., 2013). In the literature, it is seen that schemas have been studied with many variables.

In our country, it has been observed that the subject of study has expanded in recent years. In our country, the concept of schema has been studied with parenting styles (Hamamci & Kapçi, 2010, p. :131), relationship sensation (Yigit & Çelik, 2016, p. :85), self-esteem (Bozduğan, 2023, p. :70), indecision (Söylemez, 2019, p. :74), death anxiety (Geçit, 2018, p. :48), social anxiety and rejection (Zörer, 2015, p. :100), depression and anxiety (Gürkan, 2012, p. :58). Abroad, schemas have been studied with variables such as abuse (Calvete, 2014, p. :740; Lumley & Harkness, 2007, p. :649; Specht et al., 2009, p. :260), violence (Calvete et al., 2007, p. :794), marital satisfaction (Tavakol et al, 2016, p. :210), body satisfaction (Braitman, 2001, p. :88), depression and neglect (Schwartz, 2023, p. :33), substance use disorder (Tobi, 2021, p. :54), intimacy in romantic relationships (Stiles, 2004, p. :57), attachment (Farr, 2010, p. :72), forgiveness and revenge (Brock, 2014, p. :37), risky sexual behaviours (Switzer, 2006, p. :18).

Based on the studies conducted in the literature, this study, in which the information of the studies on maladaptive schemas in romantic relationships is synthesized, is important in order to see the studies on the subject, the related topics and the results as a whole. In this sense, systematic reviews are valuable as they provide information about the development and methods of the subject and shed light on new topics for experts in the field (Goodfellow, 2009). It is thought that this study will increase the areas of studies on schemas by guiding new researchers about unstudied topics. The aim of the study is to systematically analyze the researches conducted in Turkey on early maladaptive schemas in romantic relationships. In this direction, answers to the following sub-research questions were sought.

Theses on maladaptive schemas in romantic relationships in Turkey;

1. What is the year-by-year distribution like?
2. How is the distribution according to their types?
3. How is the distribution according to the institutes where they were published?

4. How is their distribution according to the measurement tools used?

5. What are the sample groups studied and how are they distributed according to their size?

6. What are the variables used? How is their distribution?

2. Method

In this study, postgraduate theses published in Turkey on "early maladaptive schemas in romantic relationships" were reviewed and their results were analyzed. We choosed systematic review study design. Systematic review helps to see the advantages and disadvantages of the subject studied by sorting, classifying and presenting a general framework in a chronological order and provides guidance for future studies (Erkuş 2019; Hatipoğlu 2021).

Systematic reviews are studies in which previous studies on a scientific subject are analyzed according to the inclusion and exclusion criteria and the results are synthesized and presented (Aslan, 2018; Karaçam, 2013). Based on the studies in the literature, this review study on maladaptive schemas in romantic relationships is valuable in terms of seeing and understanding the subjects studied, the research groups involved and the results as a whole. The research is limited to the studies included in the study, the results of the research and the method used.

2.1. Research Design

In the systematic review study, the studies in the YÖKTEZ database were scanned by considering the inclusion-exclusion criteria created by the researcher (Table 1), and data were collected by document analysis method. Document analysis, which is a qualitative research method, is the systematic and careful analysis of written documents related to the subject under investigation (Kıral, 2020). In the research, studies that did not meet the criteria were excluded and research was conducted with studies that met the criteria.

2.2. Study Group of the Research

The study group of this research consists of 12 postgraduate theses on "Early maladaptive schemas in romantic relationships" between 2017-2023, which were accessed by searching the YÖKTEZ database with preset keywords.

2.3. Data Collection Tool

In this research, the "Research Evaluation Form", which was created by the researcher by taking the opinions of two experts in the field, was used to examine the sources in a systematic way. With the form created, it was aimed to look at the research study systematically and to increase the validity and reliability of the research. In the research, the evaluation form included 8 categories such as author of the research, the year of publication, the study group of the research, the scales used in the research, the variables examined in the research, the type of the research and the main findings.

2.4. Process

In the formation of the study group of this research, the Turkish studies published on this subject were determined by using the keywords "early maladaptive schemas" and "romantic relationships" in the postgraduate theses in the YÖKTEZ database between 20-11-2023 and 29-12-2023, and the studies to be included in the study group were determined by considering the inclusion criteria in Table 1.

Table 1.

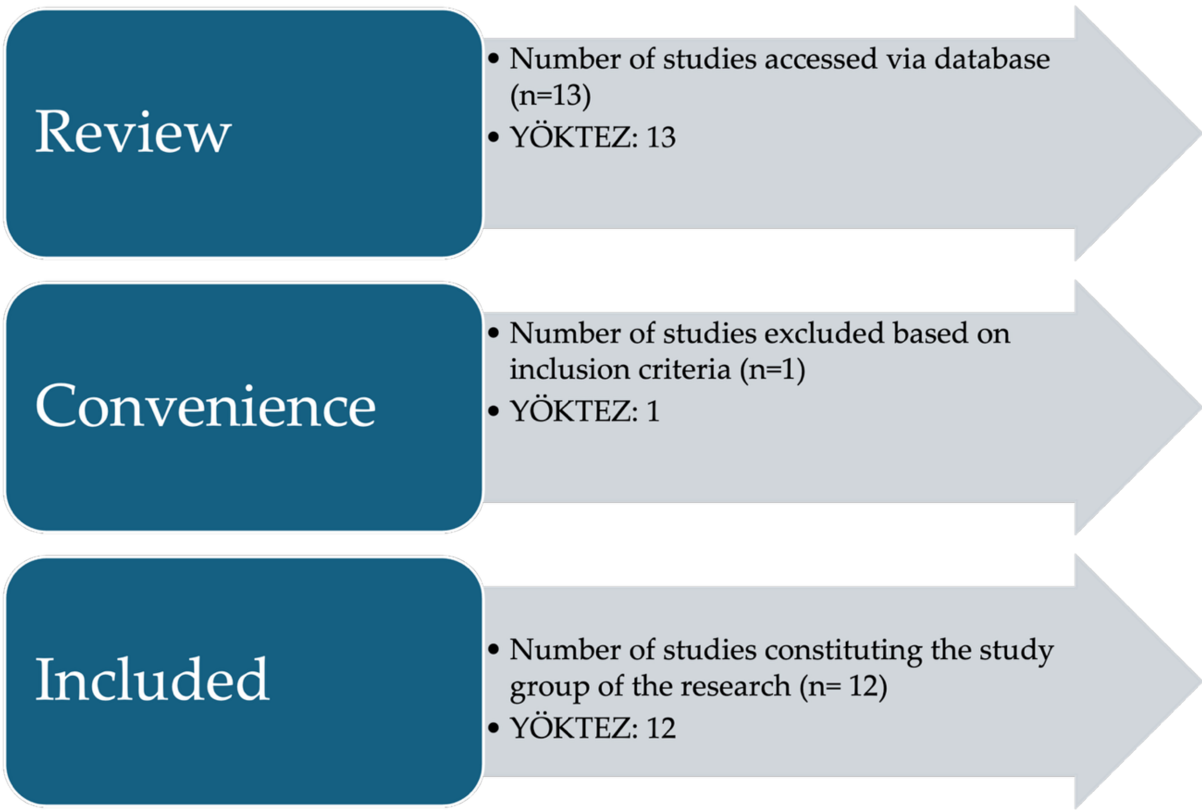
Inclusion Criteria

1. Graduate theses with "Early maladaptive schemas" and "Romantic relationships" in the research title were included in this study.
2. Graduate theses in the YÖKTEZ database were included in this study.
3. Graduate theses with full text access permission were included in the study.
4. Theses published between 2017-2023 were included in this study.
5. Only studies written in "Turkish" language were included in the study.

As a result of the literature review, 13 postgraduate theses were reached. Considering the inclusion criteria, 12 postgraduate theses that met the criteria were included in the review. The PRISMA flow diagram for the process of determining the studies examined in the review and selecting the studies used in the research group is as shown in Figure 1.

Figure 1.

PRISMA Flow Diagram Showing the Stages for Identification and Selection of Documents



3. Result

The postgraduate theses conducted in Turkey on "early maladaptive schemas in romantic relationships" and prepared in "Turkish" were analyzed according to the years of publication, research method, institute and thesis type, study groups and size of the groups, measurement tools, data analysis methods and variables studied. Information about the distribution of the studies is presented in the tables below.

As a result of the literature review, 13 postgraduate theses were reached. When the inclusion criteria were taken into consideration, the study was conducted with 12 postgraduate theses that met the criteria. The studies analyzed in the review study are shown in Table 2 in detail.

Table 2.

Reviewed studies in the scope of current research

Thesis Type	Author and Year	Thesis Title	Topics	Scales Used	Participants	Key Findings
Doktora Tezi	Kubin Mete, 2023	İstismar-ihmal öyküsü ve romantik ilişkilerde bağlanma: Bilişsel duygu regülasyonu ve erken dönem uyumsuz şemaların rolü	Çocukluk İstismarı , Romantik İlişkilerde Bağlanma , Duygu Regülasyonu , Erken Uyumsuz Şemalar	Childhood Trauma Scale , Cognitive Emotion Regulation Scale , Young Schema Scale Short Form , Inventory of Experiences in Close Relationships	Romantik ilişkisi olan 304 üniversite öğrencisi	Çocukluk travmalarının, kopukluk ve reddedilme ile hasarlı özerklik şema alanını pozitif olarak yordadığı belirlenmiştir. Kopukluk ve reddedilme ile özerklik şema alanının, çocukluk travmaları ile kaygılı bağlanma arasındaki ilişkiye tam aracılık ettiği bulunmuştur.
Yüksek Lisans Tezi	Ünal, 2023	Genç yetişkinlerde romantik ilişki istismarı: Erken dönem uyumsuz şemalar ve toplumsal cinsiyet rolü algıları	Romantik İlişki İstismarı , Toplumsal Cinsiyet Rolleri Algısı , Erken Uyumsuz Şemalar	Gender Role Formation Scale , Young Schema Questionnaire Short Form , Romantic Relationship Assessment Scale	Romantik ilişkisi olan 477 genç yetişkin	Erken dönem uyumsuz şemalardan duygusal yoksunluk ve iç içe geçme/bağımlılık şemalarının romantik ilişki istismarı mağduriyeti ile daha yüksek düzeyde ilişkili olduğu sonucuna varılmıştır.
Yüksek Lisans Tezi	Mardikyan, 2022	Üniversite öğrencilerinde erken dönem uyumsuz şemalar ve öz-şefkat düzeyleri ile romantik ilişkilerdeki irrasyonel inançlar arasındaki ilişkinin incelenmesi	Öz-Şefkat , Romantik İlişkilerde İrrasyonel İnançlar , Erken Uyumsuz Şemalar	Self-Compassion Scale , Young Schema Questionnaire Short Form , Irrational Beliefs in Romantic Relationships Scale	Romantik ilişkisi olan 160 üniversite öğrencisi	Erken dönem uyumsuz şemaların tüm alt boyutları ile Öz-Şefkat Ölçeği arasında ve romantik ilişkilerdeki irrasyonel inançların alt boyutlarından ıraksak düşünme, sosyal zaman kullanımı, zihin okuma, fiziksel yakınlık ve cinsiyet farklılıkları arasında istatistiksel olarak anlamlı ilişkiler bulunmuştur.
Doktora Tezi	Ertürk, 2022	Romantik ilişkilerde ilişki istikrarı: Borderline kişilik örgütlenmesi, ilişkilerde manipülasyon ve flört şiddeti bağlamında bir inceleme	İlişki İstikrarı , Borderline Kişilik Örgütlenmesi , Erken Uyumsuz Şemalar , Duygusal Manipülasyon , Flört Şiddeti	Relationship Stability Scale , Borderline Personality Inventory , Young Schema Questionnaire Short Form , Attitudes Towards Violence in Close Relationships Scale , Manipulation in Human Relationships Scale	Romantik ilişkisi olan 499 yetişkin	Bozuk sınırlar, özerklik ve kopukluk alanlarına ait uyumsuz şema alanları ile borderline kişilik arasında, borderline kişilik ile istismar, şiddet, manipülasyon arasında pozitif ilişkiler bulunmuştur. İlişki memnuniyeti ile diğer yönelimli olma ve kopukluk alanları arasında negatif korelasyon tespit edilirken, ilişki yatırımı ile kontrol ve diğer yönelimli olma alanları arasında pozitif korelasyon bulunmuştur. Uyumsuz şemaların Borderline Kişilik Örgütlenmesi'nin

						oluşumunda etkili bir rol oynadığı keşfedilmiştir.
Yüksek Lisans Tezi	Demir, 2022	18 yaş ve üzeri bireylerde erken dönem uyumsuz şemalar ve bağlanma stilleri ile romantik ilişki eğilimleri arasındaki ilişki: Şema Terapi Modeli çerçevesinde bir inceleme	Romantik İlişki Eğilimleri , Yetişkin Bağlanma Stilleri , Erken Uyumsuz Şemalar , Şema Terapi	Multidimensional Relationship Scale , Young Schema Questionnaire Short Form , Experiences in Close Relationships Inventory	Romantik ilişkisi olan 451 yetişkin	Romantik ilişki eğilimlerinin erken dönem uyumsuz şemalar tarafından anlamlı şekilde yordandığı gözlenmiştir.
Yüksek Lisans Tezi	Ar, 2021	Romantik ilişkilerde çatışmanın erken dönem uyumsuz şemalar ve bilişsel esneklik ile ilişkisi	Romantik İlişkilerde Çatışma Çözüm Tarzları , Bilişsel Esneklik , Erken Uyumsuz Şemalar	Romantic Partner Conflict Scale , Young Schema Questionnaire Short Form , Cognitive Flexibility Inventory	Romantik ilişkisi olan 455 yetişkin	Çatışma çözüm tarzlarının tüm alt boyutlarının erken dönem uyumsuz şemalarla ilişkili olduğu ve uyumsuz şemaların sosyodemografik değişkenlere göre değiştiği sonucuna varılmıştır.
Yüksek Lisans Tezi	Savaş, 2021	Romantik ilişki inançları ve romantik ilişki doyumunun erken dönem uyumsuz şemalar perspektifinden incelenmesi	İlişki Doyumu , İlişki İnancı , Erken Uyumsuz Şemalar	Relationship Beliefs Scale , Young Schema Questionnaire Short Form , Relationship	Romantik ilişkisi olan 457 yetişkin	Erken dönem uyumsuz şemalardan alınan puanlar arttıkça ilişki doyumunun azaldığı gözlenmiştir. Başarısızlık şeması hariç diğer tüm şemaların ilişki inançlarını olumlu yönde etkilediği bulunmuştur.
Yüksek Lisans Tezi	Karahisar, 2021	Üniversite öğrencilerinde erken dönem uyumsuz şemalar ve yetişkin ayrılık kaygısı ile romantik ilişki odaklı obsesif-kompulsif belirtiler arasındaki ilişkinin incelenmesi	Romantik İlişki , Yetişkin Ayrılık Kaygısı , Erken Uyumsuz Şemalar , Obsesyonlar ve Kompulsiyonlar	Adult Separation Anxiety Questionnaire , Young Schema Questionnaire Short Form , Scale for Obsessive-Compulsive Symptoms Focused on Romantic Relationships	Romantik ilişkisi olan 160 üniversite öğrencisi	Erken dönem uyumsuz şemalar ve yetişkin ayrılık kaygısı arasında anlamlı bir ilişki bulunmamıştır. Ancak, uyumsuz şemalar ile romantik ilişki obsesyonları ve kompulsiyonları arasında istatistiksel olarak anlamlı bir ilişki bulunmuştur.
Yüksek Lisans Tezi	Kılıçarslan, 2021	Genç yetişkinlerde romantik ilişkilerdeki irrasyonel inançlar, stresle başa çıkma tarzları ve erken dönem uyumsuz şemalar arasındaki ilişkinin incelenmesi	İrrasyonel İnançlar , Stresle Başa Çıkma Tarzları , Erken Uyumsuz Şemalar	Scale for Irrational Beliefs in Romantic Relationships , Young Schema Questionnaire Short Form , Coping Styles with Stress Scale	Romantik ilişkisi olan 407 genç yetişkin	Aktif başa çıkma tarzlarının Kopukluk, Bozuk Özerklik ve Yüksek Standartlar şema alanlarındaki puanlarla negatif yönde, pasif başa çıkma tarzlarının ise bu şemalarla pozitif yönde korelasyon gösterdiği anlamlı bir ilişki gözlenmiştir.
Yüksek Lisans Tezi	Batman Kavak, 2020	Üniversite öğrencilerinde erken dönem uyumsuz şemalar ile romantik ilişkilerdeki obsesif-kompulsif belirtiler ve ilişki	İlişki Doyumu , Romantik İlişkilerde Obsesif-Kompulsif Belirtiler , Erken Uyumsuz Şemalar	Romantic Relationship Obsessions and Compulsions Scale , Young Schema Questionnaire Short Form , Relationship Satisfaction Scale	Romantik ilişkisi olan 411 üniversite öğrencisi	Romantik ilişkilerdeki obsesyonlar ve kompulsiyonlar ile Kopukluk ve Reddedilme, Bozuk Özerklik ve Performans, Bozuk Sınırlar, Diğer Yönelimli Olma, Aşırı Tetiktelik ve

		doyumunun incelenmesi				Engelleme, ve Baskılama şemaları arasında pozitif bir ilişki bulunmuştur.
Yüksek Lisans Tezi	Bayar, 2021	Yetişkin bireylerde erken dönem uyumsuz şemalar, romantik ilişkilerdeki bağlanma stilleri, ilişki doyumu ve başa çıkma mekanizmaları arasındaki ilişki	İlişki Doyumu , Başa Çıkma Mekanizmaları , Erken Uyumsuz Şemalar , Bağlanma Stilleri	Experiences in Close Relationships Inventory , Young Schema Questionnaire Short Form , Relationship Satisfaction Scale , Young Avoidance and Compensation Scale	Romantik ilişkisi olan 460 yetişkin	Erken dönem uyumsuz şemalar ile ilişki doyumu arasında negatif bir ilişki bulunmuştur. Uyumsuz şemaların cinsiyet, ilişki durumu ve eğitim geçmişine göre değiştiği de belirlenmiştir.
Yüksek Lisans Tezi	Tok, 2017	Üniversite öğrencilerinde erken dönem uyumsuz şemalar, romantik ilişkilerdeki obsesif-kompulsif belirtiler ve ilişki doyumunun incelenmesi	İlişki Tarzı , Başa Çıkma Tarzı , Erken Uyumsuz Şemalar , Romantik İlişki	Multidimensional Relationship Scale , Young Schema Questionnaire Short Form , Multidimensional Coping Inventory in Close Relationships	Romantik ilişkisi olan 200 yetişkin	Başa çıkma tarzları ve ilişki tarzları alt boyutları ile uyumsuz şemalar arasında bir ilişki bulunmuştur. İlişki doyumu, özgüven ve atılganlık puanlarının ceza ve yüksek standartlar şemalarında daha yüksek olduğu bulunmuştur. Başa çıkma tarzları puanlarının da bu şemalarda daha yüksek olduğu bulunmuştur.

Note: The studies examined within the scope of the research are listed according to their publication years.

Table 3 shows the distribution of the postgraduate theses examined within the scope of the study according to their publication years. When Table-3 is examined, it is seen that only 1 (8.3%) postgraduate thesis was published in 2017 and there were no other thesis studies until 2020. In 2020 (8.3%), only 1 (8.3%) thesis was published. In 2021, 5 (41.6%) and in 2022, 3 (24.9%) postgraduate theses were published. In 2023, 2 (16.6%) postgraduate theses were published. When we look at the table, the most postgraduate thesis studies were conducted in 2021 (41.6%) and 2022 (24.9%). In 2021, the most studies were carried out in other years. It is seen that thesis studies, especially in the last 3 years, have increased rapidly compared to previous years.

Table 3.

Distribution of Theses by Publication Years

Years	n	%
2017	1	8.3
2018	0	0.0
2019	0	0.0
2020	1	8.3
2021	5	41.6
2022	3	24.9
2023	2	16.6
Total	12	100

When Table 4 is analysed, 2 of the theses were prepared at doctoral level (17%) and 10 of them were prepared at master's level (83%). According to the results, it was found that most of the theses on early maladaptive schemas in romantic relationships were at master's level.

Table 4.

Distribution of Graduate Theses by Type

Type	n	%
Doctoral Thesis	2	17
Master Thesis	10	83
Total	12	100

Table 5 shows the information about the postgraduate theses on early maladaptive schemas in romantic relationships according to the institutes in which they were published. When the results are analysed, it is seen that 7 of the theses were published in postgraduate education institute (58.3%), 2 of them were published in social sciences institute (16.6%), 2 of them were published in educational sciences institute (16.6%) and 1 of them was published in health sciences institute (8.3%). According to this finding, it can be said that the theses on early maladaptive schemas in romantic relationships were mostly conducted in the postgraduate education institute, while the least number of studies were conducted in the institute of health sciences.

Table 5.

Distribution of Graduate Theses by the Institute of Publication

Institute Name	n	%
Health Sciences Institute	1	8.3
Educational Sciences Institute	2	16.6
Social Sciences Institute	2	16.6
Graduate School of Education	7	58.3
Total	12	100

Information about the sample group of the studies is given in Table 6. When the table is examined, it is seen that the study sample on early maladaptive schemas in romantic relationships differed as "university students", "young adults" and "adult individuals". When we look at the table, it is seen that most of the studies were conducted with adults and least with young adults. The distribution of the study group can be a guide for future research. New researches can be carried out with samples that have not been studied or have been studied less.

Table 6.

Distribution of Studies by Sample Group

Study Groups	n	%
University Students	4	33.3
Young Adults	2	1.6
Adults	6	50
Total	12	100

Table 7 gives information about the sample size of the analysed studies. According to the table, it is seen that the maximum sample group size in 8 studies is between 401-600 (67%) people. It is seen that the sample size of 3 studies was between 0-200 (25%) people and the sample size of 1 study was 201-400 (8.3%) people. It can be said that the majority of the studies on early maladaptive schemas in romantic relationships were conducted by collecting data from people between 401-600. In addition, it is seen that the studies differ according to the sample size.

Table 7.

Distribution of studies by sample size

Sample Size of Study Group	n	%
0-200	3	25
201-400	1	8.3
401-600	8	67
Total	12	100

The information about the scales used by the analysed studies to collect data is given in the table above. Table 8 shows that "Young Schema Scale" (34.2%) (Jeffry Young, 2003) was used the most in relation to maladaptive schemas in romantic relationships. This scale was used in all theses on maladaptive schemas in romantic relationships. Experiences in close relationships inventory (Fraley, 2000) (8.5%) was used in 3 different studies, multidimensional relationship scale (5.7%) (Büyükşahin, 2005) was used in 2 different studies, irrational beliefs in relationships scale (5.7%) (Sarı & Korkut Owen, 2015) was used in 2 different studies, It is possible to see that obsessive-compulsive symptoms scale (5.7%) (Doron, 2012) was used in 2 different studies, Relationship beliefs scale (5.7%) (Gizir, 2012) was used in 2 different studies and Relationship Satisfaction Scale (5.7%) (Curun, 2000) was used in 2 different studies. In addition to these scales, the information on the scales used 1 time is also given in the table.

Table 8.

Distribution of Studies by Data Collection Instruments

Data Collection Instrument	n	%
Young Schema Questionnaire Short Form	12	34.2
Experiences in Close Relationships Inventory	3	8.5
Multidimensional Relationship Scale	2	5.7
Irrational Beliefs Inventory in Relationships	2	5.7
Obsessive-Compulsive Symptoms Scale	2	5.7
Relationship Beliefs Scale	2	5.7
Relationship Satisfaction Scale	2	5.7
Cognitive Emotion Regulation Scale	1	2.8
Childhood Trauma Scale	1	2.8

Gender Role Inventory	1	2.8
Relationship Stability Scale	1	2.8
Evaluation of Romantic Relationship Scale	1	2.8
Borderline Personality Inventory	1	2.8
Attitudes Toward Relationship Violence Scale	1	2.8
Manipulation in Interpersonal Relationships Scale	1	2.8
Self-Compassion Scale	1	2.8
Romantic Partner Conflict Scale	1	2.8
Total	35	100

Information about the variables analysed in the study on maladaptive schemas in romantic relationships is given in Table 9. It is seen that the most researched variable in the studies is early maladaptive schemas (30%), which is included in 12 studies, and then relationship satisfaction (7.5%) is the most researched variable. Coping styles (5%), irrational beliefs in romantic relationships (5%), obsessions and compulsions (5%) were investigated in 2 studies each. It is also seen that there are variables analysed 1 time in the studies. Coping with stress, Cognitive flexibility, Conflict resolution styles, Self-compassion, Adult attachment styles, Emotion regulation, Romantic relationship tendencies, Dating violence, Emotional manipulation, Borderline personality organisation, Relationship style, Relationship stability, Perception of gender roles, Romantic relationship abuse, Attachment styles, Relationship beliefs, Attachment in romantic relationship, Childhood abuse, Adult separation anxiety variables were examined 1 time each (2%. 5%) of the studies examined the relationship between romantic relationship and maladaptive schemas. Based on the table, romantic relationships and maladaptive schemas, relationship satisfaction, coping styles, irrational beliefs, obsessions and compulsions were the most studied topics.

Table 9.

Variables Examined in Studies

Variables Examined	n	%
Early Maladaptive Schemas	12	30
Relationship Satisfaction	3	7.5
Coping Styles	2	5
Irrational Beliefs in Romantic Relationships	2	5
Obsessions and Compulsions	2	5
Adult Separation Anxiety	1	2.5
Childhood Abuse	1	2.5
Attachment in Romantic Relationships	1	2.5
Relationship Beliefs	1	2.5
Attachment Styles	1	2.5
Romantic Relationship Abuse	1	2.5
Perception of Gender Roles	1	2.5
Relationship Stability	1	2.5
Relationship Style	1	2.5
Emotional Manipulation	1	2.5
Dating Violence	1	2.5
Romantic Relationship Tendencies	1	2.5
Emotion Regulation	1	2.5
Adult Attachment Styles	1	2.5
Self-Compassion	1	2.5
Conflict Resolution Styles in Romantic Relationships	1	2.5
Cognitive Flexibility	1	2.5
Coping Styles with Stress	1	2.5
Total	40	100

In Table 10, information about the research methods of the studies on early maladaptive schemas in romantic relationships in Turkey is given. According to the table, 11 studies were conducted using quantitative method and 1 study was conducted using mixed method. Qualitative method was not used in the analysed studies. It was determined that the thesis study conducted with mixed method was a doctoral thesis.

Table 10.

Research Methods Used in Studies

Research Design	n	%
Quantitatice	11	91.6
Mixed	1	8.3
Total	12	100

4. Discussion and Conclusion

When the studies were evaluated on a year basis, it is seen that the most thesis studies on the subject were conducted in 2021. It was found that 5 (41.6%) of the total 12 studies belonged to 2021. It was noteworthy that most of the theses analyzed (83%) were master's theses (n=10). In all these studies analyzed within the scope of the research, quantitative method was used. Relational survey design was used within the quantitative method. In one thesis, both quantitative and qualitative studies were conducted using mixed method. There were no qualitative studies in the theses analyzed. When the sample group of the studies was analyzed, it was seen that most of the studies were conducted with adult individuals. In the research, it was observed that there were few studies conducted with university students. It is seen that maladaptive schemas have been studied with many variables on the basis of romantic relationship. It is seen that the studies examined in this study generally focus on the variables of maladaptive schemas and relationship satisfaction, relationship stability, coping styles, irrational beliefs. It was observed that all of the studies examined in the research used the Young schema scale to measure maladaptive schemas.

Early maladaptive schemas are lifelong disruptive themes consisting of factors such as not fully meeting basic needs in childhood and adolescence, traumatic experiences and temperament (Klosko & Young, 2019). When maladaptive schemas are triggered in interpersonal relationships, the individual may use unhealthy coping strategies to avoid negative emotions. Thus, they may experience problems in communication (Thimm, 2010). In studies on romantic relationships, it is seen that individuals develop maladaptive schemas according to the degree of satisfaction of needs in childhood and reflect these schema patterns to their close relationships (Bartholomew & Shaver, 1998; Hazan & Shaver, 1994). Due to this situation, issues such as mate selection, intensity of emotions, and relationship satisfaction are in the prioritized subject area of maladaptive schemas along with romantic relationships. In this study, it was aimed to systematically examine the thesis studies on "early maladaptive schemas in romantic relationships" in Turkey and the thesis studies were reported regularly.

When the studies were evaluated on a year basis, it is seen that the most thesis studies on the subject were conducted in 2021. It was found that 5 (41.6%) of the total 12 studies belonged to 2021. Especially in the last 3 years, research on the subject has increased in our country (Borges & Dell'Aglio, 2020; Eken & Cihangir Çankaya, 2022). It is thought that the field of use of schema therapy has expanded and gained intensity in recent years, so it is thought to be used effectively in studies. Schema therapy is a holistic therapy and has been used more in recent years as some therapies have been inadequate. Although its effectiveness increases due to more permanent changes in individuals with the change of schemas, more studies have started to be carried out in recent years as the subject areas studied have expanded.

It was noteworthy that most of the theses analyzed (83%) were master's theses (n=10). In our country, it is more difficult to enter a doctoral program than a master's program and the education period lasts longer. Therefore, it is more likely to study a subject at master's level (Coşkun et al., 2014). When the number of master's and doctoral graduates of the last 3 years is examined in the YÖK information system, it is seen that the number of master's graduates is 4 times higher than the number of doctoral graduates. The low number of doctoral graduates may explain the low number of doctoral theses in this field.

In all these studies analyzed within the scope of the research, quantitative method was used. Relational survey design was used within the quantitative method. In one thesis, both quantitative and qualitative studies were conducted using mixed method. There were no qualitative studies in the theses analyzed. Quantitative studies provide convenience to researchers in terms of generalization of results and practicality of application. However, it is thought that the use of qualitative and mixed methods to identify the problem and create solution suggestions will contribute more to the schema and romantic relationships (Uzun et al., 2018). It is thought that research in which qualitative and quantitative studies are used together will contribute to the literature in terms of originality and allow in-depth examination of the sample (Tiftik, 2021). The use of different research methods on a subject provides richness in the field by answering different questions of the subject (Cook & Cook, 2016). In addition, considering that romantic relationships are specific to individuals, interviewing the individuals in the sample group one by one will provide information to the researcher about the presence of other variables that will affect the relationships. It will guide those who will conduct new studies in the field about variables and study group.

When the sample group of the studies was analyzed, it was seen that most of the studies were conducted with adult individuals. It may have been effective that maladaptive schemas are grounded in childhood and adolescence and their negative aspects emerge in relationships, especially in adulthood (Rafaeli et al., 2013). In the research, it was observed that there were few studies conducted with university students. It is thought that examining maladaptive schemas on the basis of romantic relationships especially in emerging adulthood will contribute to the literature. In this period, the importance of dating relationships increases, and the individual puts the individual with whom he/she has a romantic relationship in an important place. Problems related to romantic love with intense emotions can be experienced. (Steinberg, 2017). In the research conducted, it was found that most emotional, academic, romantic and economic problems were experienced in emerging adulthood (Erkan et al., 2012). Therefore, it is thought that increasing studies with university students will provide new information.

It is seen that maladaptive schemas have been studied with many variables on the basis of romantic relationship. It is seen that the studies examined in this study generally focus on the variables of maladaptive schemas and relationship satisfaction, relationship stability, coping styles, irrational beliefs. In studies conducted abroad (Dumitrescu & Rusu, 2012; Mihić et al., 2008), relationship satisfaction, coping styles, attachment variables were found to be related to maladaptive schemas. It was concluded that maladaptive schemas were related to or predicted most of the variables examined in the study. If the schemas are maintained in romantic relationships, the individual experiences conflict within himself/herself and decreases his/her satisfaction in the relationship. In studies on romantic relationships, it has been observed that more work has been done with satisfaction and stability in the relationship due to the increase in separations recently (Ertürk & Arikan, 2022). It is thought that the variables are overstudied in the studies due to the fact that they are also included in the romantic relationship ground.

It was observed that all of the studies examined in the research used the Young schema scale to measure maladaptive schemas. It is thought that the development of other scales suitable for the sample group and in which schemas in romantic relationships can be studied will expand the field of studies on the subject. In addition, scales were predominantly used in the analyzed studies. Due to the lack of qualitative studies, scales are used too much in the studies.

This study is a systematic review that aims to examine the studies on maladaptive schemas in romantic relationships in Turkey. Systematic review is important in terms of shedding light on new research topics by determining the level of knowledge on a particular subject, how it has developed over time and the deficiencies in the literature (Yilmaz, 2021). In this context, 12 graduate theses were examined in detail with the PRISMA report with various inclusion/exclusion criteria, the findings were shown in tables and the results were discussed and suggestions were presented to the researchers. In the process of organizing the study, the researchers did not take sides (BIAS) in a way that would affect the course of the study in a certain direction, and the results were discussed in the light of the literature. It is thought that the data presented in this study will be useful to see the gaps in the subject areas to be studied on maladaptive schemas in romantic relationships. Researchers can reach deeper information by conducting qualitative and mixed studies on this topic. Thus, they can contribute to the enrichment of this subject in the literature. More studies can be conducted with university students and adolescents in terms of sample group. In the PDR units of universities, information about maladaptive schemas within the framework of romantic relationships can be provided. Awareness of the client can be ensured through individual therapies when needed. Activities can be carried out on the effectiveness of maladaptive schemas in pre-marital information, couple therapies and communication issues, and the awareness of adults on this issue can be increased. In addition, it is thought that providing information about the first period experiences that cause maladaptive schemas, especially to parents, will help at the level of prevention work.

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Research Article

Video Club Designs in Improving Teachers' Noticing

Elif Nur TANIR GÜÇYETMEZ *[1], Sibel YEŞİLDERE İMRE [2]

* *Corresponding elifnurtanir@gmail.com*
[1]*Ministry of National Education Kayseri, Türkiye*
[2]*Dokuz Eylül University, Türkiye*

Abstract

This study examines studies on video club designs focusing on noticing skills of teachers and pre-service teachers. In this context, 18 articles published in the last twenty years on video club designs focusing on noticing skills in the field of mathematics education were systematically examined. As a result of the examination, differences in video club designs of the studies were determined. In addition, the results of the studies examined in terms of noticing skills as well as the results of the studies examining the differences in video club designs were evaluated. As a result of the analysis, it was determined that there were differences in video club designs in terms of the videos used, participants, facilitators' directions and frameworks used. It was determined that the participants were generally teachers and the videos were used in the form of video clips. In addition, it was determined that frameworks were used in some studies to help teachers focus their attention on certain teaching moments. Furthermore, it was determined that the facilitators directed the participants' attention to the mathematical thinking processes of the students, the teaching practices of the teachers and the student interactions. The results of the studies regarding noticing skills were determined to be on student knowledge and thoughts, social interactions and teaching processes. In addition, the results of some studies that different video club designs can create different effects were presented.

Keywords: Video Club, Noticing, Mathematics Education, Systematic Review

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Öğretmenlerin Fark Etme Becerilerini Geliştirmede Video Kulüp Tasarımları

Özet

Bu çalışmada öğretmenlerin ve öğretmen adaylarının fark etme becerilerine odaklanan video kulüp tasarımlarına ilişkin araştırmalar incelenmiştir. Bu doğrultuda son yirmi yılda matematik eğitimi alanında fark etme becerileri üzerine odaklanmış video kulüp tasarımlarına ilişkin yayımlanan 18 makale sistematik olarak incelenmiştir. İnceleme sonucunda çalışmaların video kulüp tasarımlarındaki farklılıkları belirlenmiştir. Ayrıca incelenen çalışmaların fark etme becerileri bağlamındaki sonuçlarının yanı sıra video kulüp tasarımlarındaki farklılıkları inceleyen çalışmaların da sonuçları değerlendirilmiştir. Yapılan analiz sonucunda video kulüp tasarımlarında; kullanılan videolar, katılımcılar, kolaylaştırıcıların yönlendirmeleri ve kullanılan çerçeveler açısından farklılıklar olduğu tespit edilmiştir. Genellikle katılımcıların öğretmen olduğu, videoların ise video klip şeklinde kullanıldığı tespit edilmiştir. Ayrıca bazı çalışmalarda öğretmenlerin dikkatlerini belirli öğretim anlarına yoğunlaştırmalarına yardımcı olması açısından çerçeveler kullanıldığı tespit edilmiştir. Bunun yanı sıra çalışmalarda kolaylaştırıcıların, katılımcıların dikkatini öğrencilerin matematiksel düşünme süreçlerine, öğretmenlerin öğretim uygulamalarına ve öğrenci etkileşimlerine yönlendirdiği belirlenmiştir. Çalışmaların fark etme becerilerine ilişkin sonuçları ise öğrenci bilgi ve düşünceleri, sosyal etkileşimler ve öğretim süreçleri üzerine olduğu tespit edilmiştir. Ayrıca bazı araştırmaların farklı video kulüp tasarımlarının farklı etkiler yaratabileceğine ilişkin sonuçları sunulmuştur.

Anahtar Kelimeler: Video Kulüp, Fark Etme Becerileri, Matematik Eğitimi, Sistematik Derleme

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1. Introduction

Video records social interactions and human behaviors in their natural environments and contexts, making them available for later and more convenient examination (Lemke, 2007). Sherin (2004), who examined the chronological history of the use of video in teacher education, suggested that the place of videos in education, which provided teachers with the opportunity to think about classroom interactions, dates back to the 1960s. In the 1960s, a video-based approach called "micro teaching" was developed, which included experiments with teaching at a micro level (Olivero, 1965). Sherin stated that in the 1970s, the lesson analysis method came to the fore as a different use of video in teacher education. With this method, unlike micro teaching, where participants had the opportunity to try and practice a specific skill, participants learned to identify specific teacher and student behaviors. In the 1980s, the idea of examining the actual teaching of experienced teachers through video in teacher education was developed. In this context, it was aimed to examine the teaching strategies and methods of experienced teachers so that teacher candidates can become more expert (Sherin, 2004). Sherin reported that in the 2000s, the use of video provided an opportunity to think about teaching practices. Sherin also stated that video would be beneficial for future studies and attributed this to three features of video: providing a permanent record of what happens in a classroom, being collectable and editable, and being able to be viewed multiple times for multiple purposes. Therefore, video is a tool that can present various real classroom environments, as well as being able to be slowed down, edited, and watched more than once. Video technology provides easy access to the classroom atmosphere and to observe of interactions between teachers and students inclusively (Sherin, 2004). It also offers teachers the opportunity to see remarkable situations and to gain different perspectives each time (van Es & Sherin, 2010). It can be said that with these opportunities offered by the video tool, the use of video has an important place in both professional development and pre-service education.

The increase in studies on the use of video along with the compatibility of video use with technological developments has enabled new and different types of activities to be carried out in mathematics education (van Es & Sherin, 2002; van Es & Sherin, 2006). In this direction, pre-service teachers were able to effectively adapt to the school culture by monitoring and analyzing teaching and learning activities in pre-service education (Koh, 2015). In addition to the importance of video in pre-service education, it also has an important place in the professional development of teachers (Sherin & van Es, 2009; van Es & Sherin, 2002; van Es & Sherin, 2006; Walkoe, 2015). It has been put forward that watching instructional videos helps mathematics teachers learn to observe and make sense of complex teaching practices (Sherin & van Es, 2009; van Es & Sherin, 2010).

In mathematics education, videos, have become an ideal tool to examine and support the development of individuals' noticing skills. Noticing skills include the process of teachers paying attention to students' mathematical thinking, interpreting students' thoughts, and deciding on the next teaching action based on these thoughts (Jacobs et al., 2010). In other words, noticing is related to teachers' ability to identify important students' thoughts and use them in teaching. In addition, teachers' noticing skills have been associated with their ability to analyze the teaching process through video (Luna & Sherin, 2017). In other words, the process of analyzing the video is a way to develop one's noticing skills (Amador et al., 2020). Moreover, it has been shown that the development of noticing skills of both teachers and pre-service teachers can be achieved with video club designs, which are a video method mostly used in mathematics education and include discussion processes of teachers about certain lesson videos (van Es & Sherin, 2002; van Es & Sherin, 2008; Walkoe, 2015). Video clubs, which are based on video analysis of classroom interactions of a group of participants, contributed to teachers' learning to notice (van Es, 2011). In addition, it has been determined that teachers' ability to pay attention to students' mathematical thoughts and reason about these students' thoughts increased with video club designs (Sherin & van Es, 2009; van Es & Sherin, 2008; Walkoe, 2015). Therefore, the use of video club designs played a role in the development of teachers' ability to notice students' mathematical thinking.

Video Club Designs in Mathematics Education

In their study on noticing, Sherin and van Es (2002) defined “video club” as meetings held regularly to watch and discuss videos of lessons. The main purpose of video clubs is to enable teachers to develop “professional vision”, that is, to specialize in understanding classroom interactions with selective attention and reasoning (Sherin & van Es, 2002; Sherin & van Es, 2009). Therefore, this specialization process is related to teachers’ attention to important features of classroom interactions and their ability to interpret them. In this context, video clubs, namely video discussions held in group environments, have been seen as environments that provide teachers with the opportunity to develop noticing (Sherin & van Es, 2009; van Es & Sherin, 2008; van Es & Sherin, 2006).

Video clubs, which were used as professional development meetings in which mathematics teachers watched and discussed video sections from their classes (van Es & Sherin, 2008; Sherin & van Es, 2009; van Es & Sherin, 2010), have become a method used in studies designed on video analysis in both pre-service education and professional development (Erbay, 2018; Mitchell & Marin, 2015; Walkoe, 2013; Charalambous et al., 2018; Sherin & Han, 2004). Therefore, video clubs allowed a group of teachers or pre-service teachers to analyze certain lesson videos and reflect on the teaching process. González (2018) put forward that the discussion environment provided by video clubs could help participants determine the teaching moves necessary to reveal and use students' prior knowledge. In this context, video clubs were used to support individuals' subsequent teaching practices and processes. Video club practices played a role in learning new ways of understanding both learning and teaching.

Video clubs were generally conducted under the guidance of facilitators who showed video clips and then led the discussion about the student thoughts in the video clips and the teaching process (van Es & Sherin, 2008). It has been put forward that the gains gained during video clubs are related to the actions of the facilitators who led the discussion (Superfine et al., 2019). In other words, the role of the facilitator is important in terms of guiding the discussion at a predetermined target point in a video club meeting (van Es & Sherin, 2008). At the same time, it can be said that the content of the videos, which are an important part of the video club meetings, is also an important factor in the video analysis process.

Systematic reviews conducted to understand the effects of the video analysis process, which is the most important dimension of video club designs, on teachers' professional development constitute an important literature base in this field. Gaudin and Chaliès (2015), who conducted one of these studies, examined the studies on video viewing in the field of education and examined teachers' activity as they view a classroom video, the objectives of video viewing, the types of videos viewed, and the effects of video viewing on teacher education and professional development. Santagata et al. (2021) examined thirty-five refereed articles focusing on improving mathematics teachers' noticing skills through a video-based program. They revealed findings regarding the theoretical perspectives of the studies, the use of video technologies, research questions, and methods. These reviews provided valuable information on how video technologies are an effective tool in teacher education and professional development. In addition, the various roles of the video tool in teacher education and professional development were examined and its connection with noticing skills was tried to be clarified. Moreover, the relationship between video clubs, which are a video-based design, and teachers' noticing skills has been examined in many studies. On the other hand, no studies have been found in the literature that systematically examine the differences in video club designs and the results of the studies in the context of noticing skills. In this context, the aim of the study is to examine video club designs in the context of noticing skills and to reveal the basic results of the studies. In this respect, it is thought that it will contribute to the literature on video-based studies and guide researchers.

The research problems are as follows:

1. What are the differences in the video club designs of the studies?

2. What are the results of the studies?

- What are the key results of the studies regarding noticing?
- What are the results of the studies examining the differences in video club designs?

In the light of these research problems, the method, findings and finally the results and discussion sections will be presented in the following sections of the article, respectively.

2. Method

Within the scope of this research, the differences in video club designs of the studies and the key results of the studies were examined. In this direction, systematic review method was preferred. Systematic review is a scientific research method in which the studies conducted on a subject are comprehensively reviewed, inclusion and exclusion criteria are applied, and the results obtained are brought together and evaluated (Aslan, 2018; Karaçam, 2013).

2.1. Screening and Analysis Process

Both national and international databases were used during the screening process of the studies. The titles, abstracts and keywords of the publications were searched through five online databases (ScienceDirect, Scopus, Web of Science, Dergipark, ERIC) by including the years 2005-2025. During the screening, the screening code containing the words ("video clubs"

OR "video club") AND mathematics AND (noticing OR notice) was used in both Turkish and English. The studies included in the research are shown in Figure 1, based on the PRISMA flow chart created by Moher et al. (2009). The inclusion and exclusion criteria in the screening process were as follows:

Inclusion criteria:

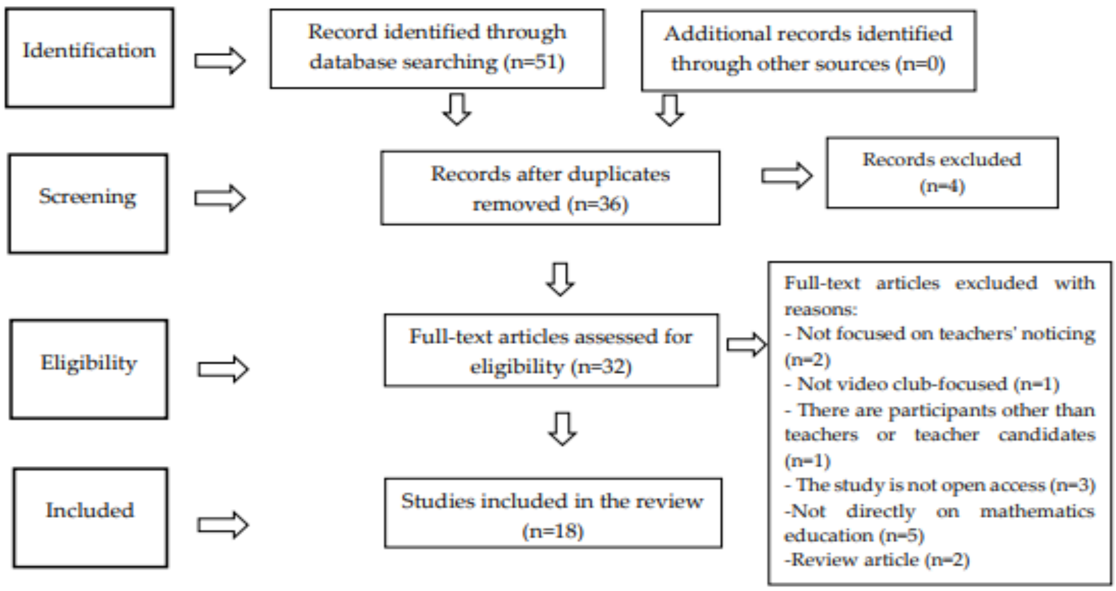
- Articles published in a peer-reviewed journal.
- Written in English or Turkish.
- Empirical studies that include qualitative, quantitative, or mixed methods.
- Related to the noticing skills of teachers or pre- service teachers.
- Full texts of the studies are accessible.
- Related to mathematics education.
- Video club-focused

Exclusion criteria:

- Involvement of participants other than teachers and pre-service teachers.
- The study is not open access.
- Including different fields other than mathematics education
- Being other than empirical studies (literature reviews were excluded).

Figure 1.

Literature Selection Process



As a result of the screening, 51 studies were identified. In the final stage, 18 articles were determined for the research according to the inclusion and exclusion criteria. 18 articles that met the criteria were included in the systematic review. The collected data were examined with content analysis. Codes were determined with the characteristics of the studies and then themes were created. The data were organized according to the themes and the findings were interpreted.

2.2. Ethics Committee Permission

Since this study was not conducted on humans or animals and is a compilation study, no application was made to the ethics committee and no approval was received.

3. Results

In this section, findings regarding the differences in video club designs and the results of the studies examined are included.

3.1. Findings Regarding the Differences in Video Club Designs

This section discusses the differences in video club designs of the studies examined within the scope of the systematic review. The participants of the studies, the types of videos used, the frameworks and the guidance of the facilitators were examined. The characteristics of the participants of the studies are given in Table 1.

Table 1.

Participants of the Studies

Participants	Studies (Author, Year)	Frequency (n)
Teachers	Amador et al., 2023; Gonzalez, 2018; Gonzalez & Skultety, 2018; Gonzalez & Vargas, 2020; Han et al., 2023; Mitchell et al., 2022; Osuna & Munson, 2024; Özdemir-Baki, 2020; Özdemir-Baki & Akgün, 2024; Özdemir-Baki & Kılıçoğlu, 2020, 2023; Sherin & van Es, 2009; Stovall et al., 2024; van Es & Sherin, 2006; van Es & Sherin, 2008; Wallin & Amador, 2019	16
Pre-service Teachers	Mitchell & Marin, 2015; Walkoe, 2015	2

It is shown in Table 1 how the examined studies are distributed according to participants. It was determined that the participants in 16 of the examined studies were teachers, while the participants in the other 2 studies were pre-service teachers.This shows that the studies were mostly carried out within the scope of professional development.

Table 2.

Types of Videos Used

Category	Video Type	Studies (Author, Year)	Frequency (n)
Teachers	Full class videos	Özdemir-Baki, 2020; Özdemir-Baki & Akgün, 2024; Özdemir-Baki & Kılıçoğlu, 2020, 2023	4
	Video clips	Amador et al., 2023; Gonzalez, 2018; Gonzalez & Skultety, 2018; Gonzalez & Vargas, 2020; Han et al., 2023; Mitchell et al., 2022; Osuna & Munson, 2024; Sherin & van Es, 2009; Stovall et al., 2024; van Es & Sherin, 2006; van Es & Sherin, 2008; Wallin & Amador, 2019	12
Pre-service Teachers	Video clips	Mitchell & Marin, 2015; Walkoe, 2015	2

In Table 2, the types of videos used in the studies are examined in 2 categories as video clips and full lesson videos. While full lesson videos cover the entire course process, video clips are in the form of edited lesson videos. It was determined that video clips were mostly used in the studies (n=14). Full lesson videos were used in 4 of the studies. In addition, the types of videos used were categorized in terms of teachers and pre-service teachers. According to the table, in the studies where the participants were teachers, the number of studies using full lesson videos (n=4), which provide a holistic examination of the classroom teaching processes, is less than the number of studies using video clips (n=12). In the studies where pre-service teachers participated, it is seen that only video clips were used (n=2).

Frameworks Used in Video Club Designs

It has been found that in some studies, frameworks were used to help teachers focus their attention on specific teaching moments (Han et al., 2023; Mitchell & Marin, 2015; Mitchell et al., 2022; Walkoe, 2015).

In the studies by Mitchell and Marin (2015) and Mitchell et al. (2022), the Mathematical Quality of Instruction (MQI) framework was utilized to help teachers evaluate critical mathematical events during classes. In these studies, participants were asked to code lesson videos using this framework. The MQI framework was used to support teachers in deepening their understanding of student thinking.

Walkoe (2015) used the Algebraic Thinking Framework in his study. This framework was developed to enable teachers to observe students' algebraic thinking in more depth. The discussion process of the video club design was guided by the Algebraic Thinking Framework.

In the study by Han et al. (2023), framework of statistical reasoning was used when teachers analyzed students' thoughts. This framework was developed to ensure that teachers carefully select and understand students' thoughts.

Facilitators' Directions in the Video Club Process

The studies' video club designs include facilitators who direct video analysis meetings. In the examinations, it was determined that facilitators have important roles in providing guidance to video club meetings in line with certain goals. It was determined that facilitators directed discussions regarding the video analysis process to certain pedagogical focuses in the video club process. In the examined studies, it was determined that facilitators directed participants' attention to students' mathematical thinking processes, teachers' teaching practices, and student interactions.

In the majority of the studies, facilitators guided the discussions to ensure that the participants focused on the students' mathematical thinking and teaching practices (Amador et al., 2023; Özdemir-Baki, 2020; Özdemir-Baki & Akgün, 2024; Özdemir-Baki & Kılıçoğlu, 2020; Gonzalez, 2018; Gonzalez & Skultety, 2018; Gonzalez & Vargas, 2020; Han et al., 2023; Mitchell & Marin, 2015; Mitchell et al., 2022; Sherin & van Es, 2009; van Es & Sherin, 2006; van Es & Sherin, 2008; Walkoe, 2015; Wallin & Amador, 2019). In one of these studies, Walkoe's (2015) study, unlike the others, it was determined that the pre-service teachers were guided to focus on the students' algebraic thinking with the guidance of a framework (Algebraic Thinking Framework). In another study conducted with the framework, Han et al. (2023), the facilitator directed teachers to understand students' mathematical reasoning more deeply by focusing on students' statistical variability. Similarly, in the studies of Mitchell et al. (2022) and Mitchell and Marin (2015), the facilitator directed participants' focus to mathematical content and student thinking using the Mathematical Quality of Instruction (MQI) framework. In the reviews, it was determined that facilitators directed participants to student interactions in some studies. For example, in the study of Stovall et al. (2024), the facilitator encouraged teachers to analyze students' talk and think about how they could create more equitable discussion environments in the future. In the study of Osuna and Munson (2024), the facilitator directed discussions to ensure that teachers reflect on student interactions. Similarly, in the study of Özdemir-Baki and Kılıçoğlu (2023), the facilitator directed discussions in a way that enabled participants to reflect on the classroom interactions they observed. In addition, in this study, the facilitator also encouraged teachers to think about their own practices.

3.2. Results of the Studies

The results of the studies reviewed were considered in two different ways: key results related noticing and results of studies examining differences in video club designs.

Tablo 3.

Key Results Related to Noticing

Theme	Category	Studies (Author, Year)	Frequency (n)
Key Results Related to Noticing	Student Knowledge and Thoughts	Amador et al., 2023; Gonzalez, 2018; Gonzalez & Skultety, 2018; Gonzalez & Vargas, 2020; Han et al., 2023; Mitchell & Marin, 2015; Mitchell et al., 2022; Özdemir-Baki, 2020; Özdemir-Baki & Akgün, 2024; Özdemir-Baki & Kılıçoğlu, 2020, 2023; Sherin & van Es, 2009; van Es & Sherin, 2006; van Es & Sherin, 2008; Walkoe, 2015; Wallin & Amador, 2019	16
	Social Interactions	Osuna & Munson, 2024; Özdemir-Baki & Kılıçoğlu, 2023; Stovall et al., 2024	3
	Teaching Processes	Amador et al., 2023; Gonzalez, 2018; Gonzalez & Vargas, 2020; Han et al., 2023; Mitchell & Marin, 2015; Osuna & Munson, 2024; Özdemir-Baki, 2020; Özdemir-Baki & Akgün, 2024; Özdemir-Baki & Kılıçoğlu, 2020, 2023; Sherin & van Es, 2009; Stovall et al., 2024; van Es & Sherin, 2006; Walkoe, 2015; Wallin & Amador, 2019	15

According to the examinations, the results of the studies on noticing skills were categorized as student knowledge and thinking, social interactions and teaching processes. It was determined that the results of the studies on noticing were mostly in the context of student knowledge and thinking (n=16). Studies on this subject show how the skills of teachers or pre-service teachers to notice students' thinking are strengthened through video clubs. Some studies have limited the context of student thoughts to certain topics. For example, there are studies focused on statistical variability reasoning (Han et al., 2023), algebraic thinking (Walkoe, 2015), problem-solving processes (Amador et al., 2023; Gonzalez, 2018; Gonzalez & Skultety, 2018; Gonzalez & Vargas, 2020; Han et al., 2023; Mitchell & Marin, 2015; Osuna & Munson, 2024; Özdemir-Baki & Akgün, 2024; Özdemir-Baki & Kılıçoğlu, 2020, 2023; van Es & Sherin, 2008).

Another category where the results on noticing skills are dominant is the ‘teaching processes’ category (n=15). This category includes studies that address the reflections of the participants' development in noticing skills on teaching processes. Another category, “social interactions”, includes 3 studies on the results of noticing skills. One of these studies, Özdemir-Baki and Kılıçoğlu's (2023) study, examined the effect of the development of noticing skills on social and socio-mathematical norms. Osuna and Munson (2024) determined the results of the process of teachers' in-depth analysis of student interactions using video clubs. Another study in the same category is Stovall et al.'s (2024) study. In this study, the ability of high school mathematics teachers to notice inequitable talk was examined.

Results of Studies Examining Differences in Video Club Designs

Some of the studies examined show that video clubs can be designed in different ways and can have different effects on teachers' learning processes (Gonzalez & Skultety, 2018; Han et al., 2023; Mitchell et al., 2022; Stovall et al., 2024; van Es & Sherin, 2006). For example; van Es and Sherin (2006) examined how different video club designs improved teachers' ability to notice classroom interactions. The findings showed that a structured and guided video club environment allowed teachers to focus more deeply but narrowly on students' mathematical thinking. In contrast, a more flexible and teacher-led video club model allowed teachers to consider classroom interactions from a broader perspective and focus on different topics. The results revealed that teachers' noticing skills varied depending on the video club design, with more guided structures supporting in-depth focus on specific points, while freer structures supported the development of multifaceted awareness.

Stovall et al. (2024), who examined the differences in terms of participants, examined how high school mathematics teachers noticed inequitable talk situations and how the awareness of teachers in different groups changed on this issue. Two different groups were selected in the study and their awareness of inequitable talk and student status was compared. The study revealed that different video club participants showed significant differences in their levels of noticing inequitable talk in the classroom. As a result, factors such as teacher identities, pedagogical approaches, and coaching support significantly affected the levels of noticing and taking action on inequitable talk in the classroom among different video club participants.

Gonzalez and Skultety (2018), who studied the effect of the facilitator, found that facilitators enabled teachers to focus on student thoughts, but teachers addressed student prior knowledge in a more in-depth and meaningful way in the discussions they initiated. Teachers' independent analysis in video clubs increased their noticing. Similarly, Mitchell et al. (2022) compared the effects of different types of facilitation in video clubs. The study revealed that externally facilitated and teacher-led participant-facilitated groups produced similar results in terms of learning processes. Both expert-led and teacher-led groups contributed to the professional development of teachers and raised their noticing.

Han et al.(2023) investigated how different video club designs affect the process of developing teachers' skills in noticing students' thoughts. Video club designs were used in which teachers went through different stages such as individual video watching, group discussions, and use of analytical frameworks. As a result of the study, it was observed that the awareness levels of teachers who initiated the discussions improved more. In addition, it was determined that teachers' interaction with colleagues at similar levels contributed positively to the analysis processes, but the effect of participants at very different levels on each other was more limited. In addition, it was emphasized that presenting analytical frameworks to teachers deepened the analysis processes, but sufficient guidance should be provided in advance for the effective use of these frameworks.

4. Discussion and Conclusion

With the developments in video technology, the use of video has become much easier and the ability to capture the richness and complexity of classes, so the video analysis process has gained importance in pre-service education and teacher professional development (Gaudin & Chalies, 2015). The video analysis processes of video-based studies in mathematics education are guided by elements such as the content of the videos, facilitating actions, and the use of a framework that directs the analysis process. It is thought that these elements are also reflected in video club applications, which are video-based studies implemented in line with the examination of noticing skills through video analysis. In this study, first of all, the differences in video club designs of the systematically examined studies were determined. Then, the results of the examined studies regarding noticing skills and the results of the studies examining different video club designs were presented.

It can be said that different video club designs are applied according to the goals and needs in mathematics education studies. In the current study, it was determined that there were differences in the video club designs of the studies examined according to the participants. The studies were examined as teacher participants and pre-service teacher participants and it was seen that the majority of the studies were aimed at teachers. In this context, it can be said that video clubs are generally used in the studies to support the professional development of teachers. It is thought that teachers are included in video club studies more frequently because they have the opportunity to analyze student interactions in the classroom and develop teaching strategies. Besides that, there are two studies in the current review that show that teacher candidates can develop their noticing skills through video clubs. The low number of studies aimed at teacher candidates indicates that video club studies specific to this group are less common.

In the research, the videos used in the video club designs of the examined studies were examined in two categories as video clips and full lesson videos. It was determined that video clips were mostly used in the studies. In addition, the types of videos used were categorized in terms of teachers and teacher candidates. It was determined that the videos most commonly used in the studies where the participants were teachers were in the form of video clips. In the studies where teacher candidates participated, it was determined that video clips were used in order to provide an opportunity to focus on critical components in mathematics teaching (Walkoe, 2015; Mitchell & Marin, 2015).

In video-based studies on noticing skills, where the videos used are an important factor, it has been shown that the use of a framework as a guide facilitates reaching the determined goal (Mitchell & Marin, 2015; Pascoe, 2016; Santagata et al., 2007; Tripp & Rich, 2012; Walkoe, 2015). In addition, in video-based studies, the use of frameworks in addition to video tools has also been reflected in video club designs. It has been determined that frameworks are used to help teachers focus their attention on specific teaching moments (Han et al., 2023; Mitchell & Marin, 2015; Mitchell et al., 2022; Walkoe, 2015). For example, in his study on noticing skills, Walkoe (2015) suggested that preparing facilitation questions with the guidance of a framework in line with a specific goal can better direct discussions on student thoughts. Therefore, a framework used in video club applications can direct the focus of video analysis discussions to students' mathematical thoughts. Similarly, in the studies of Mitchell and Marin (2015) and Mitchell et al. (2022), the Mathematical Quality of Teaching (MQI) framework was used for teachers to examine important mathematical moments in lessons. In the study by Han et al. (2023), a statistical reasoning framework was used during the phase of analyzing student thoughts.

In the examinations, it was observed that another factor that created differences in video club designs was the facilitators' guidance. It was determined that facilitators directed the discussions to certain pedagogical focuses during the video club process. In the examined studies, it was determined that facilitators directed the participants' attention to students' mathematical thinking processes and teachers' teaching practices and student interactions.

In the analysis of the results related to noticing skills, categories were obtained as student knowledge and thoughts, social interactions and teaching processes. It was determined that the results of the studies related to noticing skills were mostly in the context of student knowledge and thoughts (n=16). Another category in which the results related to noticing skills were predominant was the 'teaching processes' category (n=15). In addition, there were 3 studies on the results related to noticing skills in the "social interactions" category.

According to the results of the reviewed studies, it was determined that there are studies showing that video clubs can be designed in different ways and that they can have different effects on teachers' learning processes (Gonzalez & Skultety, 2018; Han et al., 2023; Mitchell et al., 2022; Stovall et al., 2024; van Es & Sherin, 2006). For example, in the study of van Es and Sherin (2006), it was revealed that teachers' noticing changed depending on the video club design, with guided structures supporting in-depth focus on specific points, while free structures supported the development of multi-faceted awareness. In the study of Stovall et al. (2024), different video club participants significantly affected the levels of noticing and taking action on unequal talk in the classroom.

There are also studies on the effect of facilitators on video club designs. For example, Gonzalez and Skultety (2018) found that teachers addressed student prior knowledge in more in-depth and meaningful ways in their self-initiated discussions. Similarly, Han et al. (2023) concluded that structured video clubs in which participants took an active role could positively affect teachers' professional awareness and pedagogical decision-making processes. In addition, Mitchell et al. (2022) compared the effects of different types of facilitation (externally facilitated groups and participant-facilitated) on teacher learning in video clubs. Both externally facilitated groups and participant-facilitated groups contributed to teachers' professional development and raised awareness.

4.1. Implications of Research

Studies that include video club designs in the context of noticing skills have been systematically examined. As a result of the examination, differences in video club designs have been addressed. In addition, the results of the studies conducted have been examined within the scope of noticing skills. In addition, the results of studies examining differences in video club designs have been determined.

It is thought that this study may contribute to the understanding of the roles of the videos to be selected and watched in video club designs, the participants, the issues related to the facilitator, and the frameworks that may be necessary to guide the video analysis in terms of the development of noticing skills of teachers or teacher candidates, and may provide a different direction to the studies on noticing skills to be conducted in professional development and teacher education.

4.2. Limitations and Suggestion

This research is limited to articles on video club designs focused only on mathematics education and noticing skills. In addition, the focus was on studies that preferred teachers and pre-service teachers as participants. Furthermore, the differences in video club designs were presented in terms of participants, the role of facilitators, videos and frames used.

In the current research, it is seen that the number of video club studies conducted on pre-service teachers is limited. Therefore, conducting more research on pre-service teachers is of great importance to understand how video club designs can be effective in this group. In addition, a limited number of studies have been reached that reveal what kind of results the differences in video club designs will produce. In this direction, the suggestion to further investigate the elements that make up the structure of video-based activities (Santagata et al., 2021) can be taken into consideration and the effects of these elements on video club designs can be examined further. In this context, video club designs can be created with different structural approaches and teachers' noticing skills can be examined in this direction.

Another issue that should be taken into consideration is the use of frames in video clubs so that participants can create a language that they can discuss (Walkoe, 2015). At this point, it is thought that additional studies are needed on how different designs of video club applications in mathematics education affect and support the noticing skills of teachers and pre-service teachers.

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ITALL

Research Article

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Thinking Through Play: How Designing Educational Games Enhances Critical Thinking, Motivation and Achievement in Science Classes

Elif KURT [1], Ayla CETİN-DINDAR *[2]

* Corresponding aylacetin@gmail.com

[1,2] Bartın University, Türkiye

Abstract

The aim of this study was to investigate the effects of designing an educational game on the topic of Force and Motion within the context of a sixth-grade science course on students' critical thinking skills, science learning motivation, and academic achievement. The study adopted a single-group pre-test–post-test design, one of the experimental methods in quantitative research. The sample consisted of 29 sixth-grade students attending a public middle school located in the central district of Bartin, Türkiye. As data collection tools, the Marmara Critical Thinking Tendencies Scale, the Science Motivation Questionnaire, and the Force and Motion Achievement Test were administered both before and after the intervention. Prior to implementation, the unit objectives were covered over approximately four weeks, after which the pre-tests were administered. The intervention phase lasted six weeks, during which the students, under the guidance of their science teacher, designed and developed educational games related to the Force and Motion unit. After completing the game design process, students played the games they had created with their peers and provided written feedback on each other's games. Subsequently, the post-tests were administered. The data obtained from the pre- and post-tests were analyzed using repeated measures tests to determine whether the educational game design process had a statistically significant impact on students' critical thinking skills, motivation to learn science, and academic achievement. The results revealed that the educational game design process had a significant positive effect on all three variables. Furthermore, the gender variable did not yield a statistically significant difference. The findings were interpreted and discussed in relation to existing literature in the field of science education.

Keywords: Science education, educational games, critical thinking skills, motivation to learn science, science achievement, force and motion unit.

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Oyun Yoluyla Düşünmek: Fen Bilimleri Dersinde Eğitsel Oyun Tasarımının Eleştirel Düşünme, Motivasyon ve Başarıya Etkisi

Özet

Bu araştırmanın amacı, altıncı sınıf fen bilimleri dersi kapsamında "Kuvvet ve Hareket" konusuna yönelik eğitsel oyun tasarımı sürecinin öğrencilerin eleştirel düşünme becerileri, fen öğrenmeye yönelik motivasyonları ve akademik başarıları üzerindeki etkisini incelemektir. Çalışma, nicel araştırma yöntemlerinden deneysel desenler içerisinde yer alan tek gruplu öntest-sontest modeline göre desenlenmiştir. Araştırmanın örneklemini, Bartın ili merkez ilçesinde yer alan bir devlet ortaokulunda öğrenim görmekte olan 29 altıncı sınıf öğrencisi oluşturmaktadır. Veri toplama aracı olarak; Marmara Eleştirel Düşünme Eğilimleri Ölçeği, Fen Bilimleri Motivasyon Ölçeği ve Kuvvet ve Hareket Başarı Testi kullanılmıştır. Uygulama öncesinde, ilgili ünitenin kazanımları yaklaşık dört hafta süresince öğretim programına uygun biçimde işlenmiş, ardından veri toplama araçları ön-test olarak uygulanmıştır. Müdahale sürecinde, öğrenciler fen bilimleri öğretmeninin rehberliğinde altı hafta boyunca Kuvvet ve Hareket konusuna ilişkin eğitsel oyunlar tasarlamış ve geliştirmiştir. Süreç sonunda, öğrenciler geliştirdikleri oyunları akranlarıyla oynamış ve oyunlara ilişkin yazılı geribildirimlerde bulunmuşlardır. Uygulamanın ardından son-testler uygulanmıştır. Toplanan veriler SPSS yazılımı kullanılarak analiz edilmiş; ön-test ve son-test puanları arasındaki farkı belirlemek ve eğitsel oyun tasarımı sürecinin etkisini değerlendirmek için tekrarlı ölçümler testi uygulanmıştır. Elde edilen bulgular, eğitsel oyun tasarımı sürecinin öğrencilerin eleştirel düşünme becerileri, fen öğrenmeye yönelik motivasyonları ve akademik başarı düzeyleri üzerinde istatistiksel olarak anlamlı bir etki yarattığını ortaya koymuştur. Ayrıca, cinsiyet değişkeninin anlamlı bir farklılık oluşturmadığı belirlenmiştir. Elde edilen sonuçlar, mevcut alanyazın çerçevesinde tartışılmış ve yorumlanmıştır.

Anahtar Kelimeler: Fen Eğitimi, Eğitsel Oyunlar, Eleştirel Düşünme Becerileri, Fen Öğrenmeye Yönelik Motivasyon, Fen Başarısı, Kuvvet ve Hareket Ünitesi

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1. Introduction

In contemporary education systems, a central priority is the cultivation of individuals equipped with critical thinking and reasoning skills, effective problem-solving abilities, and strong communication competencies. Furthermore, fostering the capacity to read, analyze, and interpret scientific information, along with developing science and technology literacy, has become increasingly essential. With the rapid advancements in science and technology, the demands of the 21st century require individuals who can adapt to evolving societal and professional challenges. In response to these demands, many developed countries place significant emphasis on science education as a cornerstone of their educational systems. By enhancing the structure and function of science curricula, these nations aim to prepare individuals who not only possess scientific knowledge but can also apply it innovatively and responsibly to address real-world issues.

This focus on science education reflects its pivotal role in shaping scientifically literate citizens who are prepared to engage in critical discourse, contribute to technological progress, and make informed decisions in an increasingly complex and interconnected world. In the 21st century, critical thinking skills have emerged as one of the most essential competencies expected from individuals, enabling them to analyze information, solve complex problems, and make informed decisions in an increasingly dynamic and information-driven world (Galinsky, 2010). Today, science education extends far beyond the mere transfer of knowledge to students. Its primary objectives now include sustaining students' interest in science, fostering their critical thinking skills, and equipping them to apply these skills across diverse contexts and real-world situations. However, achieving these goals presents significant challenges, particularly when instruction relies heavily on traditional, teacher-centered teaching approaches. In conceptually intensive courses such as science, students often struggle with understanding abstract and conceptual concepts, which can lead to frustration and disengagement. This lack of engagement not only diminishes students' interest in science but also negatively impacts their academic performance, hampers the development of critical thinking skills, and lowers their motivation to pursue and science learning. Consequently, addressing these issues has become a pressing priority in modern education systems to ensure students are prepared for the demands of an increasingly scientific and technologically driven society.

To ensure active students engagement in the learning process, it is essential for educators to design and implement instruction that accounts for individual differences by employing effective, student-centered strategies. Among such approaches, educational game design has emerged as an innovative and effective teaching strategy, particularly within the context of science education. This study investigates the impact of educational game design on students' critical thinking skills, motivation to learn science, and academic achievement. Integrating games into instruction has been shown to make learning more engaging, enjoyable, and meaningful for students. In the 21st-century educational paradigm, it is not only essential for students to learn how to simply access information but also to understand how to apply that knowledge, develop critical thinking skills, and stay motivated throughout the learning process (Akınoğlu, 2003). Within this framework, science education provides an ideal platform for fostering analytical and critical thinking abilities, as it inherently encourages inquiry, exploration, and problem-solving. Among the approaches designed to enhance science education, educational games serve as a powerful pedagogical tool, capable of transforming abstract scientific concepts into concrete, accessible ideas while simultaneously fostering students' interest and enthusiasm. The integration of educational games thus helps bridge the gap between theoretical knowledge and real-world application, supporting a more interactive, student-centered, and cognitively engaging learning experience.

The act of designing educational games further amplifies the pedagogical benefits of game-based learning by encouraging students to take on active roles in their own learning processes. This process not only sharpens their critical thinking and problem-solving skills but also enhances their scientific process skills, analytical reasoning, and ability to conduct research effectively. Through designing games, students are encouraged to access, evaluate, and apply information critically, thereby deepening their conceptual understanding and strengthening their connection to scientific content. The use of educational games, recognized as one of the innovative approaches in education, holds significant potential for increasing students' interest in science lessons and making abstract concepts more comprehensible. By incorporating elements of fun and interactivity, educational games promote active student participation and enhance engagement in the learning process. Moreover, involving students in the design of these games can foster their creativity, problem-solving abilities, and critical thinking skills, offering a more holistic learning experience. Educational games are specifically designed tools that aim to make the learning process more engaging, enjoyable, and interactive. In addition to content mastery, they support the development of essential social and emotional competencies (Çavuş & Balçın, 2017). Through their interactive nature, educational games help individuals cultivate problem-solving and critical thinking abilities, which are critical for success in both academic and real-life contexts. Empirical research indicates that as students become more actively involved in classroom activities through educational games, their academic performance tends to improve significantly. By combining entertainment with educational content, these games provide a dynamic learning environment that encourages students to engage deeply with the material while enhancing their motivation and long-term retention. Furthermore, these games foster learner autonomy by encouraging students to take initiative and responsibility for their own learning.

Students' motivation plays a crucial role in the learning and teaching process, as it directly influences their engagement, persistence, and academic success (Keller, 1979; Keller & Keller, 2010). Motivation serves as the driving force behind students' willingness to participate in learning activities, overcome challenges, and achieve their academic goals. Educators who understand the dynamics of motivation can better design instructional strategies that inspire and sustain student interest. Importantly, motivation is not a stable, trait-likecharacteristic but is instead highly context-dependent and domain-specific (Linnenbrink & Pintrich, 2002). This means that a student's level of motivation can vary significantly across different subjects, tasks, or environments. For instance, a student may be intrinsically motivated to engage with science due to a natural curiosity about the subject, while displaying less motivation in areas they perceive as less meaningful or relevant. Contextual factors such as classroom climate, instructional strategies, and the perceived relevance of content can all influence a student's motivation. Supportive and autonomy-enhancing classroom environment is more likely to foster intrinsic motivation, whereas a highly controlled or overly competitive environment may hinder it. Furthermore, the alignment of instructional content with students' interests, needs, and prior experiences can significantly enhance their engagement and sustained motivation to learn.

Numerous studies (e.g., Alamri et al., 2020; Lawlor et al., 2016) have highlighted a positive relationship between student autonomy and intrinsic motivation. When students are given opportunities to make choices and take responsibility for their own learning, their engagement and motivation tend to increase. Deci and Ryan (1985) through their Self-Determination Theory (SDT), emphasize the critical role of autonomy in fostering intrinsic motivation. According to SDT, intrinsic motivation, engaging in activities for inherent satisfaction rather than external rewards, is more likely to thrives when individuals feel they are acting on their own desire, free from external pressures or controls. This autonomy fosters deeper connections to personal values and promotes genuine interest, enjoyment, and persistence in learning tasks. The SDT also acknowledges the role of extrinsic motivation, which involves engaging in activities for external outcomes such as rewards, recognition, or avoiding penalties. While extrinsic motivation may be effective in certain contexts, it is often associated with short-term compliance rather than sustained engagement. Ryan and Deci argue that learning environments that prioritize autonomy and nurture intrinsic motivation lead to improved long-term outcomes, including higher levels of academic performance, engagement, and psychological well-being (Ryan & Deci, 2000). Creating autonomy-supportive learning environments involves instructional practices such as offering students meaningful choices, providing rationale for tasks, acknowledging their perspectives, and minimizing controlling language. These practices not only enhance intrinsic motivation but also encourage psychological growth, creativity, and persistence. On the other hand, controlling environments that rely heavily on external rewards or punishments may undermine intrinsic motivation, leading to decreased engagement and lower satisfaction over time. Studies have consistently shown that students who are intrinsically motivated tend to exhibit higher levels of academic success, persistence, and intellectual curiosity (Algharaibeh, 2020; Covington & Meller, 2001; Fuertes et al., 2020; Lepper et al., 2005; Yamauchi & Miki, 2003).

Additionally, learning activities that promote autonomy, such as goal setting, peer assessment, and self-assessment, play a crucial role in fostering intrinsic motivation (Alamri et al., 2020; Larsen et al., 2020; Mikami, 2020). According to Larsen et al. (2020), activities involving self- and peer-monitoring have a particularly significant impact on cognitive learning outcomes. These activities not only enhance students' knowledge but also alleviate feelings of anxiety and boredom, creating a more positive and productive learning environment. Peer-monitoring, in particular, facilitates collaborative learning, encouraging students to engage actively while providing mutual support in understanding and applying concepts. By integrating such autonomy-supportive practices into educational games, educators can cultivate a more self-directed and motivated learning experience, leading to both academic and emotional benefits for students.

Despite these promising benefits of educational games, there is a noticeable gap in the literature regarding the effects of the educational game design process, particularly on students' critical thinking skills, motivation to learn science and academic achievement. In this context, designing educational games specifically for middle school students on the topic of Force and Motion offers a valuable opportunity for both pedagogical innovation and empirical investigation. Yılmaz and Deniş Çeliker (2022) mentioned that since there has been the limited number of studies, particularly on the Force and Motion unit, it is a significant opportunity for this study to address gaps in the literature and examine the effects of developing educational games on various factors. Therefore, not only does this approach actively involve students in the learning process, but it also has the potential to improve their critical thinking skills, enhance their motivation to learn science, and positively influence their overall academic performance. Therefore, the present study aims to design and implement an educational game development process for sixth-grade students focusing on the Force and Motion unit. Accordingly, the study seeks to address the following overarching research problem: "What is the effect of designing an educational game in science courses on students' critical thinking skills, motivation to learn science, and academic achievement in science?"

To explore this problem comprehensively, the research is structured around the following sub-research questions:

- Does designing educational games in sixth-grade science courses have a significant effect on students' critical thinking skills?
- Does designing educational games in sixth-grade science courses have a significant effect on students' motivation to learn science?
- Does designing educational games in sixth-grade science courses have a significant effect on students' academic achievement in the Force and Motion unit?
- What are sixth-grade students' views on the process of designing educational games in the Force and Motion unit?

This research aims to provide insights into the potential benefits of integrating educational game design into science education, with a particular focus on enhancing students' cognitive and motivational outcomes, as well as their academic performance in conceptually challenging topics.

2. Methodology

In this study, the "Single-Group Pretest-Posttest Design," which is considered a weak experimental design within quantitative research methods, was employed (Fraenkel, Wallen, & Hyun, 2012). This design involves administering pre-test and post-test measures to assess the effect of an intervention applied to a single group of participants. The pre-test provides baseline data, while the post-test allows for an evaluation of the changes or effects following the intervention. Due to the use of a single group in this design, qualitative data were also incorporated to control for potential confounding variables and to enhance the validity of the findings. Additionally, to improve the reliability and validity of the results, students' views regarding the educational games they developed were gathered. This qualitative feedback was used to provide a deeper understanding of the impact of the intervention, offering insights into students' experiences and perceptions, which helped strengthen the overall conclusions of the study.

2.1. Participants

The study involved 29 sixth-grade students attending a boarding regional elementary school in the central district of Bartin province during the 2023-2024 academic year. Of the students who participated in the study, 15 were female (51.72%) and 14 were male (48.28%). The students' ages ranged from 11 to 12 years old. Data collection tools were administered to the participants both before and after the intervention. This approach employed a single-group pre-test and post-test design, which is considered a weak experimental design, to assess whether there was a significant difference between the pre-test and post-test results. The objective was to evaluate the impact of the intervention on the students by comparing the measurements taken prior to and following the application.

Instruments

Both quantitative and qualitative data-collecting tools were used in this current study. Three quantitative scales were used to collect data to assess students’ critical thinking skills, motivation to learn science and academic achievement on the Force and Motion unit.

The Marmara Critical Thinking Tendencies Scale (MCTTC) was developed by Özgenel and Çetin (2018) to assess students' critical thinking skills. The validity and reliability of the scale were tested by the researchers who developed it, and based on the results from the scale development studies, it was determined to be both valid and reliable. The scale consists of 28 items considering six factors and utilizes a five-point Likert-type scaleat. Participants are asked to rate their behaviours related to critical thinking skills by selecting response options, from never to always. The Cronbach's alpha coefficients for the scale range from r = 0.35 to r = 0.65, indicating a reasonable level of internal consistency. A higher score in each factor reflects more substantial characteristics associated with that specific dimension. On the other hand, for practical reasons and due to the limited sample size, the analysis was conducted based on the total scores and average values of participants' responses for a more straightforward interpretation of the scores.

The Science Motivation Questionnaire (SMQ), developed by Glynn and Koballa (2006), aims to assess students' motivation for learning science. The scale was translated and adapted into Turkish by Cetin-Dindar and Geban (2015). The SMQ consists of 30 items and uses a 5-point Likert-type scale. Participants are asked to respond to each item by selecting response options, from never to always. When considering all the items of the scale, the Cronbach's Alpha coefficient for internal consistency, indicating the scale's reliability, was found to be 0.913. This scale, applied before and after the intervention, aims to measure students' motivation to learn science.

The Force and Motion Achievement Test (AT) was used to evaluate students' learning outcomes related to the sixth-grade Force and Motion unit. The test consists of 12 multiple-choice questions designed explicitly for the sixth-grade Force and Motion unit. It was prepared by science education experts, measurement and evaluation specialists, and teachers from the Ministry of National Education. The test is publicly available on the official website of the General Directorate of Measurement, Evaluation, and Examination Services (ODSGM, 2024). These science assessment tests were developed by 150 teachers from various provinces and subsequently reviewed by 34 teachers and 37 academicians to ensure the validity, reliability, and overall quality of the questions before publication. The finalized version was published and made accessible for free download via the ODSGM online platform.

Two qualitative data-collecting tools were utilized in this research. One of them was a self-evaluation form, throughwhich written reflections were gathered from each student involved in designing an educational game. At the end of the implementation, students were asked to reflect on their experiences throughout the design process. Specifically, they were prompted to describe their feelings during game development, the challenges they encountered, and the strategies they used to overcome those challenges. The second qualitative data-collecting tool involved peer feedback on the educational games developed by classmates. After all the educational game development processes were completed, the students had the opportunity to play all of the games in a classroom setting. Following this activity, students were asked to provide feedback on the games they played. For this purpose, they were given a set of eight open-ended questions developed by the researchers. These questions were designed to elicit students' perspectives on the educational, visual, and functional aspects of the games. The questions included: "How do you think the game looks visually?", "Do you find the game easy or difficult to play?", "What did you learn while playing the game? Do you think the game was educational?", "Were the questions in the game easy or difficult? Was the number of questions sufficient?", "Did you enjoy playing the game?", "Do you find the game visually appealing and easy to understand? Were there any features of the game you found lacking?", "Would you want to play this game again?", and "If you could modify this game, what changes would you like to make?".

2.2. Implementation

All preliminary preparations were completed before the implementation process began. In the first stage, the researcher identified the topic for the educational game development by exploring which science unit students perceived as most challenging. Informal feedback from the students through the daily classroom conversations revealed that they had a reluctance and negative attitudes toward the Force and Motion unit, which they frequently considered difficult. This feedback highlighted the need to develop an educational game specifically for this unit. Additionally, several factors were found to contribute to students' difficulties with this unit. These included the presence of numerous abstract concepts, the frequent use of graphs, students' limited skills in graph interpretation and construction, the integration of mathematical operations, and a lack of hands-on activities in the science textbooks. These challenges, combined with insights from the daily classroom discourse and the teaching experience of the science teacher (one of the researchers in this study), led to the decision to focus the game design on the Force and Motion unit.

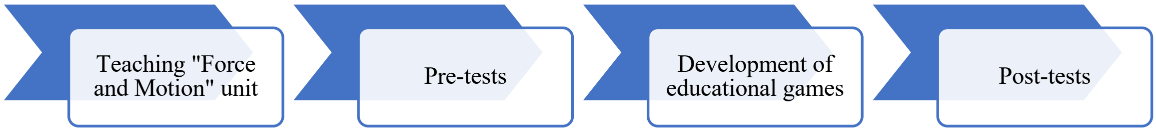
Following the identification of the target topic, a formal application was submitted to the relevant authorities, and the ethical approval and administrative permissions for the implementation and use of data collection tools were obtained. Before the game design phase began, all curriculum-basedlearning outcomes related to the Force and Motion unit were delivered over a four-week period, ensuring that students had completed the unit prior to the intervention.

In the 2022-2023 academic year, the learning outcomes related to the Force and Motion unit were delivered to the sixth-grade students in alignment with the national science curriculum, using various techniques including video presentations and problem-solving activities. Once all the relevant content was covered, a six-week educational game design process was launched within the scope of the elective course titled "Science Applications." The course met for two hours per week over approximately six weeks. In this phase, the students were tasked with designing an educational game related to the Force and Motion unit. The teacher acted as a facilitator throughout this process, providing guidance, answering students' questions, and offering support where necessary. The role of the teacher was to ensure that students were on track, encouraging them to apply the knowledge gained from the lessons while fostering their creativity and problem-solving skills in the game design process.

Pre-tests (MCTTC, SMQ, and AT) were administered to the students to assess the effects of the developed educational games on students' critical thinking skills, motivation to learn science, and force and motion concepts. Afterwards the pre-tests, the students were asked to develop games based on the targeted learning outcomes of the Force and Motion unit Throughout this process, the teacher closely monitored students' progress and provided formative feedback as needed. A total of 18 educational games were developed, each accompanied by instructional materials such as rule cards and explanatory notes. After the completion of the game design phase, the post-tests (MCTTC, SMQ, and AT) were administered to the students (Figure 1). Additionally, qualitative data were collected through student self-evaluation forms and peer feedback to gain insights into their experiences during the game design process.

Figure 1.

The stages of the study



During the educational game design process, students followed a structured set of stages, each aimed at promoting creativity, critical thinking, and content integration. The steps were as follows:

- *Initial Stage*: The students were first asked to examine the learning outcomes related to the Force and Motion unit and select the outcome they wanted to design a game around.
- *Research and Idea Generation*: After selecting the learning outcome, the students conducted preliminary research and generated ideas for the rules and materials required for their game. They were encouraged to draw inspiration from existing games they were familiar with (e.g., board games like Ludo, Bingo, or card games) or to create entirely original concepts. Students were also told that they could incorporate the learning outcomes either explicitly (e.g., through information or question cards) or implicitly (e.g., by embedding problems to be solved during gameplay).
- *Game Concept and Material Planning*: No liminations were imposed regarding the types of materials or games format. Students were encouraged to design games that were both educationally meaningful and engaging. Emphasis was placed on the importance of playability with peers and alignment with the selected learning outcomes.
- *Game Rules and Scoring System*: Students were asked to clearly define the rules of the game and determine the criteria for winning or losing. It was suggested that they include a scoring system that would align with the rules and dynamics of the game. Additionally, students were encouraged to incorporate levels or stages in the game to increase its difficulty and sustain player interest.
- *Material Selection:* Students were advised to use low-cost and easily accessible materials. The use of recycled materials was also recommended to promote sustainability,

highlighting the potential to create cost-effective and environmentally friendly educational games.

- *Design and Content Development*: Once the game concept was finalized, the students began the content develeopment and sketching process. They were encouraged to utilize various resources, such as the internet, books, and encyclopedias, to research and refine their content. The students were informed that they could base the content and questions for the game on textbooks or other supporting materials.
- *Prototyping and Feedback*: Students developed initial prototypes of their games and then obtained feedback from the teacher and classmates to refine their designs. Based on the feedback, they revised the game components, materials, or visuals to improve clarity, educational value, and playability. Collaboration, creativity, and peer support were strongly encouraged during this iterative stage.
- *Testing and Iteration*: In this stage, students tested their educational games by creating prototypes and observing their flow and interaction to identify areas requiring refinement. The games were tested in small peer groups to evaluate gameplay, rules, and educational content. Students received feedback from their peers, observed the test sessions, and made further improvements in response to this formative evaluation.
- *Finalization and Presentation*: In the final stage, students completed the final versions of their games, incorporating revisions based on prior testing. Once completed, the students presented their educational games to the class, explaining the learning objectives, materials used, game rules, and instructions. They also shared their design experiences, discussing the challenges they faced during the design process and the suggestions they received. Classmates provided written feedback using structured peer review forms.
- *Final Product*: A total of 18 educational games were developed on the *Force and Motion* topic. Throughout the design process, the teacher worked closely with the students, offering guidance, motivation, and feedback. Upon completion, the educational games were then tested in the classroom to assess their usability and effectiveness. During this process, students completed self-evaluation forms to reflect on their design experiences and the learning outcomes associated with their games.

2.3. Data analysis

Both quantitative and qualitative data were collected in this study. Quantitative data were analyzed using the SPSS 22 software package. Prior to analysis, the dataset was examined for missing values, data entry errors, and outliers. Next, the normality assumption was assessed to determine the suitability of parametric tests. Since the sample size was below 50, measures of central tendency and the Shapiro-Wilk test statistics were used for the normality (Pallant, 2016). As the significance levels for all variables in the normality test exceed 0.05, it was concluded that the data were normally distributed ($p > .05$).

In this study, repeated measures tests were used to analyze the data and determine whether the dependent variables showed a significant difference between different groups or conditions. This test is appropriate for examining whether the differences between measurements taken from the same group under two different conditions or time points are statistically significant (Pallant, 2016). Pre-test and post-test scores were used to compare students' critical thinking skills, motivation to learn science, and academic achievement. For each scale, total scores were computed by averaging item responses. The means of the two measurements were analyzed, and the significance of the differences was evaluated at a 95% confidence interval ($p < 0.05$). The results were used to test and interpret the study's hypotheses by highlighting the differences between the pre-test and post-test scores of the dependent variables.

Qualitative data were analyzed using content analysis procedures (Marshall & Rossman, 2006). Categories and codes were generated based on the students' responses to the open-ended questions. In the initial stage of data analysis, each researcher independently reviewed and coded the responses. Following this, the researchers compared their coded categories, identifying similarities and discrepancies. Cross-checks were conducted to ensure inter-coder reliability. Through discussion and consensus, the the final coding scheme was established and used to interpret the qualitative findings.

3. Results

Descriptive statistics were calculated for the study variables, and their normality distributions were checked. The results are presented in Table 1, the skewness and kurtosis values for all variables fell within acceptable ranges, indicating that the data were approximately normally distributed. As a result of the variables demonstrating normal distribution, parametric statistical tests were applied to the analyses of the three research sub-problems.

Table 1.

Descriptive Statistics of the implemented tools

Variables	N	Min.	Max.	Mean	SD	Skewness	Kurtosis
MCTTC (pre-test)	29	1.89	4.32	2.7635	0.60	1.066	.639
MCTTC (post-test)	29	2.93	4.61	3.8214	0.47	-.179	-.967
SMQ (pre-test)	29	1.43	4.43	3.0448	0.66	-1.28	.630
SMQ (post-test)	29	2.13	4.70	3.7552	0.54	-1.107	2.096
AT (pre-test)	29	1.00	11.00	5.0345	2.38	.620	.368
AT (post-test)	29	4.00	12.00	8.8276	2.99	-.175	-1.665

The first sub-research question of this research was formulated as: "Does designing educational games in sixth-grade science courses have a significant effect on students' critical thinking skills?" The null hypothesis developed to address this research question is as follows: "Designing educational games in sixth-grade science courses has no significant effect on students' critical thinking skills." To test this hypothesis, the MCTTC, consisting of 28 items, was administered to the sixth-grade students as both a pre-test and a post-test before and after the intervention. These tests were used to analyze whether students' critical thinking skills changed as a result of the educational game design process. The data were analyzed using the SPSS software, and the results are presented in Table 2. A paired-sample t-test was applied to evaluate the differences. When examining Table 2, it is evident that there was a 1.06-point increase in students' critical thinking skills after the application. This difference was found to be statistically significant according to the paired-sample t-test analysis, $t(28) = -10.905$, $p < 0.05$. Since the significance value is less than 0.05, it indicates that the difference between the pre-test ($M = 2.76$, $SD = 0.60$) and post-test ($M = 3.82$, $SD = 0.47$) critical thinking scores are statistically significant (see Table 3). The 95% confidence interval for the mean difference ranges from -1.26

to -0.86. Additionally, the eta squared value was calculated as 0.81, indicating a medium effect size (Pallant, 2016).

Table 2.

A paired-sample t-test results of critical thinking skills

	Paired Differences					t	df	Sig.(2-tailed)
	Mean	SD	Standard Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
pre-MCTTC– post-MCTTC	-1.058	.522	.0970	-1.257	-.859	-10.905	28	.000

The second sub-research question of the research was framed as: "Does designing an educational game in sixth-grade science courses have a significant effect on students' motivation to learn science?" The null hypothesis created to address this question is as follows: "Designing educational games in sixth-grade science courses has no significant effect on students' motivation to learn science." To test this hypothesis, the Science Motivation Questionnaire (SMQ), which consists of 30 items, was administered to the sixth-grade students as both a pre-test and a post-test before and after the educational game design application. The objective was to assess whether there was any change in the students' motivation to learn science as a result of the intervention. The data obtained from these tests were analyzed using the SPSS package program. For this analysis, a paired-sample t-test was used, and the results are presented in Table 3. It is observed that there is an increase of 0.71 points in students' learning motivation after the application of educational game design. This difference was found to be statistically significant, with the results of the related samples t-test analysis showing $t(28) = -10.900$, $p<0.05$. Since the p-value is less than 0.05, it indicates that the difference between the pre-test ($M = 3.05$; $SD = 0.66$) and post-test ($M = 3.76$; $SD = 0.54$) scores for learning motivation is statistically significant. The 95% confidence interval for the mean difference lies between -0.86 and -0.57, confirming the reliability of the result. Additionally, the eta squared value of 0.81 suggests a medium effect size, indicating a substantial impact of the educational game design intervention on students' motivation to learn science (Pallant, 2016).

Table 3.

A paired-sample t-test results of motivation to learn science

	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	SD	Standard Error Mean	Lower	Upper	t	df	Sig.(2-tailed)
pre-SMQ–post-SMQ	-.710	.379	.070	-.855	-.566	-10.090	28	.000

To test the third sub-research question of the research, which focuses on whether designing educational games in sixth-grade science courses has a significant effect on students' academic achievement in the Force and Motion unit, the hypothesis was stated as follows: "Designing educational games in sixth-grade science courses has no significant effect on students' science assessment in the Force and Motion unit." The AT, consisting of 12 questions focused on the Force and Motion unit, was administered to the students as both a pre-test and post-test. This allowed for an evaluation of whether students' academic achievement test scores changed due to the application of educational game design. The data collected from the pre-test and post-test results were analyzed using the SPSS package program. For testing the hypothesis, a paired-sample t-test was conducted. The results, including statistical findings, will be presented in Table 4. The analysis will provide insights into whether there was a significant difference in students' assessment test scores before and after the intervention, helping to determine the impact of educational game design on students' academic achievement. When examining Table 4, a significant improvement is observed in students' academic achievement in the Force and Motion unit after the application of educational game design. Specifically, there is a 3.79-point increase in students' scores on the AT. The results of the paired-sample t-test analysis showed that there is a statistically significant difference, with a test statistic of $t(28) = -9.53$, $p < 0.05$. This indicates that the difference between the pre-test ($M = 5.03$; $SD = 2.38$) and post-test ($M = 8.83$; $SD = 2.99$) scores is significant. The 95% confidence interval for the mean difference is between -4.61 and -2.98, confirming that the increase in achievement scores is both statistically significant and meaningful. Additionally, the eta squared value was calculated as 0.76, which indicates a medium effect size, suggesting that the educational game design had a notable impact on students' achievement in the unit. This analysis supports the hypothesis that designing educational games in the sixth-grade science course positively affects students' academic achievement in the Force and Motion unit.

Table 4.

A paired-sample t-test results of the assessment test

	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	SD	Standard Error Mean	Lower	Upper	t	df	Sig.(2-tailed)
pre-AT–post-AT	-3,793	2,144	,398	-4,609	-2,977	-9,525	28	,000

For the fourth sub-research question of the research, which aimed to explore sixth-grade students' views on the educational games they designed, students were asked to provide their reflections through open-ended written responses. The analysis of the students' written responses revealed that all students expressed positive feelings toward the educational game design process. This finding indicates a high level of engagement and enjoyment, suggesting that the activity was both motivating and enriching for the students. The students' enjoyment could be attributed to their active involvement in a creative, hands-on learning experience that allowed them to apply scientific knowledge in an innovative and meaningful context. Further examination of the students' reflections (as shown in Table 5) would provide more detailed insights into their feelings about various aspects of the game design process, such as their perceptions of creativity, challenge, and learning outcomes.

Table 5.

The students' self-evaluation reflections on developing educational games

Category	Students' Quotations
Cognitive effect	I learned science subjects faster by designing games.
Affective effect	I loved science class. I started to love it more.
	I enjoyed designing games.
	The lesson is great and fun.
	I liked it.
	It was good.
	We are very happy thanks to our teacher; the lessons are going perfectly
Designing	I have a hard time designing games.

When students presented the educational games, they had developed to their peers and received feedback, the qualitative analysis of their responses revealed three distinct thematic categories. These categories, which reflect students' perceptions of the games and the feedback process, are summarized in Table 6.

Table 6.
The students' evaluation feedback about the games designed by their classmates

Category	Students' Quotations
Educational Value	It helped me remember topics we had forgotten. It helped me understand and reinforce the subject matter. There were no flaws in the game. The game was very short. It would have been better if the questions were more challenging. The game was short, and there were few questions. The game was very entertaining and helped me recall old topics. The game was entertaining and allowed us to review the topic. Someone unfamiliar with science could learn a few things thanks to this game. I learned about the concept of speed through this game. I did not enjoy it very much because it ended quickly and had few questions. The game had very few questions. Adding more difficult ones would improve it. I learned questions related to force. We played it and liked it a lot. It helped me learn science. There were a few questions, and the game was easy. The game was very entertaining, and the questions were excellent.
Enjoyment and Fun	I played it with great pleasure. The game was very nice. A very nice game; I liked it very much. It was fun. I liked the game very much. It was a different game, and I enjoyed it. It was very difficult and made me a little bored; I did not like the game. It was very enjoyable. I loved it. Among all the games, this was my favorite. Even though I got bored waiting at times, it was very fun and beautiful. In a word, it was great. It was a big surprise for us. I did not like it very much. We competed as Boys versus Girls, and it was very fun.
Design Aspect	There are no negative aspects. The design is nice. I did not like the design; the questions were few, but the creativity was good. I got a little bored because the game went on for too long. The game was very nice, but the design was poor. A great game! The fun design was nice, and I liked it. The logical aspect of the game was very enjoyable. I did not like it much. I disliked the black coloring of the questions and the glass. The questions were too easy. The cards were prepared too small, so I did not like it much, though the questions were nice.

Category	Students’ Quotations
	The game was perfect, except for the question cards being small. The game was very nice, but there were too few cards. It was a nice touch to have different colored cards based on the difficulty level of the game.

The feedback provided by the students regarding the peer-designed educational games centered around three main themes:

> *Educational Value*: Students assessed the extent to which the games facilitated learning, particularly in reinforcing key concepts from the Force and Motion unit. Many students emphasized that they were able to understand and retain important scientific content while engaging with the games.
>
> *Enjoyment and Engagement*: A common thread across responses was the high level of enjoyment experienced during gameplay. Students frequently described the games as “fun” and expressed appreciation for the opportunity to learn in an interactive and entertaining format, highlighting the successful integration of learning and play.
>
> *Design Features*: Students commented on various aspects of the games’ design, including visual appeal, clarity, and usability. While many praised specific elements such as layout or creativity, some also provided constructive criticism, offering suggestions for improvement to enhance clarity and user experience.

In summary, the feedback from students reflected a positive overall reception of the educational games. They found the educational games to be both enjoyable and educational, and they appreciated the design elements that contributed to the overall experience. The quantitative data collected during the study demonstrated that the educational game design process had a positive impact on students' critical thinking skills, motivation to learn science, and academic achievement in the Force and Motion unit. These improvements were statistically significant, indicating that the game design process was an effective educational tool. Furthermore, the qualitative data aligned with the quantitative findings and provided more richer insights into the students' experiences. The students not only enjoyed the game design process but also reported that they learned through play. The games were not viewed as mere entertainment; they served as cognitive tools that encouraged deep learning, making the process both enjoyable and educational. The teacher, who was also one of the researchers, observed several positive outcomes during the process. According to the teacher's reflections:

- Students' interest in science lessons increased.
- Students actively participated in lessons and were more engaged with the subject.
- The concept of force and motion was reinforced as students repeated it through the games.
- The educational games played a key role in helping students learn new information.
- Passive students became more involved in the lessons, contributing to a more dynamic classroom environment.

In conclusion, the integration of educational game design into the science curriculum not only enhanced students' conceptual understanding but also promoted the development of critical cognitive and social skills. he approach fostered a more interactive, engaging, and effective learning environment, demonstrating its potential as a powerful instructional tool in science education.

4. Discussion and Suggestions

The first sub-research question of the study aimed to investigate whether designing educational games in the sixth-grade science course has a significant effect on students' critical thinking skills. To test this hypothesis, the Marmara Critical Thinking Tendencies Scale was applied to the students as both a pre-test and post-test. The analysis revealed a 1.06-point increase in students' critical thinking skills scores after the educational game design process. The difference was found to be statistically significant, confirming that the educational game design process had a positive impact on the development of students' critical thinking skills. This finding aligns with the existing literature that emphasizes the importance of using diverse teaching methods to develop critical thinking. Researchers have pointed out that critical thinking skills can be nurtured through innovative teaching strategies (Akkocaoğlu Çayır & Akkoyunlu, 2016; Karadağ & Demirtaş, 2018; Papadopoulos & Bisiri, 2020). For instance, Papadopoulos and Bisiri (2020) aimed to enhance students' critical thinking skills through a training program that incorporated game-based activities. The program made learning more interactive and collaborative, fostering both individual and group work, which were crucial for developing critical thinking. Thus, the results of this study contribute to the growing body of research supporting the idea that integrating educational games into the curriculum can be an effective method for enhancing students' critical thinking abilities. While much of the current literature on educational games involves researcher-designed or digital game environments, there is a noticeable scarcity of studies exploring student-designed physical (non-digital) games, particularly at the middle school level. This study contributes to a growing body of research that highlights the educational potential of student-driven, hands-on game design, offering a compelling alternative to more technology-centered approaches.. In research where educational game design is conducted by pre-service teachers, several important conclusions have been drawn. First, it has been found that educational games are not only enjoyable but also demanding processes requiring significant effort and creativity (Küçükşen Öner, Cetin-Dindar, & Sarı, 2024). These games provide students with opportunities to learn through hands-on experience and active participation, fostering deeper understanding and retention of the subject matter. Additionally, the game design process itself can promote essential 21st-century skills such as critical thinking, problem-solving, collaboration, and creativity.

For the game design process to be successful, certain key factors must be considered. The game designer should align the design with the intended educational objectives, ensuring that the game serves as an effective learning tool. Additionally, the knowledge level and needs of the target audience should be carefully analyzed to make the game accessible and engaging. Lastly, the game must integrate an enjoyable and interactive learning experience, balancing educational content with elements of fun to maintain students' motivation and interest throughout the activity. These findings emphasize the importance of strategic planning and intentional instructional design when implementing educational game activities in science education. By integrating theoretical knowledge with practical applicationgame design transforms traditional classrooms into student-centered, experiential learning environments that promote deep engagement (Korkmaz, Cetin-Dindar, & Oner, 2023). Future studies could explore additional dimensions, such as the long-term effects of educational game design on students' academic achievement and the development of skills, as well as the potential benefits of incorporating diverse cultural and disciplinary perspectives into the game creation process.

The holistic approach adopted by the Turkiye Century Education Model (2024) aligns with the objective of cultivating well-rounded individuals who not only excel academically but also demonstrate critical thinking, problem-solving abilities, and a strong sense of ethical responsibility. This educational approach emphasizes the importance of developing higher-level thinking skills, particularly critical thinking, to prepare students to engage with the world in a responsible and ethical manner. One of the central goals of this model is to nurture students who are capable of questioning information, conducting independent research to identify accurate knowledge, and evaluating their inferences with reflective reasoning. In this regard, the model goes beyond content delivery, aiming instead to foster individuals who are equipped to solve problems, think critically, and contribute constructively to their communities and society at large. This study, which investigates the impact of educational game design on students' critical thinking skills, directly contributes to the literature surrounding this new educational model. By demonstrating how engaging students in hands-on, creative processes like game design can enhance their cognitive abilities, particularly critical thinking, the research supports the implementation of such innovative methods within the broader educational reforms in Turkiye.

In summary, this study offers valuable insights into how game-based learning can be effectively integrated into educational practices to meet the goals of the Turkiye Century Education Model (2024). By fostering critical thinking and problem-solving skills, the study aligns with the model's broader aim of producing responsible, ethical individuals equipped with the necessary tools to navigate and contribute to an ever-changing world. The findings of this study align with existing literature regarding the positive impact of educational game design on students' motivation to learn science. By applying the Science Motivation Questionnaire as a pre-test and post-test, the study observed a significant increase in students' motivation to learn science education after engaging with educational games. This result mirrors previous research, which supports the notion that educational games make science lessons more enjoyable, engaging, and ultimately more effective in boosting student motivation. Studies have shown that when educational games are used in teaching science, students' intrinsic motivation to learn is enhanced, as games help make learning more interactive and fun. Educational games have been shown to activate intrinsic motivation by fostering curiosity, providing challenges, and encouraging participation, which in turn increases attention, focus, and overall engagement (Yurt, 2007). Furthermore, beyond the cognitive gains, research has highlighted that educational games can enhance students' social and affective skills as well, providing a comprehensive learning experience that also nurtures emotional and social development

(Babaandaç, 2013; Bayat, Kılıçaslan & Şentürk, 2014; Karamustafaoğlu & Kaya, 2013; Yıldız, Şimşek & Ağdaş, 2017). Moreover, several studies have demostrated that educational games foster a positive attitude towards the subject matter, thereby increasing intrinsic motivation. This finding is consistent with previous research, which indicates that students who engage in educational games develop a more favorable view of the subject, as well as greater intrinsic motivation (Beker Baş & Karamustafaoğlu, 2020; Gürpınar, 2017; Korkmaz, 2018; Şentürk, 2020; Serdaroğlu & Güneş, 2019; Yazıcıoğlu, Çavuş & Güngören, 2019). Educational games introduce an element of enjoyment and curiosity into the learning process, making lessons more engaging and productive. This finding is consistent with studies (e.g., Beker Baş & Karamustafaoğlu, 2020) that show how integrating games into science education increases students' intrinsic motivation and promotes sustained engagement with the subject matter. Motivation, as a critical factor in learning, is enhanced by the interactive and competitive nature of games, as well as their ability to make abstract concepts more accessible. This is consistent with the findings of Tasgin and Tunç (2018), who observed that students with low levels of participation in conventional lessons became more active and engaged when exposed to game-based activities. In this respect, educational games serve as an inclusive instructional tool, reaching a diverse range of learners and addressing varying needs within the classroom.

In conclusion, this study contributes to the expanding body of evidence supporting the integration of educational game design into science education as a means of enhancing both academic achievement and student motivation. By making learning experiences more enjoyable, interactive, and learner-centered, educational games foster a more dynamic and supportive environment that aligns with the vision and pedagogical priorities of the Türkiye Century Education Model (2024).

The findings of this study regarding the effect of educational game design on student academic achievement in the Force and Motion unit align with research that suggests educational games can positively influence academic performance. The significant increase in assessment test scores from pre-test to post-test demonstrates that educational games, when applied appropriately, can enhance students' learning outcomes. This aligns with existing literature that emphasizes the positive impact of educational games on science achievement (Atakul, 2022). The idea that educational games can improve academic performance is well-supported in literature. Game-based learning environments tend to promote greater focus and motivation, which in turn foster deeper engagement and improved performance. Educational games also create interactive and dynamic learning conditions that enhance content retention and conceptual understanding. However, it is also important to acknowledge that not all studies have found educational games to be effective in improving academic performance. Some researchers, including Yiğit (2007), Bayırtepe and Tüzün (2007), and Ataöver (2005), have found no significant effects on academic achievement when educational games were used. This inconsistency can be attributed to several factors, such as the design and implementation of the game, the teaching methods used, the student profile, and the content of the game. As Candan Tosun and Koçak (2021) emphasized, the effectiveness of educational games depends on their pedagogical coherence and purposeful integration into the learning environment. Therefore, while educational games hold significant potential as a learning tool, their success is not guaranteed in all contexts. Effective integration of educational games into the curriculum requires careful planning, design, and adaptation to meet the needs of the students and align with the learning objectives. When designed correctly and implemented with pedagogical expertise, educational games can serve as a powerful tool for improving student achievement.

Furthermore, the study highlights that the perception of educational games among educators can sometimes be negative. As Tosun (2011) pointed out, some science and technology teachers may perceive educational games as a "waste of time" or as causing confusion in the classroom. This perception may hinder the broader adoption of educational games in teaching. However, in the constructivist learning approach, which emphasizes active participation and student-centered learning, educational games are particularly valuable. They engage students, make learning more motivating and enjoyable, and help develop important skills such as problem-solving, creativity, and self-confidence. In conclusion, educational games, when carefully designed and applied, can be an effective for enhancing student achievement in science education. While their success may depend on various factors such as teacher approach and game content, they provide an engaging and interactive learning experience that benefits students' academic performance and overall development (Korkmaz, Cetin-Dindar, & Oner, 2023).

Based on both the self-evaluations of students and the peer evaluations of their classmates, it can be concluded that developing educational games is particularly effective for teaching abstract and complex scientific concepts. These games make learning more interactive and enjoyable, thus promoting deeper engagement. Many students indicated that the educational games facilitated the reinforcement and retention of knowledge, as the repetitive nature of game-based activities allowed them to revisit and consolidate previously learned content. Additionally, students noted that the games made the lessons more enjoyable, helped them recall forgotten topics, and increased their interest in the subject matter, especially when elements of competition were incorporated. However, some students mentioned that the games were too short, which suggests that there may be a need to adjust the length of the game activities to better engage students. Despite this minor limitation, the overall consensus was that the use of educational games enriched the learning experience, making science lessons more enjoyable, efficient, and motivating. These findings are consistent with previous literature. For instance, Garvey (1990) noted that games are motivating, fun, and satisfying for students. Zhu (2012) also demonstrated that games significantly increase students' interest in the subject matter, while Demirel (2002) showed that even students who were typically less engaged can become active participants through the use of interactive educational games.

From the teacher's perspective, the application process went smoothly, with no disciplinary issues reported during the educational game design phase. The teacher observed that all students were actively engaged throughout the process, which further supports the idea that educational games can contribute to increased student participation and engagement. Moreover, the teacher highlighted notable improvements in students' social skills, particularly during collaborative group work. These observations are consistent with previous studies by Çavuş, Kulak, Berk, and Öztuna Kaplan (2011) and Boyraz and Serin (2015), science lessons that incorporate educational games improve not only academic achievement but also fosters the development of social competencies. Students exhibited improvements in important areas such as teamwork, rule adherence, and mutual respect, which are essential for social and emotional development. In conclusion, the integration of educational games in science courses proved to be an effective strategy for enhancing both academic learning and social-emotional development. The games fostered a positive learning environment where students were more motivated and engaged, making the learning process both fun and effective. These findings are in line with the existing literature and underscore the multidimensional benefits of game-based learning in fostering holistic student development.

The findings of this study indicate that designing educational games in science education significantly enhances students' critical thinking skills, motivation to learn science, and academic achievement in the Force and Motion unit. These results emphasize the potential of educational games as a multifaceted pedagogical tools that extend beyond transmission of academic knowledge, promoting a broad spectrum of social, cognitive, affective, psychomotor, communication, and creative thinking.

The findings of this study have significant implications for science education and beyond. Integrating educational games into the curriculum can provide an engaging and interactive alternative to traditional teaching methods, better addressing the diverse learning needs of students. To optimize the impact of such strategies, it is essential to provide comprehensive professional development for teachers in designing and implementing educational games. Furthermore, games must be aligned with curricular objectives, adapted to students' developmental and cognitive levels, and designed to promote active participation within a collaborative classroom culture.

While the study highlights the potential of educational games, it is important to recognize some limitations. The findings are based on a specific context (sixth-grade science course on force and motion unit) and may limit the generalizability of the findings to other subjects or grade levels. Additionally, the success of game-based learning depends heavily on the teacher's facilitation skills, the quality of the games, and the engagement of students. Future research could explore the long-term impact of educational games on learning retention and skill development, the effectiveness of game-based learning across different subjects and educational levels, and the use of digital and immersive technologies (e.g., virtual reality) in educational games to enhance student engagement and learning outcomes.

In conclusion, this study demonstrates the considerable educational value of engaging students in the design and implementation of educational games within science education. By supporting the development of both academic and non-academic competencies, educational games represent a holistic and student-centered approach to teaching and learning. When carefully designed and effectively implemented, such practices have the potential to transform traditional classrooms into dynamic learning environments that cultivate curiosity, motivation, and lifelong learning skills.

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ITALL

Review Article

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A Low-Visibility, High-Potential Resource for Teachers' Lifelong Learning: MOOCS

Ayşe Bağrıacık Yılmaz[1]

* *Corresponding ayse.yilmaz@adu.edu.tr*
[1] *Aydın Adnan Menderes University*, Türkiye

Abstract

It is of great importance that teachers, who are at the forefront of society's learning journey, continuously update their knowledge and skills to maintain their professional competence and provide a quality learning environment for students, thus continuing lifelong learning. Lifelong learning is an important concept that is increasingly being incorporated into our country's policies. In this regard, distance education offers a wide range of opportunities for lifelong learning, particularly for individuals who are unable to participate in face-to-face training due to its independence from time and space. MOOCs can be considered the most up-to-date and appropriate opportunity distance education offers for lifelong learning. MOOCs are platforms open to everyone's participation over the internet, can include courses on almost any subject, and can reach millions of students. The most important feature that differentiates them from other internet resources is that they are in a course format. Thanks to MOOCs, obtaining certificates from universities recognized worldwide is possible. However, when the Turkish literature was analysed, it was seen that there was not enough emphasis on the potential of MOOCs for teachers. Therefore, in this study, the opportunities offered by MOOCs to teachers, who have an important role in shaping and transforming society, in the context of lifelong learning, were examined. The opportunities were discussed under eight headings: learning regardless of time and place, professional development, personal development, foreign language learning, networking and collaboration, technology use and digital literacy, learning motivation, and job opportunities.

Keywords: Lifelong learning, MOOCs, distance education, teacher education

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Öğretmenlerin Hayat Boyu Öğrenimi için Görünürlüğü Düşük, Potansiyeli Yüksek Bir Kaynak: KAÇD

Özet

Toplumlara öğrenme yolculuğunda rehber olan öğretmenlerin, mesleki yeterliliklerini sürdürebilmeleri ve öğrencilere nitelikli bir öğrenme ortamı sağlayabilmeleri için bilgi ve becerilerini sürekli güncellemeleri dolayısıyla hayat boyu öğrenmeye devam etmeleri büyük önem taşımaktadır. Hayat boyu öğrenme ülkemiz politikalarında da kendine gittikçe daha çok yer bulan önemli bir kavramdır. Uzaktan eğitim ise zaman ve mekândan bağımsız olması nedeniyle özellikle yüz yüze, planlı eğitimlere katılma olanağı olmayan bireyler için hayat boyu öğrenme için geniş fırsatlar sunmaktadır. Kitlesel Açık Çevrimiçi Dersler (KAÇD), uzaktan eğitimin hayat boyu öğrenme için sunduğu en güncel ve uygun fırsat olarak değerlendirilebilir. KAÇD'lar internet üzerinden herkesin katılımına açık, hemen her konuda ders içerebilen ve milyonlarca öğrenciye ulaşabilen platformlardır. Onları diğer internet kaynaklarından ayıran en önemli özellik ise bir kurs formatında olmalarıdır. KAÇD'lar sayesinde dünya çapında tanınan üniversitelerden sertifika almak da mümkündür. Ancak Türkçe literatür incelendiğinde KAÇD'ların öğretmenler için taşıdığı potansiyele yeterince vurgu yapılmadığı görülmüştür. Dolayısıyla bu çalışmada, toplumun şekillenmesinde ve dönüşümünde önemli bir role sahip olan öğretmenlere KAÇD'ların hayat boyu öğrenme bağlamında sunduğu fırsatlar incelenmiştir. Bu fırsatlar, zaman ve mekandan bağımsız öğrenme, mesleki gelişim, kişisel gelişim, yabancı dil öğrenme, ağ kurma ve işbirliği, teknoloji kullanımı ve dijital okuryazarlık, öğrenme motivasyonu ve iş fırsatları olmak üzere sekiz başlık altında ele alınmıştır.

Anahtar Kelimeler: Hayat boyu öğrenme, KAÇD, uzaktan eğitim, öğretmen eğitimi

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1. Introduction

In today's world, where knowledge and technology are constantly changing and developing, it has become necessary for individuals to be open to learning not only in a particular educational process but also throughout their lives. Lifelong learning is critical for individuals to maintain their personal development, adapt to social changes, and keep their professional competencies current. Teachers are an important group that cannot be excluded from lifelong learning. It is of great importance that teachers, who guide societies in their learning journey, continuously update their knowledge and skills to maintain their professional competencies and provide a qualified learning environment for students. Changes in educational programs, new teaching approaches, and the rapid development of digital technologies mean teachers must be open to continuous learning.

In our country, various initiatives have been carried out to support teachers in maintaining their lifelong learning. Although these studies are mainly carried out through face-to-face courses/trainings, it is seen that the twelfth five-year development plan of our country includes the statement 'Distance education opportunities in lifelong learning will be increased and digital content development studies will be carried out' in article 675.1 (Development Plans, 2025). Distance education has the potential to provide individuals with broad and flexible opportunities in lifelong learning by offering learning opportunities independent of time and space (Bozkurt, 2015; Kır & Bozkurt, 2020; Oh et al., 2019). One of the most concrete steps taken in our country to ensure lifelong learning of individuals through distance education is the 'Distance Education Gateway' platform prepared by the Presidency of Human Resources Office (2025). Individuals can access this platform, which includes many free trainings, with their government username (e-devlet) and password. Although there is various content on this platform that teachers can benefit from, it should not be forgotten that the lifelong learning opportunities offered by distance education to teachers are much broader.

Massive Open Online Courses (MOOCs), one of the distance education platforms that can contribute to teachers' lifelong learning, offer free and flexible learning opportunities to millions of people around the world. MOOCs are an innovative learning environment that enables individuals to learn anytime and anywhere through information and communication technologies. In the constantly renewed information structure of the digital age, MOOCs offer an important opportunity for individuals to keep themselves up-to-date and meet their learning needs (Bozkurt, 2015).

In Coursera, one of the most well-known MOOC platforms, more than 10,000 courses are offered by more than 300 universities and companies. In Coursera's survey of more than 55 thousand students in 2023, 95% of the students stated that the platform contributed to them; 43% stated that the courses they took on this platform increased their performance at work (Coursera, 2023). MOOCs provide an inclusive learning environment, especially for individuals who cannot access traditional education due to time and space constraints. However, despite this high potential, MOOCs are not visible enough at the level of institutions, individuals, and researchers, especially in our country.

There are very few publications on MOOCs in the Turkish literature. According to the results of the study conducted by Haymana and Dağhan (2020), authors in Turkey do not pay enough attention to MOOCs. Until 2018, only four of the 123 articles published on MOOCs in the Web of Science database were by Turkish authors. As of April 2025, only 34 of the 1162 publications in the Web of Science database between 2019 and 2025 with MOOC or Massive Open Online Courses in the title belonged to authors from Turkey.

According to Kesim and Altınpulluk (2014), massive open online courses contribute to individuals' lifelong learning processes in various ways. In addition to supporting both professional and personal development of individuals, these courses offer significant savings in terms of time and cost. At the same time, they allow individuals to renew themselves without leaving their working life. One of the important advantages of this system is that it provides access to accurate and reliable information. In addition, the fact that there is no limit to the number of participants and that it offers a structure that is open to interaction are among the positive aspects of massive open online courses.

The fact that MOOCs are a lifelong learning opportunity was also emphasized by Bozkurt (2015) in the Turkish literature; in the related study, the characteristics of MOOCs were mainly focused on. An important study linking lifelong learning and MOOCs was conducted by Bayır (2021). Bayır described MOOCs as the most up-to-date form of digital technologies used for lifelong learning. Similarly, Tonbuloğlu (2020) also mentioned MOOCs as a potential distance education format for lifelong learning.

In the existing studies that associate lifelong learning with teachers, teachers' lifelong learning competencies (Akçay, 2021), attitudes towards lifelong learning (Tenekeci & Uzunboylu, 2020), digital literacy skills (Gökbulut, 2021), 21st century skills (Yalçın İncik, 2020), various demographic characteristics (Yıldız Durak & Tekin, 2020), etc., variables and their relationship with lifelong learning were investigated. Öztürk (2022), on the other hand, questioned the effects of having used MOOCs on teachers' communication skills, learning styles, etc., variables.

MOOCs are one of the most effective tools that come to mind when it comes to teachers' lifelong learning. These platforms have many advantages for teachers, such as collaboration with colleagues, learning in accordance with their own programs, acquiring new knowledge, and professional development (Bakogianni et al., 2020). In the words of Manning et al. (2014), MOOCs not only contribute to the professional development of teachers but also have the potential to collaborate and interact with international colleagues. Curriculum developers, leading teachers, and educational administrators should examine the growing impact of MOOCs in today's world, where distance professional development opportunities are evolving.

In the international literature, there are many studies on teachers' interaction with MOOCs (Bakogianni et al., 2020; Koukis & Jimoyiannis, 2018; Koutsodiomu & Jimoyiannis, 2015; Manning et al., 2014; Misra, 2018; Stutchbury et al., 2023). In our country, there are a few studies on teachers' use of MOOCs. Among these studies, 972 teachers were included in the doctoral thesis conducted by Öztürk (2022), and it was determined that 6.2% of these teachers had previously participated in MOOCs. However, no information was provided on how teachers benefit from these platforms. Vezne (2020) associated MOOCs with adult education and included eight teachers as adults in his study. As a result, it was determined that MOOCs contribute to the personal and professional development of teachers. However, the point to be noted here is that the teachers in the study group were asked to register and complete one MOOC within the scope of the Lifelong Learning course at master's level. The study did not provide information about the previous MOOC experiences of these teachers.

The research conducted by Uslu and Öztürk (2019) is evidence that teachers' awareness of this issue should be increased in our country. In the aforementioned study, when teachers interested in language teaching were asked whether they had information about MOOCs, it was determined that they confused MOOCs with platforms such as YouTube and Moodle and were extremely unfamiliar with this concept. It is a fact that teachers' awareness and use of MOOCs in our country should be increased. In addition, it is thought that a specific study on how teachers can benefit from MOOCs can be guiding for teachers and policymakers. In this context, this study aims to address the opportunities offered by MOOCs, especially for teachers in the context of lifelong learning, and to raise awareness for more widespread and effective use of these digital learning tools.

2. Lifelong Learning

The European Commission (2002) defines lifelong learning as 'a set of activities aimed at improving the individual's knowledge, skills and competences in various fields from birth to death'. The Ministry of National Education (2018), on the other hand, addresses this concept in a similar framework to the European Commission with the definition of 'All kinds of learning activities that the individual participates in throughout his/her life outside formal education in order to develop his/her knowledge, skills and competences with an individual, social and employment-related approach'.

According to the Eurostat dictionary (2025), lifelong learning covers all learning activities in which individuals participate throughout their lives with the aim of developing their knowledge, skills, and competences in personal, social, civic, or professional fields. The main factor that distinguishes these activities from non-learning activities, such as cultural or sportive activities, is the learning intention of the individual. Aksoy (2013), on the other hand, examined many definitions in the literature and considered lifelong learning as 'formal, non-formal, lifelong learning activities in which individuals participate throughout their lives in order to improve their knowledge, skills, attitudes, behaviors and competencies by identifying their interests with an approach related to individual, social, cultural, economic and especially employment, and the certification of the results of these activities'.

The concept of lifelong learning is based on the idea of building a knowledge-based and continuously developing society that will enable individuals to meet their learning needs through various learning tools and meaningful learning experiences (UNESCO, 2016). Lifelong learning differs from other concepts related to education in terms of its individual-centered approach, the importance it attaches to forms of learning other than formal education, its transformation of the traditional function of the school, its encouragement of the participation of social stakeholders in education, and the fact that it does not see education as a process limited to certain ages or periods. In addition, the lifelong learning approach increases individuals' investment in knowledge and in themselves and supports them in acquiring the basic competences necessary to sustain their lives (Güleç et al., 2012).

The European Commission emphasizes that it is necessary to develop skills in eight basic areas within the scope of lifelong learning: (a) communication in the mother tongue, (b) communication in a foreign language, (c) basic competences in mathematics, science and technology, (d) digital competences, (e) learning to learn, (f) social and civic competences, (g) initiative and entrepreneurship competence and (h) cultural awareness and expression competence (European Commission, 2007). When we consider all these, it becomes clear that an individual with lifelong learning skills should have the qualities of taking responsibility for learning, being open to change, thinking critically, using ways of accessing information effectively, integrating digital technologies in a purposeful way, interacting with different cultural structures, developing sensitivity to social problems, having an entrepreneurial mindset and transferring what they have learnt to different areas of life. These individuals not only maintain their individual development but also actively contribute to social and economic transformation processes. In this context, lifelong learning can be considered as a dynamic process that enables the individual to constantly renew himself/herself and to be an active subject in all areas of social life.

The concept of lifelong learning has found a place in the policies of our country for about 25 years and maintains its importance. It is seen that lifelong learning is given great importance in all development plans of our country from the eighth five-year development plan covering the years 2001-2005, including the twelfth five-year development plan covering the years 2024-2028 (Development Plans, 2025). In the twelfth five-year development plan, lifelong learning is included in the main purpose of education as follows:

'The main objective is to ensure that all individuals have equal access to quality education and lifelong learning opportunities on the basis of the principle of inclusiveness, to develop their academic, social and professional skills in accordance with international standards, to ensure that they have competence in analytical thinking, financial literacy, collaborative work and leadership, to internalize national, spiritual, moral, humanitarian and social values, and to grow up as responsible to the family and society to which they belong.'

The provision, improvement, and monitoring of lifelong learning processes of individuals in our country have been carried out by the General Directorate of Lifelong Learning (GDLL) under the Ministry of National Education since 2011. GDLL (2025) explains its mission as 'Providing guidance services from cradle to grave in the process of transformation into a learning society; supporting the individual to take responsibility in the development of humanity by developing knowledge, consciousness, and competencies; providing quality training that can be documented and monitored.'

Lifelong learning is an approach that contributes to the individual and professional development of various professional groups. However, from the perspective of shaping the effects of this process on society, teachers are in a key position. As individuals who encourage, guide, and model learning, teachers' adoption and maintenance of a lifelong learning approach has a strategic importance that can indirectly support the development of other professional groups.

3. Teachers and Lifelong Learning

With the transition to the information society, individuals becoming lifelong learners has come to the fore not only as an individual but also as a social necessity. In a constantly developing and changing world, individuals are expected to update their knowledge, acquire new skills, and produce creative solutions to the problems they face. In this framework, lifelong learning has become an indispensable process not only for students but also for teachers who prepare them for the future. According to the Turkish Ministry of National Education (2006), teachers are expected to continuously improve their professional competences in areas such as teaching processes, planning, evaluation, and human relations in line with lifelong learning and to be individuals who are open to innovations, flexible, and willing to learn.

Since teachers are expected to develop lifelong learning skills of their students, they should be in a continuous learning endeavor throughout their own lives and actively seek new learning opportunities (Selvi, 2011). In Turkey, lifelong learning activities of teachers are officially carried out by the General Directorate of Teacher Training and Development (GDTD). GDTD undertakes various tasks such as developing policies, collaborating with relevant institutions, and organizing pre-professional and in-service training in order to determine and improve the professional competencies of teachers. It also conducts research on teacher education and carries out joint studies with public institutions, universities, and non-governmental organizations (GDTD, 2018).

The Ministry of National Education (MoNE) offers face-to-face in-service training to teachers within the scope of lifelong learning. However, only a limited number of teachers and administrators can attend these trainings. Due to this situation, the Distance Education Module has been added to the EBA (Eğitim Bilişim Ağı/ Education Informatics Network) infrastructure. Thanks to this module, in-service training can be provided to hundreds of teachers at the same time through remote access. In addition, teachers' professional development is supported through live broadcasts over the EBA infrastructure (Ergün, 2022).

The Teacher Information Network (Öğretmen Bilişim Ağı/ÖBA), which was established by the MoNE to support the personal and professional development of teachers in a multidimensional way, also includes more than a hundred trainings (MoNE, 2022). However, lifelong learning is a phenomenon that cannot be expected to be organized only by institutions due to the fact that it takes place at any time. As Collins (2004) states, self-initiated learning is the most common and effective form of lifelong learning. Therefore, teachers should adopt lifelong learning not as a duty but as a natural way of life.

It has been revealed in various studies (Akın et al., 2023; Bakogianni et al., 2020; Doğan, 2024; Kabal, 2019; Kılıç, 2015; Sevinç & Çelebi, 2020) that teachers have high lifelong learning tendencies, and there are many studies in the literature addressing the phenomenon of lifelong learning with teachers. However, as will be detailed below, the issues of how teachers perform lifelong learning and how they benefit from digital opportunities have been ignored or not sufficiently researched in the literature.

In the literature, teachers' lifelong learning tendencies are addressed from different perspectives, and their relationship with various variables is questioned. For example, Sevinç and Çelebi (2020) investigated the relationship between lifelong learning disposition and professional satisfaction based on the data obtained from 250 teachers from various branches and found that there was no significant relationship between the related variables. On the contrary, Topdemir et al. (2022) investigated the relationship between lifelong learning disposition and professional satisfaction of master trainers and teachers working in public education centers and determined that lifelong learning disposition predicted professional satisfaction by 76%. In addition, lifelong learning has a positive moderate relationship with teachers' happiness (Kabal, 2019).

Lifelong learning is also examined according to demographic variables. Sevinç and Çelebi (2020) found that there is no variation in lifelong learning tendency according to branch, experience, gender, and graduation degree (associate, undergraduate, graduate). Similarly, Akyol et al. (2018) determined that there is no significant effect on lifelong learning disposition according to variables such as monthly income, gender, marital status, and employment status. The results of Yıldız Durak and Tekin's (2020) study revealed that gender, daily internet usage level, branch, professional seniority, weekly course load, and in-service trainings received in the field of information technologies did not change the lifelong learning tendency. In the study conducted by Kaan (2023) focusing on academic staff, it was determined that women had higher lifelong learning tendencies. On the other hand, Doğan (2024) found that teachers with an associate's degree were more open to lifelong learning than teachers with a bachelor's degree.

Researches reveal that it is extremely important for teachers to make effective use of technology in lifelong learning processes. In the studies conducted by Doğan (2024) and Yücel (2024), it is seen that teachers' information literacy and digital competence levels directly or indirectly positively affect their tendency towards lifelong learning and their professional satisfaction. In a study conducted with counsellor teachers (Doğan, 2024), a strong and significant relationship was found between lifelong learning competence and basic competencies in the use of technology. These findings suggest that digital skills play a supportive role in teachers' lifelong learning process. As a matter of fact, skills in information, media, and technology use are among the skills that individuals who want to be successful in the 21st century should have. 21st-century individuals are expected to use technology as a tool to research, organize, evaluate, and communicate information; access, manage, integrate, evaluate, and generate new knowledge by using digital technologies appropriately (P21, 2019).

Today, distance education is the first method that comes to mind when it comes to learning from digital communication tools. Distance education is a flexible learning opportunity that individuals who want to learn can access from anywhere and at any time. While distance education in our country is carried out mainly through open education faculties or distance education centers of universities before the COVID-19 pandemic, it has become a phenomenon that almost all individuals interact with and become familiar with after the COVID-19 pandemic. Although educational institutions have returned to predominantly face-to-face education with the end of the pandemic, society has continued to benefit from the advantages of distance education. In particular, there are 'learning and teaching/awareness-raising' oriented accounts with hundreds of thousands of followers on social media platforms such as YouTube and Instagram. There are numerous accounts on these platforms from which teachers can benefit. One of the platforms that the society, and therefore teachers, are not yet sufficiently aware of, but whose potential is extremely high, is Massive Open Online Courses.

4. Massive Open Online Courses

MOOC refers to online learning environments where anyone with internet access can access course content and interact with other participants (Fini, 2009). These programs, which are usually led by universities, appeal to large masses and do not require any prerequisites for participation. While MOOCs, which use video lectures, live sessions, social platforms and various educational materials, exhibit an informal structure in terms of freedom of participation, they also have formal features in terms of being carried out within the framework of a specific education plan and offering accredited certificates (Çebi & Aydın, 2023).

MOOCs are generally defined as open-ended education programs offered to thousands of learners over the internet (Misra, 2018). MOOCs have the potential to support lifelong learning, eliminate barriers in the learning process, provide equal opportunities in education, and most importantly, secure the liberation of knowledge (Zawacki-Richter et al., 2018).

4.1. Features of MOOCs

MOOCs have four main features: mass, openness, online, and course format (Kop, 2011).

Being online: MOOCs are carried out with an internet connection using information communication technologies. These platforms are registered with the help of an email address. Generally, asynchronous distance education method is used, but in the blended MOOC types that have emerged in recent years, courses can be supported by face-to-face education (Anders, 2015).

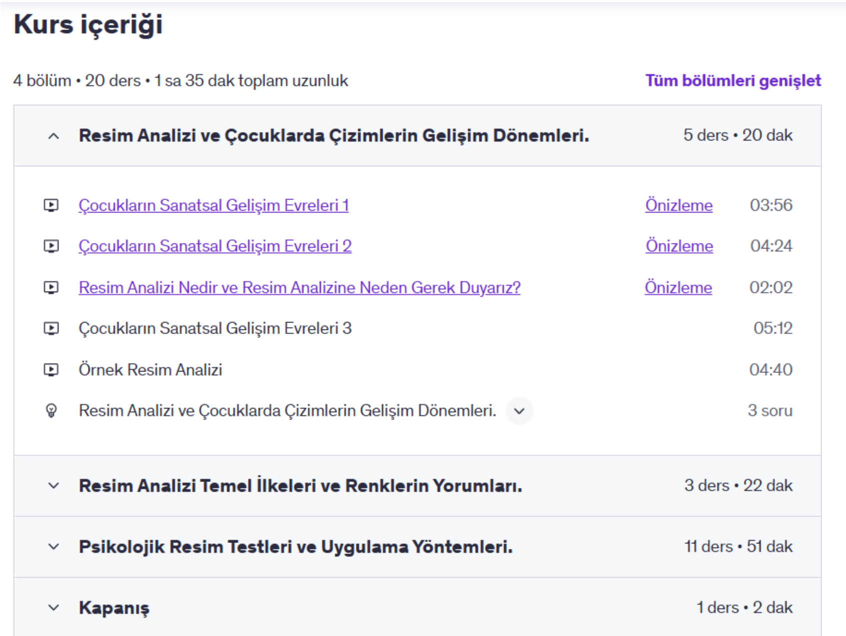
Massiveness: According to Rodriguez (2011), 'massive' refers to the ability of thousands of students to participate in the course at the same time. Unlike small-scale online learning environments, MOOCs can provide education to a large number of participants simultaneously (Haymana & Dağhan, 2020). The current number of students of Coursera, one of the most well-known MOOC platforms worldwide, is more than 125 million (Coursera, 2025a), which reveals the extent of massiveness.

Openness: The concept of "openness" encompasses multiple dimensions: the use of open-source software, an open registration process accessible to all, an open curriculum structure (allowing flexibility and adaptability during the course), open access to learning resources, transparent assessment procedures where applicable, and the learners' ability to adapt to various learning environments (Rodriguez, 2011). Thanks to this openness, individuals participating in MOOC platforms can withdraw from the learning process at any time, interact with other participants, use learning resources freely, and contribute to knowledge production. Furthermore, those who wish may earn a certificate by completing the course and fulfilling the requirements (Çebi & Aydın, 2023).

Course format: MOOCs are distinguished from other online learning resources (such as websites or social media platforms) by their structured course format. For example, below is the content of a course titled "Analysis of Children's Drawings" offered on Udemy, one of the widely used MOOC platforms (Udemy, 2025). As can be seen, details are provided regarding the number of weeks, the topics covered each week, and the duration of each module. This structure resembles the syllabus typically used in face-to-face education. Additionally, upon closer examination of the course page, it becomes evident that the course is organized around specific learning objectives, which are elaborated in detail. This enables learners to access more structured and high-quality educational content than random online materials (Çebi & Aydın, 2023).

Figure 1.

Course Content of the "Analysis of Children's Drawings" Course (Udemy, 2025)

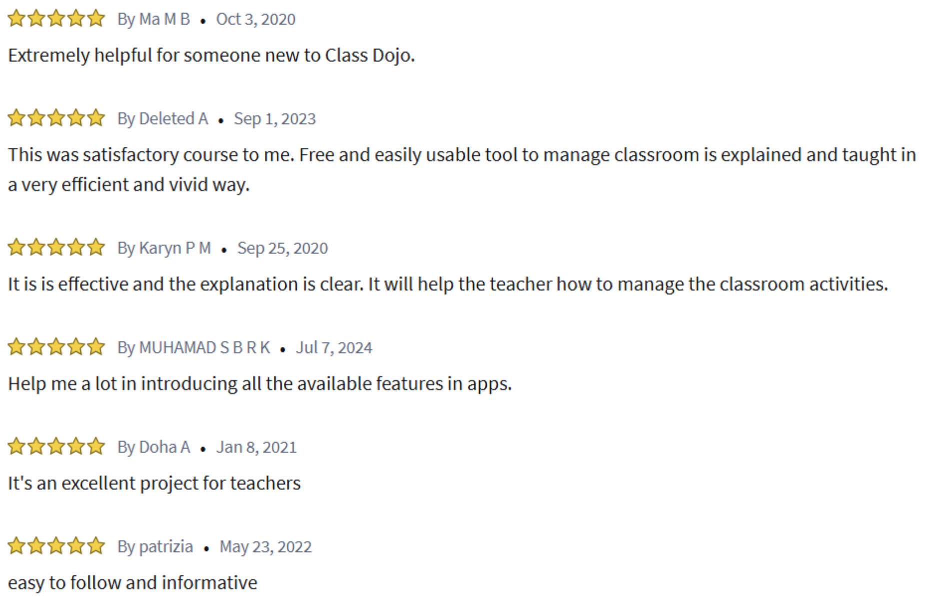


4.2. Widely Used MOOCs

Among the most widely used MOOCs worldwide are Coursera, edX, XuetangX, Udacity, Khan Academy, Udemy, and FutureLearn (Atik & Ata, 2018; Çebi & Aydın, 2023). Notably, an agreement has been established among these platforms between Khan Academy and the Turkish Ministry of National Education, allowing access to its content in Turkish via the EBA platform (Çebi & Aydın, 2023). Udemy is also a MOOC platform that offers relatively more Turkish-language content and instructors than other platforms. However, the language barrier has largely been eliminated thanks to the availability of Turkish subtitles on many MOOC platforms. This study will not delve into the detailed features of these platforms. Instead, the main point to be emphasized here is that these widely used platforms also offer a wealth of content for teachers. Figure 1 shows a screenshot of the learners' views on the course named "Improving Classroom Management with Class Dojo" on Coursera.

Figure 2.

Comments on the Course "Improving Classroom Management with Class Dojo" (Coursera, 2025c).


By Ma M B • Oct 3, 2020
Extremely helpful for someone new to Class Dojo.

By Deleted A • Sep 1, 2023
This was satisfactory course to me. Free and easily usable tool to manage classroom is explained and taught in a very efficient and vivid way.

By Karyn P M • Sep 25, 2020
It is is effective and the explanation is clear. It will help the teacher how to manage the classroom activities.

By MUHAMAD S B R K • Jul 7, 2024
Help me a lot in introducing all the available features in apps.

By Doha A • Jan 8, 2021
It's an excellent project for teachers

By patrizia • May 23, 2022
easy to follow and informative

Examining the reviews in Figure 2 shows that teachers have benefited from the course and expressed satisfaction with it. Of course, it is unrealistic to expect all learners to benefit equally from all courses. However, it can be suggested that when teachers identify appropriate and useful courses for their needs, they are likely to be satisfied with MOOCs.

5. Opportunities Offered by Massive Open Online Courses for Teachers

MOOCs are platforms designed for the benefit of all individuals. As outlined in the introduction section, various studies have emphasized that these platforms offer lifelong learning opportunities. There is no requirement to belong to any particular profession to enroll in and complete a MOOC. For instance, the course mentioned in the previous section, "Analysis of Children's Drawings," can be taken by a parent curious about the messages conveyed through their child's drawings, an academic seeking to develop expertise in this area, or a preschool teacher. This section discusses the advantages that the features of MOOCs offer for teachers in terms of lifelong learning.

5.1. Learning Independent of Time and Space

MOOC technology has the potential to enable large-scale learning that is flexible enough to meet the needs of diverse groups of participants (Bozkurt, 2015; Kennedy et al., 2019). Thanks to their flexibility in terms of time and location, MOOCs provide an important opportunity for teachers who, due to numerous responsibilities, may otherwise have limited access to professional development opportunities (Wei et al., 2009). MOOCs are also preferred because they allow learners to progress at their own pace (Vezne, 2020). In a study conducted with Greek teachers, Bakogianni et al. (2020) found that teachers emphasized the ability to participate in courses at times that suited their schedules as a key advantage of MOOCs. The fact that MOOCs offer time- and space-independent learning has also been evaluated by distance education experts as a valuable lifelong learning opportunity (Kesim & Altınpulluk, 2014).

In Turkey, especially among subject teachers, there are often several-hour gaps between classes in their schedules. During these periods, teachers may face difficulties attending face-to-face courses outside of school, which can be a discouraging barrier to their lifelong learning. However, through MOOCs, teachers can seize lifelong learning opportunities in personal and professional development whenever available.

5.2. Professional Development

MOOCs offer significant benefits for working professionals, particularly teachers, and as a result, many courses on these platforms are specifically designed for them (Ji & Chao, 2016). These platforms have become an important resource for teachers seeking to continue their professional development after completing their undergraduate education. Offering a low-cost yet effective learning experience, MOOCs stand out as a powerful and innovative solution for meeting teachers' ongoing professional development needs (Mahmood & Bibi, 2017). Through MOOCs, individuals can renew and upskill themselves without interrupting their professional lives, thus supporting their lifelong learning (Kesim & Altınpulluk, 2014).

In the study by Bakogianni et al. (2020), teachers reported that MOOCs allowed them to improve their knowledge and skills, and they stated that they would recommend MOOCs to their colleagues for professional development. Similarly, in another study in which teachers experienced a MOOC platform (Stutchbury et al., 2023), 89% of teachers reported that MOOCs positively impacted their professional development. According to teachers' perspectives, MOOCs contribute positively to their professional confidence (Koukis & Jimoyiannis, 2018). Teachers who have previously participated in a MOOC report better communication with their students and stronger subject matter knowledge than those who have not (Öztürk, 2022).

The literature contains a substantial number of studies addressing the contributions of MOOCs to teachers' professional development. Indeed, it can be said that MOOCs are most frequently associated with professional development for teachers; however, it is important to note that these platforms offer benefits in many other areas.

5.3. Personal Development

Teachers may also wish to pursue lifelong learning for personal reasons, and in today's world, this has become not only a choice but also a necessity. It has been found that teachers who participate in MOOCs devote more time to their personal development compared to those who do not (Öztürk, 2022). This can be interpreted in two ways: individuals may use MOOCs specifically to enhance their personal development, or become aware of the need for personal development through their MOOC participation. In either case, this represents a positive step toward lifelong learning.

Learners join MOOCs to acquire new knowledge or enhance their existing competencies. Some learners enroll in MOOCs without expecting credits or credentials (Hew & Cheung, 2014), indicating that their participation is driven by intrinsic motivation. In Vezne's study (2020), teachers who had experienced MOOCs reported that they learned new things, gained new perspectives, and developed greater self-confidence, positively contributing to their personal development.

Personal development can encompass many areas, including hobbies, sports techniques, language learning, time management, and health—its scope is essentially limitless. Significantly, progress in personal development can also positively impact professional development. For example, a teacher who takes a time management or stress management course to organize their home life better is highly likely to apply these skills professionally. Moreover, the fact that these courses stand apart from general internet resources is noteworthy. For instance, the course titled Managing Emotions in Times of Uncertainty and Stress (Coursera, 2025b), offered on the Coursera platform, is delivered by Yale University. Learning from instructors at some of the world's leading universities represents a significant opportunity for lifelong learning.

5.4. Foreign Language Learning

MOOCs can also contribute to teachers' lifelong learning in terms of language acquisition. Teachers can achieve this in two ways. The first is enrolling in courses related to language instruction offered on MOOC platforms. For instance, Udemy, which frequently features Turkish instructors, offers 1,680 courses dedicated to English language learning (Udemy, 2025a). The second way is through incidental language learning that occurs while participating in any course delivered via MOOCs. Until recently, the fact that MOOC platforms generally offered courses in foreign languages—primarily English—posed a barrier for many learners. However, with recent advancements in artificial intelligence technologies, many MOOC platforms now support various languages. Today, learners can follow course content presented in various languages in their native language. This, in turn, can help learners become more familiar with a foreign language while engaging with the course material. The literature notes that language barriers have posed challenges for teachers participating in e-Twinning projects, which encourage collaboration with teachers from other countries (Bozpolat & Bolsu, 2022; Küçüktaşçı, 2022). Language learning facilitated by MOOCs, free from temporal and spatial constraints, may help overcome such issues.

5.5. Networking and Collaboration

MOOCs enable learners to collaborate around topics of interest and support each other through knowledge sharing during the learning process (Xiong, 2018). The knowledge teachers gain through MOOCs is not limited to course content; peer support, discussions, and interactive networks often inspire new classroom activities and teaching strategies that can be integrated into curricula (Manning et al., 2014). In a study conducted by Koukis and Jimoyiannis (2018) involving 326 teachers, nearly all participants stated that MOOCs constituted a learning community that fostered interaction and collaboration with fellow educators. Similarly, in a study by Stutchbury et al. (2023), 40% of teachers who had participated in MOOCs reported resolving their problems through collaboration with peers. One participant in the same study even mentioned placing a kettle and tea bags in his/her office after completing a MOOC to foster a more collaborative environment with colleagues.

These examples illustrate that MOOCs can be platforms encouraging teachers to collaborate with their peers. However, it is important to note that such opportunities for interaction may not be available on all platforms. While some MOOC platforms include discussion or forum modules facilitating communication among participants, others may lack such features. Therefore, teachers who aim to engage in collaborative learning should opt for platforms that explicitly support interaction.

5.6. Technology Use and Digital Literacy

As is well known, individuals in the 21st century are expected to effectively use digital technologies to access, analyze, and produce information. Teachers are consistently encouraged to integrate technology into teaching practices. Of course, the benefits of technology use and digital literacy extend beyond professional contexts, offering significant advantages in everyday life. MOOCs not only provide content on how teachers can effectively use technology in the classroom, but it can also be expected that completing any MOOC course will positively influence teachers' overall technological proficiency. Indeed, teachers have described MOOCs as experiences that enhanced their technological knowledge, particularly in integrating web-based tools into educational practices (Koutsodiomu & Jimoyiannis, 2015; Koukis & Jimoyiannis, 2018). Some teachers further reported that, after engaging with MOOCs, they felt more competent in using computers and ICT (Stutchbury et al., 2023).

5.7. Motivation and Lifelong Learning

An individual's desire to learn often begins with a lack of knowledge or skills, and if the learning experience proves satisfying, it is likely to be sustained. MOOCs can be viewed from this perspective. A learner who engages with MOOCs out of a desire to learn and finds the experience fulfilling will likely seek further learning opportunities. Indeed, in a study conducted by Vezne (2020), teachers who had experienced MOOCs expressed a willingness to participate in more courses, citing their accessibility, alignment with personal learning pace, affordability, simplicity, and support for lifelong learning. According to the findings of Stutchbury et al. (2023), participation in MOOCs not only impacts teachers' motivation but also positively influences their students' motivation. Some teachers reported becoming more creative in their classrooms after completing a MOOC, which led to increased participation and engagement among their students.

5.8. Employability and Certification

Today, holding a diploma from a degree program may no longer be sufficient for securing employment, leading graduates to seek alternative pathways to enhance their employability. Most MOOC platforms offer certificates—some free, others paid—upon completion of specific courses. Due to their alignment with industry needs, up-to-date content, and relatively low cost, MOOCs provide micro-credentials and degrees that help individuals adapt to the evolving demands of the labor market (Özbek, 2019). One of the key challenges in MOOC environments is the lack of accreditation, which limits the practical use of the certificates earned (Çebi & Aydın, 2023). While there is no guarantee that all employers will recognize these certificates, it is believed that having certifications from globally recognized universities in their portfolios could benefit teachers applying to private institutions.

6. Discussion and Conclusion

Lifelong learning is an individual necessity in our society and an educational goal supported by government policies. The most recent five-year development plan highlights that lifelong learning cannot be limited to face-to-face education alone and that the opportunities offered by distance education should be utilized effectively (Development Plans, 2025). In this context, one of the most significant contributions of distance education to lifelong learning is the potential of MOOC platforms, which provide access to large population due to their massive and open structures. While MOOCs are accessible to all individuals, this study focuses on teachers, who play a crucial role in shaping and transforming society. It examines the opportunities MOOCs offer them in the context of lifelong learning.

Like any educational technology and instructional model, MOOCs come with a range of advantages and disadvantages. Frequently highlighted challenges include high dropout rates (Aharony & Bar-Ilan, 2016; Voudoukis and Pagiatakis, 2022; Vázquez-Cano et al., 2021), limited interaction with instructors and peers (Aharony & Bar-Ilan, 2016; Dolan, 2014; Manning et al., 2014), and language barriers (Liyanagunawardena et al., 2013). Nevertheless, rather than focusing solely on these limitations, it is more constructive to highlight the potential of MOOCs to support teachers' lifelong learning. The benefits of MOOCs for educators can be categorized into eight main categories: learning independent of time and place, professional development, personal development, foreign language acquisition, networking and collaboration, technology use and digital literacy, learning motivation, and employment opportunities.

Today, a teaching diploma alone is insufficient to be a competent teacher, just as a degree is insufficient in many other professions. Teachers are expected to update their subject-related knowledge continuously. Although the MoNE in Turkey offers online content and training through the EBA and ÖBA platforms (Ergün, 2022; MoNE, 2022) and provides in-service training throughout the year, teachers are not limited to institutionally planned professional development programs. MOOC platforms host numerous courses that teachers can integrate into their instructional practices. Various studies have shown that these courses, which teachers can access anytime and anywhere, contribute significantly to their professional development.

When the general competencies of the teaching profession are considered (MoNE, 2017), teachers are expected to grow professionally and personally. MOOCs provide excellent opportunities for personal development as well. Considering that lifelong learning also has a positive impact on individuals' happiness (Kabal, 2019), it is likely that such happiness would be reflected in their professional lives. Furthermore, MOOCs also enhance teachers' self-confidence (Vezne, 2020). Developing oneself in areas of personal interest and need can lead to positive outcomes that permeate all aspects of a teacher's life.

In today's globalized world, knowing only a single language is no longer sufficient; multilingual communication skills play a critical role, especially in collaborative international projects such as e-Twinning. This situation encourages teachers to learn a second language not only for their professional development but also for their personal growth. MOOC platforms stand out as economical and accessible learning environments that offer direct foreign language education and support implicit language acquisition through content in various disciplines. Additionally, although it is difficult to ensure meaningful interaction between students in MOOCs (Dolan, 2014), teachers can develop collaboration with colleagues they meet on these platforms (Manning et al., 2014).

The ability to integrate technology with pedagogy is already among the competencies expected of teachers (MoNE, 2017). Although teachers in Turkey receive training in this area throughout their undergraduate education, the continuous and rapid advancement of technology requires them to keep updating their knowledge and skills. Like other individuals, teachers can also benefit from the many opportunities that technology offers in their personal lives. In this context, MOOCs represent accessible and practical platforms that can directly and indirectly contribute to teachers.

MOOCs may increase teachers' desire to engage in more learning. The ability to access learning opportunities anytime and anywhere often leads to continued use of MOOCs after the initial experience (Vezne, 2020). This is also important for teachers who serve as role models for their students and communities. Students who observe their teachers actively engaging in lifelong learning will likely internalize this value for themselves. Finally, MOOCs may also present new employment opportunities for teachers. Teachers may serve as instructors on MOOC platforms or use the certificates they earn as learners to support their job applications.

7. Suggestions

While it is not possible to limit the lifelong learning opportunities MOOCs offer to teachers solely to those outlined in this study, it is evident that these platforms are valuable resources for both personal and professional development. However, the literature suggests that teachers are not sufficiently aware of the potential of these platforms. Inspired by the study conducted by Sezgin (2020), pre-service teachers should be introduced to the potential of MOOCs and encouraged to use them during their undergraduate education. Similarly, in-service training programs can include the introduction of MOOC platforms and encourage their usage among current teachers.

Despite the numerous advantages offered by MOOCs, teachers may still be reluctant to utilize these platforms for professional development. This situation indicates the need for teachers and policymakers to become aware of how MOOCs can be effectively used for teacher professional development and to develop supportive policies and practices accordingly (Misra, 2018). In this regard, it is recommended that MOOCs be included in planning lifelong learning strategies, especially concerning distance education, as emphasized in the latest five-year development plan. In addition, MoNE could collaborate with global platforms such as Coursera or edX to develop Turkish MOOC’s content or to provide access to internationally recognized certifications through the ÖBA platform.

Another suggestion for practitioners is to incorporate MOOC awareness into pre-service teacher education. At this point, the role of academics becomes important. Academics can encourage students to follow one or more MOOCs relevant to the course's subject matter. However, it should be remembered that MOOCs are based on voluntary participation; enforcing participation may lead to adverse outcomes. Therefore, it may be more appropriate to integrate MOOC content into course activities and to prefer short, concise, and free MOOCs.

Based on the findings of this study, several suggestions can also be made for future researchers. In Turkey, there appears to be a research gap regarding the extent to which teachers are aware of MOOCs, their purposes for using them, the barriers they face, and the strengths, weaknesses, and areas for improvement of these platforms. Initially, it would be beneficial to identify the reasons behind the low awareness levels among teachers. After creating awareness, a study could be designed in which teachers are encouraged to use MOOC platforms for a certain period, and the outcomes can be monitored quantitatively (e.g., changes in lifelong learning experiences) and qualitatively.

In Turkey, platforms such as EBA, ÖBA, and the Presidential Distance Education Gateway offer similar features to MOOCs, such as short, concise video lectures and certification following short assessments. Research can be conducted to explore how and to what extent teachers benefit from these platforms, as well as their opinions and expectations regarding the content provided.

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